The impact of institutional investments and net greenhouse gas emissions on government expenditure

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Abstract

The aim of ensuring to all citizens across the European Union (EU) Member States a quality life from social and economic perspectives became nowadays associated with the environmental aspects, public authorities assuming and targeting in this context more and more the objective of "green economies." In this context, public spending plays a vital role in relation to the quality of the environment and environmental sustainability, with government expenditure being able to influence the behavior of the involved agents. This paper aims to analyze the impact of institutional investments and net greenhouse gas on government expenditure. To evaluate the influence of public spending, we employed the ordinary least squares method and ARDL model (MG-mean group, PMD-pooled mean group estimator and DFE-the dynamic fixed effect model) and data regarding expenditures on education, science, and research and development (R&D) as describing the social side, the greenhouse gas emission variable as describing environmental sustainability and investments expenditures considering their beneficial effect on the economy, while controlling by real GDP per capita and foreign direct investment. Our panel includes data for the 27 member countries of the European Union, the period 2005-2020. The results of our study show that 61.5% of the variation of the general government expenditure variable is explained through the prism of the independent and control variables used in the model. The study demonstrates that the volume of government spending will depend on how government investors place their investments, but also on the amount of greenhouse gas emissions

Keywords: institutional investments, greenhouse gas emissions, government expenditure, European Union countries, ARDL model

Introduction

In today's context, environmental issues have become increasingly important, and the greenhouse effect is a real problem for all the states of the European Union. Thus, the member countries of the European Union act through their policies to reduce carbon dioxide emissions. However, the issue of climate change transcends national borders. Addressing climate change and its negative effects requires international cooperation. In this regard, world leaders concluded the Paris

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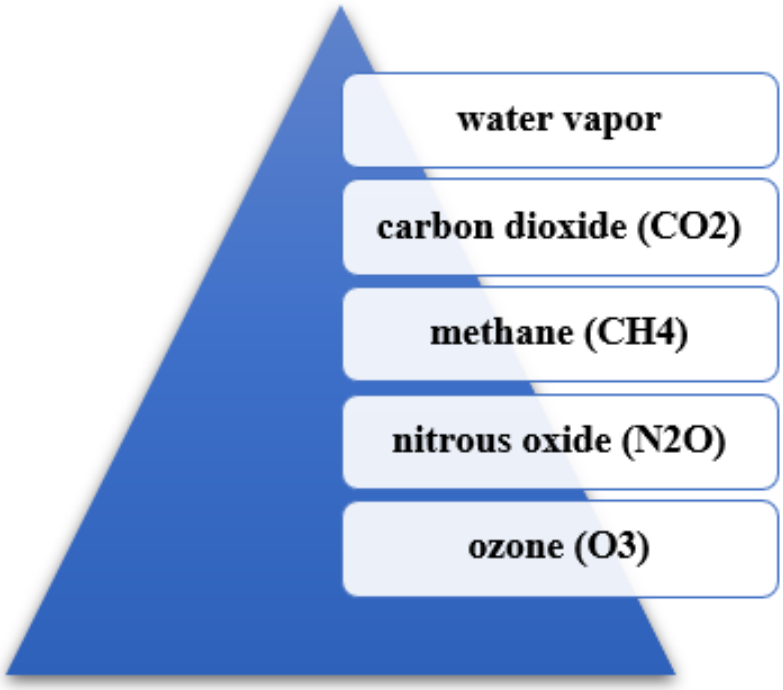
Agreement in 2015 at the UN Climate Change Conference (COP21). This international agreement "includes commitments from all countries to reduce their emissions and work together to adapt to the impacts of climate change and requires countries to strengthen their commitments over time" (Delbeke et al., 2019, p. 36).

The main greenhouse gases in the Earth's atmosphere are presented in Figure 1. The main evening-effect gases found in the Earth's atmosphere that contribute to global warming by absorbing and trapping infrared radiation are illustrated in Figure 1.

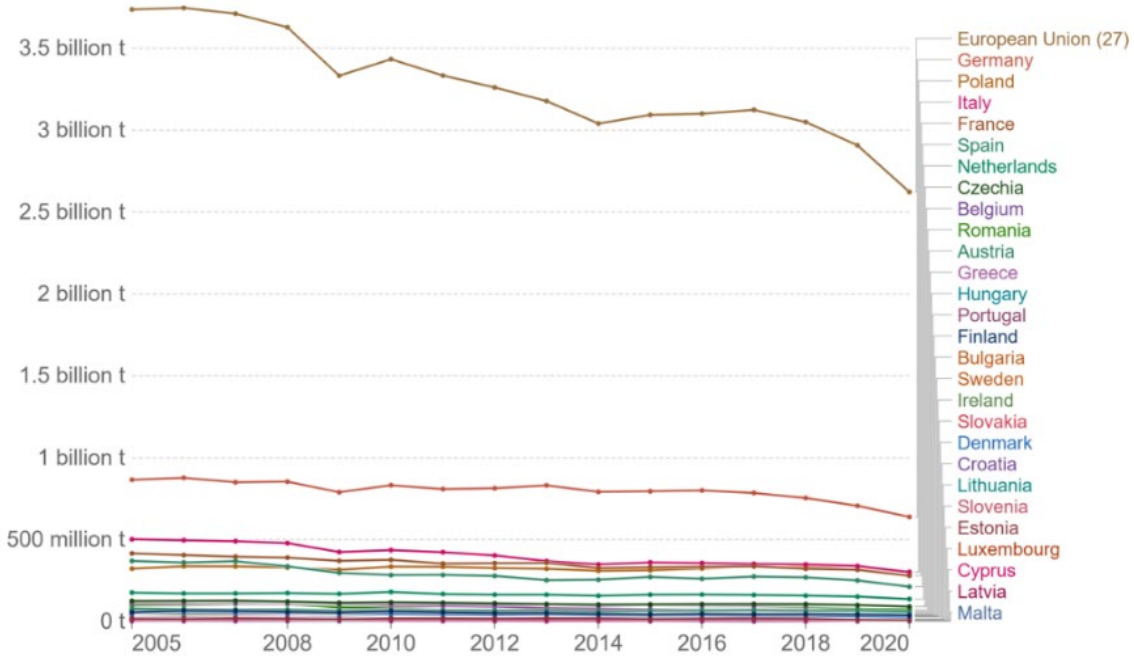
Figure 1. The main greenhouse gases



Source: Author owns work

In the traditional view, climate action has translated into measures taken by governments to reduce greenhouse gas emissions (Tosun, 2022, p. 1). However, economic literature (Boscarino, 2015, p. 5; Legagneux et al., 2018, pp. 3-4) has reached a point of convergence, namely that there are trade-offs in implementing climate action and achieving other parts of sustainable development. The public policy efforts made by the EU countries during recent years led to a decrease in CO2 emissions, as shown in Figure 2.

Figure 2. Annual CO_2 Emissions in the European Union over the period 2005-2020



Source: Ritchie, 2022

The graph above shows the evolution of annual CO_2 emissions from 2005-2020. Overall, according to the graph, a decreasing trend of CO_2 emissions can be observed in the EU member countries during the period analyzed. For example, in 2020 the EU had a total of 2.62 billion tons of CO2 emissions, and among the EU member states, the biggest producers of CO_2 are Germany (639.38 million tons), Poland (303.52 million tons) and Italy (302.28 million tons). In this context, the literature argues that investments are essential for firms to remain competitive or even viable in a carbon-constrained world (Jiang and Klabjan, 2012, p. 2). Despite public policy efforts, some studies exploring the connections between public spending and reduction of the CO_2 emissions (as Han, Farooq, Nadeem, and Noor, 2022, p. 1) are concluding that an increase in the GDP increases CO_2 emissions, while economic development significantly enhances environmental emissions. Anyway, it should be noted that the issue of environmental sustainability cannot be addressed only through (better) public spending, novel micro-policies intended to affect behaviors, technologies, and organizational practices being also needed (Guerrero and Castañeda, 2022, p.1).

Government expenditure is a fundamental pillar of economic policies, having a direct impact on economic growth, social development and financial sustainability of states. In this context, identifying the determinants of public spending is essential for understanding how governments allocate their resources. The economic literature suggests that institutional investment, greenhouse gas emissions, research and development (R&D) spending and foreign direct investment (FDI) can

significantly influence the structure and level of government spending. However, there is a limited number of studies that simultaneously analyze the impact of these variables on public spending, which is why this research contributes to filling this gap in the specialized literature.

The main purpose of this study is to investigate the relationship between institutional investment, net greenhouse gas emissions and general government expenditure by function. In addition, the analysis also includes the impact of research and development spending, as well as foreign direct investment, given that these variables can influence government decisions on resource allocation. The study provides an empirical perspective on how economic and environmental factors influence the fiscal policy of states. Methodologically, the research uses the ordinary least squares (OLS) model to estimate the relationships between the variables, along with the Dynamic Fixed Effects (DFE) model, an econometric framework derived from the Autoregressive Distributed Lag (ARDL) approach, which allows capturing dynamic effects in panel data. The choice of this method is justified by its ability to estimate short- and long-term relationships in a fixed-effects framework, which ensures a more rigorous control over heterogeneity between the analyzed states.

Through this analysis, the study contributes to the literature by providing empirical evidence on the interaction between institutional investment, greenhouse gas emissions and the structure of public spending. The results obtained may have significant implications for the formulation of fiscal and environmental policies, highlighting how economic and environmental factors influence government decisions on public spending.

This study explores the interaction between government spending, institutional investment and greenhouse gas emissions, highlighting their impact on economic competitiveness. Government investment in infrastructure and R&D contributes to improving a country's economic position, stimulating innovation and productivity growth. At the same time, regulations on greenhouse gas emissions and associated fiscal policies can influence production costs and, implicitly, the competitive advantage of the economy. By using an ARDL econometric model applied to panel data, this study analyzes the short- and long-run relationships between these variables, providing insight into how economic policies can influence sustainability and long-term competitiveness.

Literature review

Government expenditure is one of the government's intervention strategies to ensure continued economic growth. However, public administrations face a dilemma between economic development and environmental protection, given that financial resources are limited. Thus, it realizes the

efficiency of government spending for environmental protection is favorable to achieving the balance between economic growth and environmental protection.

Government spending focuses on providing services such as health, education, or electricity. We can say that in this form the role of the state is fulfilled in a vision that ensures the fulfillment of social objectives. However, nowadays it is necessary for a state to manage public funds more carefully. Society has evolved, and people's requirements are different compared to 30 years ago. Over the past 30 years, investment has evolved significantly, having a major impact on global economies. For example, during the 1990s, most investments were concentrated in traditional industries, such as manufacturing or infrastructure. Today, however, due to technological advances and digitalization, there is an increasing emphasis on investments in technology, innovation and digital infrastructure. This change has influenced people's demands, generating a greater need for skills in areas such as IT, artificial intelligence and the green economy. Also, the increase in investments in the field of sustainability and renewable energy has generated new economic opportunities, but also new challenges for governments and societies. Thus, the attention of decision-makers has turned to the way in which public money is used. Given these changes, it can be seen that the public sector depends to a large extent on private sector investments and initiatives to support sustainable development and meet current economic demands. This collaboration between the public and private sectors leads to increased productivity and stimulates the attraction of a greater volume of Foreign Direct Investment (FDI) (Othman et al., 2018). Investments of this type are directly linked to a boost in national income growth (Zhang et al., 2019), thus contributing to economic development.

Cities are blamed for most of the greenhouse gas (GHG) emissions (Hoornweg et al., 2011, p. 207). Dubeux and La Rovere (2007) state that the municipality can mitigate climate change by improving waste management systems. In this manuscript we can see the actions taken by which the citizens are obliged to sort out the waste. However, this small step must be taken more seriously. And the change should start right from each person's shopping cart. We are all tempted to buy large quantities of food that we can't eat and reach the expiration date. Thus, many of the purchased products will be transformed into food waste. And this waste will affect a family's budget in two ways. The change could start with our shopping habits. We often buy large quantities of food that we don't consume in a timely manner, which can lead to it expiring. As a result, some of the products we buy end up as food waste. This waste can impact a family's budget in two ways. The first direction and the easiest to observe is the one related to resupplying the pantry with the food necessary for living, food that was initially bought but which for reasons of validity ended up in the garbage, but which in the end a family needs in daily food. There is a need for people to plan their meals, as well

as their food needs. And the 2nd direction through which waste affects the personal budget is related to the increase in the level of sanitation fees. Municipalities are overwhelmed by the amount of waste, and this translates into higher taxes to purchase new technologies that help compost the waste. On the other hand, waste that is stored in landfills or on land near cities consumes large areas of land. In addition to this fact, this type of storage is not in line with the directions of sustainable development.

According to several studies (Wheeler, 2008; Gough et al., 2011; Guyadeen et al., 2019), government policies focus on increasing carbon prices. And this fact leads to an increase in domestic energy prices. For this reason, these studies mention the need for radical changes in the monitoring of flows of, as well as directing policies towards the modernization of houses, coupled with "social" tariffs for household energy.

The COVID-19 pandemic led to a severe economic recession that began with a health crisis. Thus, the EU member states had to develop large-scale action plans to overcome the demanding situation. Lahcen et al. (2020) quantify the potential of government investment in green building projects to stimulate the economy. Currently, it is not enough to implement a project that will generate certain returns. The current business practice is mainly focused on respecting the environment. Thus, the profits that can be obtained must be based on an activity that reduces energy consumption and does not generate high levels of pollution. We can say that public policy also had a difficult word to say in this equation. Often, any good idea must also be based on a secure foundation, which is ensured by the public factor.

It can be noticed at the European level that the population is concerned about climate change, which is increasingly present in everyday life. The major problem that changes daily life is the possibility that food can no longer be easily procured. A recent study (Laborde et al., 2021, p. 2-4) analyzed a specific part of agriculture, namely the polluting one. These authors consider that over the years government support has stimulated the development of high-emission agricultural systems. Government support has a minor impact in inducing additional global GHG emissions from agricultural production. This is attributed to the fact that support is not systematically targeted towards high-emitting products. Also, trade protection drives up consumer prices.

The balance of GHG emissions produced and those removed from the atmosphere. A key component of climate change policy and environmental sustainability. Investments in renewable energy, energy efficiency, and other mitigation strategies require substantial government funding. Adaptation measures to cope with climate change impacts (like infrastructure resilience, disaster management, and public health) also entail significant expenditures.

Government investment and spending policies have the ability to increase economic growth (Prasetyo, 2020, p. 471-472). For this reason, the allocation of financial resources to less environmentally efficient sectors should be discouraged, and resources should be allocated to more sustainable sectors. Also, according to Arfah (2021, p. 50-52), government investments have a positive impact on the industrial sector.

The results of another study (Shahbaz et al., 2020, p. 11-12) support the fact that spending on research and development is beneficial for the environment. Policy making to reduce carbon emissions is vital to focus on allocating resources to innovation. Private research and development expenses are not sufficient in the production of innovative solutions, thus, the need for public financial support appears (Wu et. al., 2021).

We are looking to investigate that government spending is influenced by greenhouse-green emissions and investments. So, we propose the following null hypothesis:

H_{0a}: Institutional investment has a negative influence on government expenditure.

H_{0b}: There is a negative association between greenhouse gas emissions and government expenditure.

Our hypothesis is substantiated by other studies (Barrett, 2009; Su and Moaniba, 2017; Basu, 2018) which consider that government investments do not always influence the development and patenting decisions of climate technologies. Likewise, other studies (Zhang et al., 2021, Kocak and Alnour, 2022, p. 1) demonstrate that there is a negative relationship between the green economy and public expenditure. In this order, we propose a 3rd null hypothesis:

H_{0c}: Government investments do not have a positive impact on public spending.

Data and Methodology

Data description

This study investigates the impact of institutional investments and net greenhouse gas on government expenditure across the 27 EU countries, during the period 2005-2020. The identified variables, and their description are presented below (Table 1).

Table 1. Variables definition

Variable name	Variable name type	Units	Source
Government_EXP	*General government expenditure by function*-dependent variable	% of GDP	Eurostat
Invest	*Investment share of GDP by institutional sectors*-independent variable	% of GDP	Eurostat

Variable name	Variable name type	Units	Source
GAS emissions	*Greenhouse gas emissions*-independent variable	% of GDP	Eurostat
R&D exp	*Gross domestic expenditures on research and development (R&D)*-control variable	% of GDP	Eurostat
GDPpc growth	Real GDP per capita growth-control variable	Chain-linked volume and as a percentage change from the previous period	Eurostat
FDI	*Foreign Direct investment in the reporting economy (stocks)*-control variable	% of GDP	

Source: Author's work

Table 2 contains a presentation of the descriptive statistics of the variables included in the analysis.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Government_EXP	432	45.18	6.77	24.20	64.90
Invest	432	22.08	4.49	10.69	53.59
Gas emissions	432	9.93	3.97	4.5-0	30.80
R&D exp	432	1.53	0.89	0.37	3.73
GDPpc growth	432	1.50	4.08	-14.60	23.20
FDI	432	404.51	1175.55	11.70	731.20

Source: author's work

The dataset contains 432 observations, with a time span of 16 years, between 2005 and 2020. On average, all countries recorded a level of General government expenditure of 45.18% of GDP in the period 2005-2020 which varies from this average by +/-6.77%. The majority of General government expenditure in these countries have values between 24.2-64.9%. On average, all countries recorded a level of Investment of 22.08% of GDP in the period 2005-2022, which varies from this average by +/-4.49%. The majority of Investment in these countries have values between 10.69-53-59%. On average, all countries recorded a level of Greenhouse gas emissions of 9.93% of GDP in the period 2005-2022, which varies from this average by +/-3.97%. The majority of Greenhouse gas emissions in these countries have values between 4,5-30.8%. On average, all countries recorded a level of Gross domestic expenditures on research and development of 1.54% of GDP in the period 2005-2022, which varies from this average by +/-0.89%. The majority of Gross domestic expenditures on research and development in these countries have values between 0.37-3.73%. On average, all countries recorded a level of Real GDP per capita of 1.50% of GDP in the

period 2005-2022, which varies from this average by +/-4.08%. The majority of Real GDP per capita in these countries have values between -14.60-23.20%.

On average, all countries recorded a level of foreign direct investment in the reporting economy (stocks) of 404.51% of GDP in the period 2005-2022, which varies from this average by +/-1175.56%. The majority of foreign direct investment in the reporting economy (stocks) in these countries have values between 11.70-731.20%. We noticed a too-high value of the maximum and used the Winsorize function, so the new maximum for this variable is 731.2.

Methodology

Our analysis is based on the use of ordinary least squares linear regression of panel data of the type:

$$y_{it} = f(X_{ij}, \beta) + \delta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is the dependent variable, Xit is a k-vector of repressors and ε_{it} are the error terms for i−1, 2, …, M cross-sectional units observed for dated periods t−1,2, …, T. The α parameter represents the overall constant in the model while δi and yt represent cross-section or period specific effects.

The present research imposes a linear conditional mean specification of the form:

$$y_{it} = \alpha + X'_{it}\beta + \delta_i + \gamma_t + \varepsilon_{it} \quad (2)$$

To analyze the relationship between government spending and determinants, this study uses a re-parameterized Autoregressive Distributed Lag (ARDL) model as an error correction model (ECM) applied to panel data. Specifically, we estimate three alternative specifications: Mean Group (MG), Pooled Mean Group (PMG), and Dynamic and Dynamic Fixed Effects (DFE) to assess the robustness of the results.

The re-parameterized ARDL (p, q, q, …, q) error correction model is specified as:

$$\Delta y_i t = \theta_i [y_{i,t-1} - \lambda'_i X_{i,t}] + \sum_{j=1}^{p-1} \xi_{i,t} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} \Delta X_{i,t-j} + \varphi_i + e_{it} \quad (3)$$

The following model specification was used:

$$\Delta \text{Governemnt}_{Exp_{it}} = \theta_i [Governement_{Exp_{i,t-1}} - \lambda'_i X_{i,t}] + \sum_{j=1}^{p-1} \xi_{ij} \Delta \text{Government}_{Exp_{i,t-j}} + \sum_{j=0}^{q-1} \beta'_{ij} \Delta X_{i,t-j} + \varphi_i + e_{it} \quad (4)$$

where $\boldsymbol{\Delta Governemnt\_Exp_{it}}$ is government expenditure by function for entity i at time t, $\boldsymbol{X_{i,t}}$ is vector of explanatory variables (Investment share of GDP by institutional sectors, Greenhouse gas

emissions, Gross domestic expenditures on research and development, Real GDP per capita growth and Foreign Direct investment in the reporting economy), $\boldsymbol{\theta_i}$ is balance adjustment coefficient $\boldsymbol{\lambda_i'}$ are conditions of the pulmonary term coefficients, $\boldsymbol{\xi_{ij}}$ and $\boldsymbol{\beta'_{ij}}$ are the coefficients of the dynamic terms of the dependent variable and the explanatory variables, $\boldsymbol{\varphi_i}$ captures fixed effects specific to each entity and $\boldsymbol{e_{it}}$ is the error term.

The Mean Group (MG) method allows the estimation of entity-specific coefficients without imposing homogeneity restrictions across countries, which allows for greater flexibility, but can introduce high variability in estimates. The Pooled Mean Group (PMG) imposes homogeneity on the long-term coefficients but allows heterogeneity in the short-term dynamics and interceptions. In contrast, the Dynamic Fixed Effects (DFE) model imposes stricter restrictions, assuming that both the long-term coefficients and the adjustment dynamics are identical for all entities analyzed, allowing only different intercepts through fixed effects.

Results

From the correlation matrix (see Table 3), we observe an inverse relationship between variables: Invest and Government_EXP, respectively Gas emissions and Government_EXP, as expected. The correlation coefficient between Government Expenditure (Government_Exp) and Investment (Invest) is -0.3675, which indicates a moderate negative relationship between the two variables. This means that, in general, an increase in government expenditure (Government_EXP) is associated with a decrease in investment (Invest), and vice versa. An increase in government expenditure can raise interest rates (by financing the public deficit), making borrowing for private investment more expensive, thereby reducing investment.

Table 3. The correlation matrix

	Government_EXP	Invest	Gas	R&D exp	GDPpc growth	FDI
Government_EXP	1.0000					
Invest	-0.3675	1.0000				
Gas emissions	-0.1294	0.0335	1.0000			
R&D exp	0.5892	-0.0004	0.1340	1.0000		
GDPpc growth	-0.5079	0.2937	0.0036	-0.1986	1.0000	
DI	-0.1665	-0.2034	0.5415	-0.1351	-0.0538	1.0000

Source: author's computations

The correlations obtained in our study are in accordance with other studies. We found a negative correlation between FDI and Government_EXP, respectively -0.1665. Wang (2005, p. 495) demonstrates through his research that public spending on capital and infrastructure has negative effects on private investment. The results of a study (Ercolano and Romano, 2018, p. 22) suggest that countries more developed in the industrial sector have a higher level of the greenhouse gas index.

There is a positive correlation between government expenditure (Government_EXP) and research and development (R&D) expenditure of 0.5892, suggesting that an increase in government investment in R&D can stimulate progress in innovation and technology. This, in turn, can contribute to economic growth. The study by Taiwo and Abayomi (2011, p. 2) supports this link, indicating that government investment in R&D can be an engine of economic growth, as innovation and technological advances foster productivity and development of various economic sectors.

Unit-root tests results

The results for unit root tests regarding the dependent variable – general government expenditure (Government_EXP) is presented in Table 4. The tests used are: 1-Levin-Lin-Chu, 2-Im-Pesaran-Shin, 3-Harris-Tzavalis, 4-Breitung, and 5-Hadri.

Table 4. The unit root tests

Variable	**Government_EXP**				
Tests	1	2	3	4	5
Level	-2.8348***	-1.6165**	0.6491***	-3.9482***	3.4088***
1-st difference	1.3978	-7.8235***	-0.1937***	-6.7255***	2.4276**
Variable	**Invest**				
Tests	1	2	3	4	5
Level	-6.0614 ***	-0.5893	9.7397**	-1.0184	6.4864***
1-st difference	-11.9594***	-7.3825***	6.5680***	-4.6801***	2.1430**
Variable	**Gas emissions**				
Tests	1	2	3	4	5
Level	-1.2772	2.3605	0.8443	5.7990	7.1169***
1-st difference	-6.7999***	-8.4656***	-0.0630***	-8.2314***	4.9859***
Variable	**R&D exp**				
Tests	1	2	3	4	5
Level	0.9359	2.9960	0.8843	5.1792	5.5576 ***
1-st difference	-4.6865 ***	-6.9915***	0.1420 ***	-7.3158***	2.1056**
Variable	**GDPpc growth**				
Tests	1	2	3	4	5
Level	-6.3713 ***	-5.1021 ***	0.3182***	-7.1399***	3.0654***
1-st difference	-8.3353***	-9.0554**	-0.2079***	-10.0622***	3.2475***
Variable	**FDI**				

Tests	1	2	3	4	5
Level	-4.8587***	-1.4322*	0.8880	4.3606	5.6801***
1-st difference	-9.2020***	-2.0710**	0.5899***	-5.9262***	2.0337**

Note: significance levels: *** p<0.01, ** p<0.05, * p<0.1
Source: author's computations

It is found that the considered variables are stationary according to table 3. The Government_EXP variable is stationary at the level in all 4 tests performed with a probability of 99%. The Invest variable is stationary at the level only through the Levin-Lin-Chu and Hadri tests with a probability of 99%, respectively 95% through the Harris-Tzavalis test. And in the first difference the Invest variable is stationary at the level in all 4 tests with a probability of 99%. The gas emissions and R&D exp variables are stationary at the level only through the Hadri test with a probability of 99%, and in the first difference they are stationary in all 4 tests with a probability of 99%; except for the Hadri test where the probability is 95%. The GDPpc growth variable is stationary at the level in all 4 tests with a probability of 99%. And the FDI variable is stationary at the level through 3 tests, with the mention that through the Levin-Lin-Chu and Hadri tests the probability is 99%, and through the Im-Pesaran-Shin test the probability is 90%. Through the prism of this we can go to the next step, namely, to perform the regression analysis to see the impact of institutional investments and net greenhouse gas on government expenditure, in the period 2005-2020. Below is the Panel Least Squares equation to illustrate public spending:

$$Government\_Exp = \beta_1 + \beta_2 * Invest + \beta_3 * Gas\ emissions + \beta_4 * R\&D\ exp + \beta_5 * GDPpc\ growth + \beta_6 * FDi + \varepsilon \quad (5)$$

The results of the estimate are presented in Table 5. The regression results indicate that government expenditure (Government_EXP) is significantly influenced by several economic factors, and the signs of the coefficients suggest certain relevant economic relationships.

First, there is a negative relationship between private investment (Invest) and government expenditure, with a coefficient of -0.432, which means that an increase in investment is associated with a decrease in government expenditure. This effect can be explained by the phenomenon of crowding out, where an increase in private investment reduces the need for government intervention, or by the fact that the government adjusts fiscal policies according to the dynamics of the private sector.

Similarly, the real GDP growth rate variable (GDPpc growth) has a coefficient of -0.537, indicating that as the economy grows, government expenditure tends to fall. This relationship

suggests a possible countercyclical fiscal policy, where the government spends more during recession and cuts spending when the economy is growing.

R&D exp also has a negative effect on government expenditure, with a coefficient of -0.236, indicating that an increase in this expenditure is associated with an overall decrease in government expenditure, possibly as a result of budget reallocation to compensate for higher energy costs.

One of the strongest factors influencing government spending is the R&D exp component, which has a coefficient of 3.997. This high coefficient suggests that there is a significant relationship between government spending on research and development and other categories of government spending. Basically, this value indicates that as the government allocates more funds to R&D, there is a tendency for government spending in general to increase. This could reflect a higher priority given to investment in research and innovation, which in turn can stimulate economic development and lead to an increase in the overall government budget.

In addition, the variable FDI, which could represent income distribution or another economic indicator, shows a very small negative coefficient (-0.000560), but statistically significant. Although its effect on government expenditure is minor, it could indicate an indirect influence on government policies.

Table 5. The relationship between government expenditure and Investment in the period 2005-2020 in the 27 EU member states

VARIABLES	(1) Government_EXP
Invest	-0.432***
	(0.0492)
Gas emissions	-0.236***
	(0.0641)
R&D exp	3.997***
	(0.245)
GDPpc growth	-0.537***
	(0.0535)
FDI	-0.000560**
	(0.000221)
Constant	52.01***
	(1.181)
Observations	429
R-squared	0.615

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: author's computations

The variables introduced in the model are statistically significant with a probability of over 99%, except for the variable FDI which is statistically significant with a probability of 95%. We

conclude that the model characteristics represented by the independent and control variables are able to account for 61.5% of the variation in the Government_EXP variable.

It is noted that there is a negative relationship between the dependent variable, Government_EXP, and the independent variable Gas emissions with a 95% probability. The results of the analysis show a negative relationship between the dependent variable, Government_EXP (government expenditure), and the independent variable, Emissions, suggesting that higher emissions are associated with a lower share of government expenditure in GDP. This trend may reflect the negative economic impact of climate change, which directly affects vulnerable economic sectors, such as agriculture. The reduction in government expenditure as a percentage of GDP could indicate that governments are less able to allocate resources for adaptation measures or to support economies affected by climate change. This suggests a decrease in the capacity of governments to invest in measures that would counteract the negative effects of emissions and climate change, such as decreased agricultural productivity and increased costs in vulnerable economic sectors. Therefore, this result reinforces the idea that climate change has negative economic effects, through its direct impact on economies and the allocation of government resources.

In the analyzed period, government expenditures have a negative relationship with GDP, a fact attributed to the fact that the source of these expenditures is GDP itself, and their level exceeds 50%. This trend is maintained in the long term, especially in the conditions where expenditure measures were taken to combat the effects determined by the Covid-19 pandemic. Thus, in the EU the level of expenses increased by 6.3% compared to 2019 (Government finance statistics, 2022).

Cointegration tests results

The co-integration test results between Government_EXP and Invest are presented in Table 6. A total of 432 observations, 27 panels and 14 periods are included in the analysis. The hypotheses of the 3 cointegration tests are:

H_0: No cointegration.

H_1: All panels are integrated.

Table 6. The co-integration tests results between general government expenditure and investment

Test	*Kao*
Test results	Statistic
Modified Dickey-Fuller t	-5.9666***
Dickey-Fuller t	-3.9907***

Augmented Dickey-Fuller t	-3.8421***
Unadjusted modified Dickey-Fuller	-6.533***
Unadjusted Dickey-Fuller t	-4.1819***
Test	*Pedroni*
Test results	Statistic
Modified Phillips-Perron t	-5.5085
Phillips-Perron t	-1.2847**
Augmented Dickey-Fuller t	-1.5593**
Test	*Westerlund*
Test results	Statistic
Variance ratio	-3.2774***

Note: significance levels: ***p<0.01, **p<0.05, *p<0.1
Source: author's computations

According to the results in table 6, we can conclude that the variables are cointegrated according to the 3 tests performed.

The co-integration tests' results between Government_EXP and GAS emissions are presented in Table 7. A total of 432 observations, 27 panels and 14 periods are included in the analysis. The hypotheses of the 3 cointegration tests are the same as above.

Table 7. The co-integration tests' results between general government expenditure and net greenhouse gas emissions

Test	*Kao*
Test results	Statistic
Modified Dickey-Fuller t	-3.2774***
Dickey-Fuller t	-2.6871***
Augmented Dickey-Fuller t	-2.9625***
Unadjusted modified Dickey-Fuller	-4.2773**
Unadjusted Dickey-Fuller t	-3.1230***
Test	*Pedroni*
Test results	Statistic
Modified Phillips-Perron t	-0.2330
Phillips-Perron t	-2.0648**
Augmented Dickey-Fuller t	-2.1665**
Test name	*Westerlund*
Test results	Statistic
Variance ratio	-2.5792***

Note: significance levels: ***p<0.01, **p<0.05, *p<0.1
Source: author's computations

According to the results in table 7, we can conclude that the variables are cointegrated according to the 3 tests performed.

ARDL model estimation results

In table 8 we presented the results of the DFE model. To analyze the relationship between government spending and selected explanatory variables, we used panel econometric models, including Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Fixed Effects (DFE), to capture both the dynamics of short- and long-run relationships and the heterogeneity between entities, thus facilitating comparison between different estimation methods.

Table 8. The DFE Model

VARIABLES	(1) mg	(2) mg	(3) pmg	(4) pmg	(5) dfe	(6) dfe
Ec		0.486**		0.0198***		0.187***
		(0.206)		(0.00290)		(0.0429)
D.invest		0.360**		0.451***		0.187***
		(0.176)		(0.127)		(0.0429)
D.gas emissions		1.172		1.201**		-0.0846
		(0.872)		(0.590)		(0.252)
D.R&D exp		-1.383		7.233***		3.976***
		(5.067)		(2.212)		(1.264)
D.GDPpc growth		0.194**		0.00387		-0.0511
		(0.0899)		(0.0487)		(0.0417)
D.fdi		-0.0861		-0.0338		-0.000730
		(0.141)		(0.0695)		(0.000818)
Gas emissions	15.58		1.922		0.572	
	(11.90)		(3.293)		(0.704)	
R&D exp	-10.29		5.468		-5.921*	
	(9.954)		(17.64)		(3.365)	
GDPpc growth	-5.275		39.69		2.299***	
	(5.004)		(51.59)		(0.477)	
FDI	0.401		0.00664		-0.000251	
	(0.352)		(0.0116)		(0.00186)	
Constant		-27.96		-27.96		-3.991*
		(23.00)		(23.00)		(2.151)
Observations	402	402	402	402	402	402

Note: Standard errors in parentheses, significance levels: *** p<0.01, ** p<0.05, * p<0.1
Source: author's computations

MG model estimation results

In the **MG model**, we observe that in the long run, the R&D exp and GDPpc growth variables have a negative influence on the Government_EXP variable. In the short term, the variables R&D exp and FDI have a negative influence on the Government_EXP variable. The variables are

statistically significant with a probability of 5% (dependent variable - Government_EXP, and independent variables - Invest and GDPpc growth).

The results of the MG model suggest that the variables analyzed influence the economy differently in the short and long term, with significant effects especially in the immediate period. In the short run, private investment (D.invest) and real GDP growth (D.GDPpc growth) have a positive and significant impact on the dependent variable, indicating that an increase in these factors stimulates economic activity. In particular, the coefficient of private investments, of 0.360, suggests that their advance is associated with economic growth, which reflects the essential role of private capital in economic dynamics. Also, the real GDP shows a positive coefficient of 0.194, which confirms that short-term economic expansion favors the growth of the dependent variable.

On the other hand, although gas emissions (D.gas emission) have a relatively high positive coefficient (1.172), it is not statistically significant, which means that there is no clear evidence of its impact on the economy. Similarly, gross domestic expenditure on research and development (D.R&D exp) has a negative coefficient of -1.383 but insignificant, suggesting that in the short run this spending does not directly and clearly influence the dependent variable. Income distribution (D.fdi) also shows a negative coefficient, but without strong statistical significance, indicating that, at least in the short term, this factor is not an essential determinant of economic development.

Regarding the error correction term, its coefficient of 0.486 is significant at the 5% level, indicating the existence of an adjustment mechanism towards equilibrium. This result suggests that the economy does not adjust instantaneously to shocks, but there is a moderate tendency to return to equilibrium over time.

In the long run, none of the variables included in the model show a significant impact on the dependent variable, although the coefficients for gas emissions (15.58), R&D exp (-10.29), real GDP (-5.275) and income distribution (0.401) suggest potential directions of economic relationships.

PMG model estimation results

In the case of **PMG model**, the error correction coefficient has a value of 0.0198 and is significant at the 1% confidence level, which suggests an extremely slow adjustment speed towards the long-run equilibrium. This indicates that, in the event of an economic shock, the return to economic equilibrium is slow and the effects of the disturbances persist for a long period.

In the short term, private investment (D.invest) has a positive coefficient of 0.451 and is significant at a confidence level of 1%. This result indicates a positive and significant impact of investment on the economy in the short term, which confirms the essential role of private capital in

stimulating economic activity. An increase in investment thus determines an immediate economic expansion.

Gas emissions (D.gas emissions) have a coefficient of 1.201, significant at a 5% level. This result suggests a positive correlation between the increase in polluting emissions and the dependent variable, which may indicate that short-term economic expansion is associated with a higher level of pollution. This relationship could be explained by an increase in industrial activity during periods of economic advance.

Research and development expenditure (R&D exp) has a positive coefficient of 7.233, significant at the 1% level, suggesting that investment in innovation and technology exerts an immediate and considerable positive effect on the economy. This result confirms the importance of R&D expenditure in stimulating economic growth.

GDP per capita growth (D.GDPpc growth) has a coefficient of 0.00387, but this is not statistically significant. This result indicates that, in the short term, changes in GDP per capita do not have a significant impact on the dependent variable, suggesting that the effects of economic expansion are more evident in the long term.

Foreign direct investment (D.fdi) has a coefficient of -0.0338, but without statistical significance. This result suggests that FDI flows do not have a clear impact in the short term, which may indicate a delay in the manifestation of their effects on the economy or the need for complementary policies to maximize the benefits of this type of investment.

In the long run, gas emissions have a coefficient of 1.922, but this is not statistically significant. Thus, in the long run, a clear relationship cannot be established between the level of gas emissions and the dependent variable, which suggests that their effects on the economy are influenced by additional factors, such as environmental policies or structural changes in the economy.

Research and development expenditure (R&D exp) has a positive coefficient of 5.468, but this is not significant. This result indicates that, in the long run, the impact of R&D investments is not clearly defined within this model. The possibility that these expenditures generate sustainable economic effects may depend on contextual factors, such as the efficiency of innovation implementation or the institutional framework.

GDP per capita growth (GDPpc growth) has a coefficient of 39.69, but without statistical significance. This suggests that although the relationship between economic growth and the dependent variable may be positive, in this model there is not enough statistical evidence to confirm this link in the long run.

Foreign direct investment (FDI) has a coefficient of 0.00664, but it is statistically insignificant. In the long run, this result indicates that the effects of FDI on the economy are not significant, which may suggest that their impact depends on institutional factors, appropriate economic policies or the degree of integration of investments into the structure of the national economy.

DFE model estimation results

In the case of **DFE model**, we observe that error correction coefficient is 0.187 and is significant at the 1% confidence level. This value indicates a moderate speed of adjustment of the economy towards equilibrium *of the economy towards long-run equilibrium. Compared to the PMG model, where the coefficient Ec was 0.0198, the adjustment in the DFE model is considerably faster, which suggests that the economy manages to correct imbalances in a relatively short time frame.

In the short term, private investment (D.invest) has a positive coefficient of 0.187, significant at the 1% level. This result indicates that, in the short term, an increase in private investment directly stimulates the economy. The positive relationship highlights the importance of private capital in supporting economic activity and creating added value in a narrow time horizon.

Gas emissions (D.gas emissions) have a coefficient of -0.0846, but this is not statistically significant. Thus, there is no clear evidence that an increase in gas emissions directly influences the economy in the short term. Unlike the PMG model, where this variable was positively significant, in the DFE model the relationship is not statistically confirmed.

Research and development expenditure (D.R&D exp) has a coefficient of 3.976 and is significant at the 1% confidence level. This result suggests that investment in research and development has an immediate positive impact on the economy. Increased spending in this sector contributes to technological progress, increased efficiency, and sustainable economic growth.

GDP per capita growth (D.GDPpc growth) has a coefficient of -0.0511, but it is not statistically significant. This value indicates that the effects of GDP per capita growth are not clearly defined in the short term, which may suggest a delay in the transmission of economic benefits to general economic activity.

Foreign direct investment (D.fdi) has a coefficient of -0.000730, but this is not significant. This result indicates that FDI flows do not have an immediate impact on the economy, which may suggest that their effects are more visible in the long term and require appropriate structural conditions to generate sustainable economic growth.

In the long run, gas emissions (Gas emissions) have a coefficient of 0.572, but it is not statistically significant. Thus, a clear relationship cannot be established between the level of polluting emissions and the dependent variable in the long run. This result suggests that the impact of emissions on the economy can be influenced by environmental policies and the transition to more sustainable energy sources.

Research and development expenditure (R&D exp) has a coefficient of -5.921* and is significant at a confidence level of 10%. This surprising result indicates a negative long-term effect of R&D expenditure on the economy. This counterintuitive relationship can be explained by the high costs of innovation, delays in the application of new technologies or inefficient allocation of resources.

GDP per capita growth (GDPpc growth) has a coefficient of 2.299* and is significant at a confidence level of 1%. This result indicates that a sustained increase in GDP per capita is associated with long-term economic growth, which underlines the importance of economic development as an essential factor of progress.

Foreign direct investment (FDI) has a coefficient of -0.000251, but this is not statistically significant. In the long run, the result suggests that the effects of FDI on the economy are uncertain, and their impact depends on the quality of governance, fiscal policy and the level of economic integration of the host economy.

The results of the DFE model highlight notable differences between the short- and long-term effects of the variables analyzed. In the short run, private investment and R&D spending have a significant positive impact, indicating that these variables play an essential role in the immediate economic dynamics. In the long run, however, R&D spending seems to have a negative impact, which may suggest difficulties in effectively capitalizing on investments in this sector.

An important result is the error correction coefficient (0.187), which indicates a faster adjustment of the economy towards equilibrium compared to the PMG model. This suggests that economic shocks are absorbed in a shorter time, reflecting a more dynamic and adaptable economy.

In the long run, GDP per capita growth remains a key driver of economic development, confirming the importance of economic progress for sustainable growth. In contrast, the effects of FDI and greenhouse gas emissions are not significant, indicating the need for additional policies to maximize the benefits of these variables on the economy.

Conclusions

Gas emissions are continuously decreasing at the European level, although there are different trends from one country to another. Renewable energy and public investment in research and

development contribute to stimulating economic growth and alleviating poverty. Thus, through the present study, we confirm the importance of investments, as well as greenhouse gas emissions, on government expenditure.

Institutional investments and net GHG emissions significantly influence government expenditure. By leveraging institutional investments, governments can fund essential infrastructure and environmental projects while managing fiscal pressures. Conversely, addressing GHG emissions requires strategic government expenditure on mitigation and adaptation measures, which can have long-term economic benefits and cost savings. Balancing these aspects is critical for sustainable development and fiscal responsibility.

We believe that the achievement of healthy economic growth in the EU must also be achieved through investments in the idea of creating the conditions for people to acquire knowledge that will transform them into capable citizens of a country. And states should spend public money on developing both physical and human capital. And the creation of a partnership between public and private investments on at least these 2 levels, we consider to be a first step towards a more sustainable future. These priorities of the economy will be transposed into benefits that will be collected gradually on a constant flow.

The regression results from table no. 5 suggest that government expenditure is negatively influenced by private investment and economic growth, which may reflect a substitution effect between the public and private sectors, as well as possible countercyclical fiscal policy. At the same time, other government expenditures contribute significantly to the total level of public spending, and factors such as energy costs and income distribution play a secondary role in determining them.

This study offers new empirical evidence supporting the future shaping of fiscal and environmental policies. While a race to bigger budgets and increased expenditures/more large redistribution through public funds seem to be consecrated nowadays (instead of more rational or efficient spending), the fiscal policy should comprise new instruments targeted to limit greenhouse gas emissions. These instruments could include both specific taxes, as “penalties” for polluting activities, and targeted expenses conceived as “rewards” for those reducing their emissions. A sustainable reduction of greenhouse gas emissions (in the long term) depends also on the economic behavior of the agents, which is why public expenditures policy could be oriented to support better education in this respect.

Recently, public and political discourse has been increasingly focused on economic competitiveness, given the global economic challenges and the transition to a sustainable economy. In this context, many governments have started to reorient their government spending and emphasize

investments in infrastructure, education and research and development, in order to stimulate long-term competitiveness. Also, policies to reduce greenhouse gas emissions have been correlated not only with environmental measures, but also with economic opportunities for innovation, which can contribute to the development of new industries and improve the competitiveness of the global economy.

The results obtained through the dynamic fixed effects (DFE) model in Table 8, applied to the 27 Member States of the European Union for the period 2005–2020, provide valuable indications on the priority directions of economic policy, especially regarding the allocation of government spending in the context of the green transition, innovation and the consolidation of sustainable economic growth.

In this context, the present study highlighted the impact of government spending and gas emissions on economic competitiveness. The results suggest that an efficient allocation of government spending, especially in areas such as research and development and green technologies, can support not only the sustainability of economies, but also increase competitiveness in the long term. In this sense, economic policies must be carefully correlated to support not only environmental protection objectives, but also the development of an economic environment conducive to innovation and competitiveness.

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