

Climate policy development and implementation from the Sustainable Development Goals perspective. Evidence from the European Union countries

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ABSTRACT

Governments all over the world are investigating how to mitigate environmental risk and how to address climate policies to achieve sustainable development goals (SDGs). This study focuses on interactions between climate policy development and different SDGs. The study analyses panel data for the EU countries. Greenhouse gas emissions were used as a dependent variable. The study tests the non-linear effects, which allow Environmental Kuznets curve phenomena to be identified and extends this line of research by checking the non-linearity and time-lagging of all explanatory variables. The research results show that it is possible to achieve climate policy goals not only directly, but also indirectly by facilitating the implementation of other SDG goals like *inter alia* SDG9 (innovation and infrastructure), SDG11 (sustainable cities and communities) and SDG17 (environmental taxation). The impact of particular policies is also dependent on geographic-specific effects, analysed with the use of factorial analysis.

1. Introduction

Sustainability risk or, in other words, the risk of non-financial factors (Environmental, Social, Governance (ESG) risk) is a type of risk that gains importance in the context of its impact on the business and the economy [1]. The definition of ESG risk is heterogeneous and work is currently underway on its unification (*inter alia* at the level of the European Banking Authority). Environmental risk is gaining importance, which is confirmed by the Global Risks Reports, showing that it is the top risk of the five risks with the greatest impact. The risk of climate change is one of the leading types of risk in this group [2]. More and more often in studies and reports it is pointed out that the risk of non-financial factors affects financial performance [3].

In the ESG risk group, environmental risk is a significant component, and within it, the risk of climate change. The risk of climate change is one of the five most impacting risks [2]. There is no sector that is not affected by climate change and its consequences [4]. Climate change determines the growing costs of running a business, but also the costs of public actions mitigating the impact of these changes [5].

Hence, governments around the world are conducting an integrated

debate on how to prevent climate change and its negative effects. This is done both on the international arena (including the United Nations Sustainable Development Goals in the field of climate) and at the level of the European Union (a number of strategic documents, including the European Green Deal, the EU's taxonomy regulation), or intergovernmental initiatives (e.g. climate summits). Individual states also undertake their own, internal efforts and actions aimed at protecting against the influence of climate risk, e.g. tax systems based on environmental taxes, the polluter pays principle, systems of subsidies and support for green transformation.

EU sustainability policies are also the answer to climate change. One of the key policies in this regard is climate policy and sustainable finance within the Capital Markets Union, and within sustainable finance, the leading role in the issue of climate change and the related risk is played by climate finance. Climate policy goals are in line with sustainable development goals (SDGs) dedicated to the environment and climate change, in particular SDG13. An important aspect here is also the question of financing climate policy development.

Among the SDGs, there is an SDG13 devoted to climate change, but it should be borne in mind that SDGs are integrated with each other,

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because their implementation should lead to the achievement of policy goals for sustainable development. Hence, it is not only the implementation and financing of SDG13 that have an impact on climate change. Climate indicators and actions, as a result of which environmental goals are achieved, are also found in other SDGs; this applies to both so-called economic and social goals. Despite several research on SDGs' contribution to climate policy implementation [6–8], the topic still leaves room for debate, especially in the area of how to finance and achieve respective goals in order to maximize their beneficial impact on the environment and counteract climate change [9]. This paper investigates this field further, focusing on SDGs' indirect impact on climate goals. The study's primary objective is based on a concept that environmental goals are achieved both directly by implementing SDG13 and indirectly by interactions between SDG 13.10 (GHG) and other SDGs. This whole perspective is depicted in Fig. 1.

Lebel [10] argues that the lack of evidence-based climate change adaptation practices results from relevant knowledge being inaccessible, unused, or missing. Most of the literature on climate change is written from a natural sciences perspective. Before 2010, only around 5 % of the scientific papers published on climate change were written from a social science perspective. Further policy research could see important contributions to climate change policy development.

Sustainable Development Goals (SDGs) are the subject of a large number of studies [11–13]; however, only some of them focus on interactions between particular goals or the impact of one goal on others, but none of the studies deal with this problem in the context of climate policy development.

The second objective of the paper undertakes that knowledge about interactions between SDG13 and other SDGs is necessary for climate policy development to be efficient. This article analyses and clarifies the relationship between climate policy development and SDGs based on the data for the EU countries. In particular, the paper raises the following research questions:

1. Which of the SDGs contribute to the achievement of climate policy development directly and/or indirectly?
2. Which SDGs have the most substantial impact on climate policy development and why?

The paper is organized as follows: the introduction is Section 1; in Section 2, the theoretical aspects related to SDGs are presented. Section 3 presents the methodological approach, data collection procedure, and description of the methods. Section 4 discusses the research results, and Section 5 is the conclusion.

2. Literature review

A successful implementation of the sustainable development strategy of Agenda 2030 is a framework to meet the global sustainable development challenge to ensure human welfare, economic prosperity and environmental protection. To that end, all SDGs must act as a system of interconnected relationships, which together take the global social and

economic system into a safe and fair functional space [14–16]. It would be unreasonable to expect that actions as part of one sustainable development goal alone will bring the desirable results with no support from the comprehensive process of social and economic intervention, which is why a synergy of their impact is necessary. Consequently, the achievement of sustainable development goals will greatly depend on whether synergies can be leveraged and trade-offs identified and resolved. The synergies observed show a broad compatibility of SDGs, where progress in one goal can contribute to the fulfilment of others [17].

The natural environment is present in each and every of the Sustainable Development Goals. For example, the goals directly linked to the quality of the environment are SDG6 (clean water and sanitation), SDG13 (climate action), SDG14 (life below water) and SDG15 (land and biodiversity), while others are indirectly connected with the environment, e.g. SDG2 (zero hunger), SDG1 (no poverty) and SDG11 (sustainable cities and communities). Some researchers go even further, being of the opinion that environmental indicators are virtually inherent in all sustainable development goals, and, in particular, they argue that at least one such indicator exists for each of the goals (except for SDG10, which horizontally connects social, environmental and economic matters). Ninety-three indicators directly related to the environment have been created as part of sustainable development goals. Our research aims to demonstrate real synergies between the respective sustainable development goals and SDG13.10, representing climate policy goals. In practice, this would allow to attain environmental goals indirectly as a positive externality of successful implementation of other social, economic and development policies.

The existence of the system of correlations has been analysed for at least a dozen or so years, their results still being inconclusive and evolving with the societies' growing awareness of the behaviours defined by sustainable development goals (see for example [18]). A good example of such an approach would be the research conducted by Pradhan et al. [19], which has demonstrated the existence of negative correlations with the same goal. Those researchers have also proved that such inverse correlations are observed mainly as part of SDG7 (affordable and clean energy), SDG8 (decent work and economic growth), SDG9 (industry, innovation and infrastructure) and SDG15 (life on land) for 25 %–40 % of data pairs. For example, the “percentage of population with access to electricity”, SDG7 indicator, has increased in some countries as a result of the expansion of renewable energy sources [20, 21]. This might not support the increase in the “share of renewable energy sources in total energy consumption”, another SDG7 indicator.

There is also the issue of goals related to climate indicators and their impact on decisions taken by enterprises. Eiadat et al. [22] argued there is a positive relation between the environmental innovation strategy and business performance. Moreover, Lee et al. [23] claimed that R&D investment in the area of CO₂ emission reduction has a positive impact on a company's performance [24].

In turn, research by De Neve and Sachs [25] has revealed there are usually more synergies than trade-offs within and across sustainable development goals in most countries. Analyses by those researchers

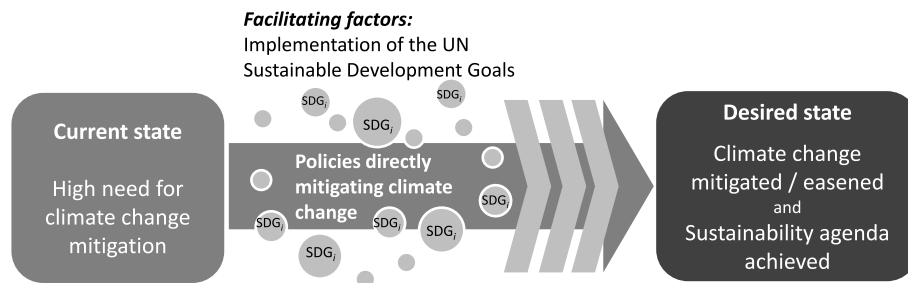


Fig. 1. Conceptual framework of the research.
Source: own elaboration

show that SDG3 (good health and well-being) is mainly connected with additional synergy benefits while SDG12 (responsible consumption and production) is significantly linked with the most problematic trade-offs. There are also studies demonstrating that most sustainable development goals are positively correlated to well-being, while the analysis by De Neve and Sachs [25] shows quite a different scenario, where SDG12 (responsible consumption and production) and SDG13 (climate action) are negatively correlated in terms of subjective well-being (SWB) [26]. However, the results of these analyses come as no surprise as the economic development measurement has long been based on the use of natural resources, causing the growth of human well-being to come, in most cases, at the expense of environmental sustainability [27,28].

Over the years, however, it has become increasingly clear that if we want to avoid an environmental breakdown, we must restrict the consumption of natural and material resources to the level consistent with the environmental limits [29,30]. This transition is captured by SDG12 and SDG13 [31]. This will entail an actual emission reduction and both quantitative and qualitative change in consumption and production patterns [32]. However, the analysis of correlations between these SDGs should be conducted taking account of the disposable household income indicator. As a matter of fact, an operating pattern can be observed in which high-income countries in particular must reduce their carbon footprint to enable consumption growth in countries undergoing economic development, where it is necessary to satisfy basic needs [33]. It is no easy task considering that a system driven by economic growth is dependent on continuously growing consumption and production to ensure employment and support sources of livelihood [34]. Consequently, in the current structures, progress achieved in SDG12 and SDG13 may have serious social and economic implications and as such have a negative impact on the well-being especially of those most vulnerable [31].

Nevertheless, environmental management does not necessarily entail a decline in well-being. Various studies have demonstrated the significance of environmental integrity to human well-being: for example, poor air quality has a negative impact on subjective well-being [35]. People are willing to pay for noticeably cleaner air; there is evidence to suggest that contact with nature improves mental health [36]. Much lesser social consequences of intensive environmental protection measures are recorded in countries where governments significantly support this action with dedicated tax and expenditure policies. A lot of studies can be found in the literature discussing the environmental impact of public expenditure, sometimes in relation to GDP. Taking 12 European countries in 1995–2008 as an example, López and Palacios [37] proved that public expenditure had played a major role in limiting sulphur oxide and ozone emissions. No such effect, though, was recorded for nitrogen oxide. Meanwhile, Czyżewski et al. [38] confirmed the correlation between the scale of public expenditure in EU-25 countries and the PM_{2.5} emission reduction, i.e. it was proved that an increase in expenditure causes PM_{2.5} to drop significantly. In other studies, Halkos and Paizanos [39] examined the impact of government expenditure on GHG emissions in respective panels, reaching the conclusion that although greater public expenditure as a share of GDP favoured a reduction in sulphur and nitrogen oxide emissions, there was no such impact on carbon dioxide. Moreover, in low-income countries, the impact of government expenditure on emission reduction is strong, but in wealthier countries there can be even a positive correlation between growing expenditure and emissions. Generally speaking, the direct effect of public expenditure is more important and becomes stronger with GDP growth and an increase in the level of democratisation.

What can be generally observed in the results of various scientists' research is a low efficiency of tax receipts on environmental protection. This can be partly explained by the fact that their level is generally declining, while the emissions of some key pollutants are on the rise (e.g. CO₂ or NH₃), suggesting that these taxes are not consistently imposed. Moreover, pollution taxes represent merely a fraction of total environmental tax revenues, their distribution varying greatly between Member

States. For example, pollution taxes imposed on farmers (applicable to NH₃ emissions, among others) were generally very low, except in a few Member States. This might suggest that the "polluter pays" principle does not yield the expected results [40].

Hence, the challenge to political decision-makers is to solve the short-term trade-off by separating the improvement in human well-being from the consumption of natural resources and greenhouse gas emissions. One of the OECD reports [41] attempts to meet this challenge by suggesting to adopt a well-being lens in climate change mitigation policies, placing humans at the centre of climate action [42]. Countries that achieve good results while ensuring high well-being indicate that there may be pathways out of poverty which do not frustrate environmental sustainability efforts. These countries represent a proportional mix of relatively large and small countries all over the world.

3. Methodology and results

This article assesses the impact of implementation of different sustainable development goals on greenhouse gas emissions based on the data for the EU countries. Greenhouse gas emissions (GHG) were used as a dependent variable representing environmental degradation or a proxy for the implementation of environmental policies, based on the literature review (see e.g. Sterpu et al., 2018; [9,43–45]). Namely, we used the greenhouse gas (CO₂ and N₂O, CH₄ in CO₂ equivalent) emissions in the kilograms (thousands) per capita indicator from the Eurostat database. Although using GHG variable encompasses only part of climate policy field, it has an important advantage because this variable covers the most popular climate policy target and is easily measurable as well comparable among different countries.

The subsequent analysis encompasses four groups of procedures:

- (1) panel data preparation and structuring of variables, including analysis of collinearity;
- (2) selection of the basic model specification through the panel data modelling, including a precedent testing of variable stationarity;
- (3) formulation of the enhanced model specification with time lags and checking the marginal effects of variables;
- (4) implementation of geographic-specific effects to the model with the use of factorial analysis.

The methodological aspects of all these stages are depicted in Fig. 2 and briefly described below. Due to the large number of analysed variables (over 70 indicators), the output for interim statistical procedures, such as a collinearity checking with variance inflation factors, stationarity checking for panel data with Levin-Lin-Chu tests, is not presented in this paper, but it is available on request.

Initially all the variables within respective SDGs were considered. All of the variables came from the Eurostat database for the period 2008–2018 to ensure a full integrity and comparability of the data. The data covered the EU 25 countries including the United Kingdom. Cyprus, Malta and Luxembourg were excluded due to the small size of their economies.

Firstly, the variables with missing observations for a whole year were excluded from the panel. This resulted in the elimination 15 variables due to data unavailability. Then, for the remaining variables full data completeness was assured, i.e. occasional missing observations were filled with proxy data, being a geometric mean of adjacent observations. This procedure encompassed less than 0.1 % of all observations and allowed to obtain a balanced panel. This augmentation is important as with the relatively short time series any missing data would eliminate full year observations, which would affect the model's credibility.

Then, the remaining variables were transformed to relative indicators for better data comparability. This alteration affected 6 variables. The final step in data preparation was devoted to the elimination of collinearity between specific variables and the GHG variable. Variance inflation factors were used to detect collinearity through the

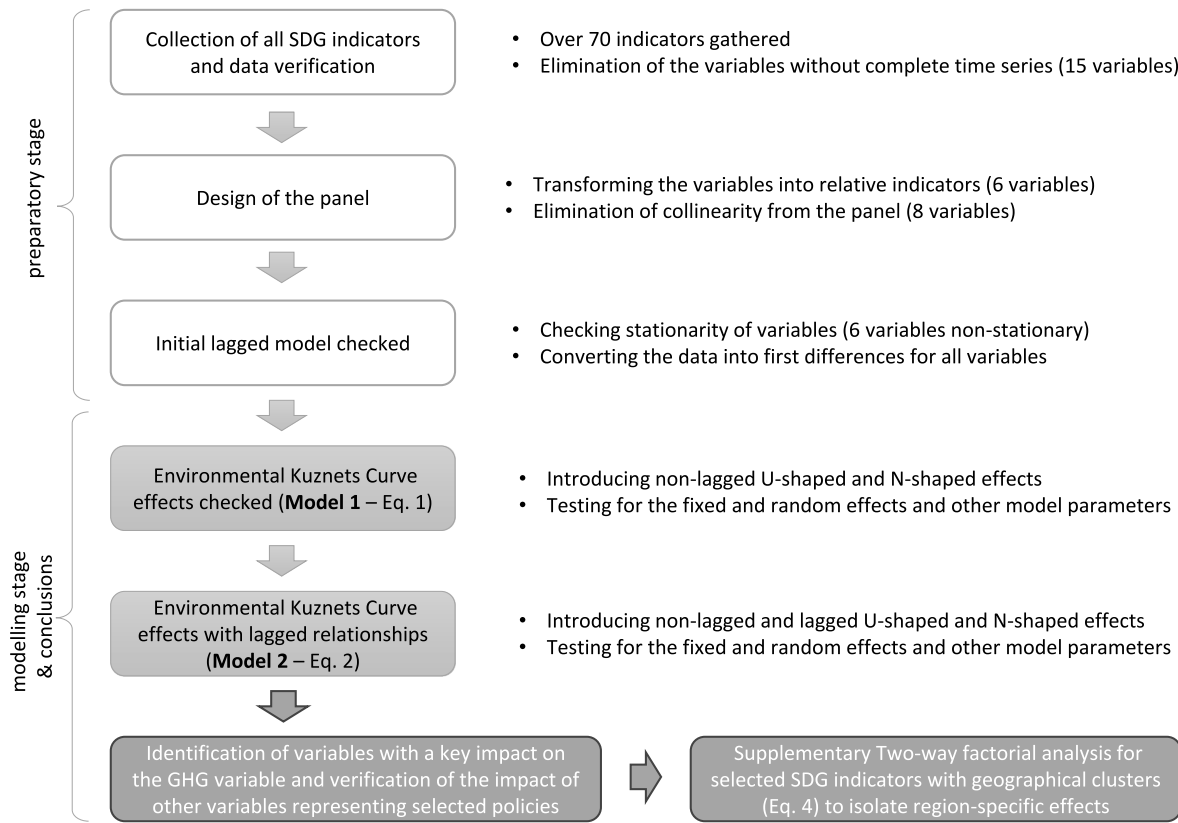


Fig. 2. Research stages.

Source: own elaboration

iterative regression process. This eliminated the additional 8 variables.

The second group of procedures was devoted to the selection of the basic model specification. At the beginning the stationarity of data was checked. We employed the Levin-Lin-Chu test for panel ADF with time lag equal to 1 [46]. The undertaken procedure revealed that 6 variables were non-stationary of degree 1. Consequently, all variables were converted from their original values to their first differences to eliminate non-stationarity. Using first differences of variables still allows for relatively easy and straightforward interpretation of model coefficients.

The subsequent econometric modelling was carried out with the panel data regression functions. It is a prevailing econometric approach in this category of research, devoted to the issues of interdependence between socio-economic development, energy policy and environmental phenomena – see e.g. Refs. [47–49].

In our research, following [47], we test the non-linear, i.e. U-shaped and N-shaped effects, which allow to identify the Environmental Kuznets curve phenomena [46]. We extend this line of research by checking the non-linearity of all explanatory variables. The regression function, which is modelled initially, has a form, as follows:

$$d_GHG_{it} = \alpha + \beta_k \cdot d_C_{it} + \gamma_k \cdot (d_C_{it})^2 + v_i + \varepsilon_{it} \quad (1)$$

where:

- d_GHG_{it} —the dependent variable (GHG), a first difference;
- d_C_{it} —set of explanatory variables (k variables) consisting of individual indicators within the specific sustainable development goals for each country and year – first differences;
- i —the cross-sectional dimension, representing individual countries analysed (from 1 to the N -th country); $I \in \{1, N\}$;
- t —the time dimension (annual data);
- α —the intercept;
- β —the structural parameters for respective explanatory variables in d_C_{it} set (1, ..., k);

γ —the structural parameters for respective explanatory variables in $(d_C_{it})^2$ set (1, ..., k);

v_i —error term representing time invariant unobserved characteristics;

ε_{it} —random error term.

As the result, a specification of the basic model (Model 1) was obtained, which is presented in Table 1. The econometric modelling was carried out with a ‘from general to specific’ approach that was based on the achievement of significance of individual variables, minimizing the information criteria (Akaike’s & Schwarz’s) as well as ensuring favourable results of joint tests on named regressors and no autocorrelation of error terms. The calculations were carried out with the Gretl ver. 1.9.90 and STATA 16.1 software. All the variables are numbered the same as in the Eurostat database (the set of SDG indicators), for example, the number: ‘01.30’ refers to ‘SDG 01.30 - Severely materially deprived people’.

In the modelling, pooled OLS panel data specification and fixed effects specification for individual i was used. The random effects specification was not feasible due to insufficient degrees of freedom in these models. The carried-out tests (test of variance of residuals and Breusch-Pagan test) indicated that the model with the pooled OLS panel data procedure is more appropriate (see test results for Model 1 in Table 1).

Model 1 allowed to unveil several significant relationships between SDG indicators and GHG, and their directions for the EU countries. It also demonstrated that GHG dependent variable can be largely explained by other SDG indicators as the adjusted R-squared ratio amounted to 91.7 %, while controlling for non-collinearity.

The enhanced model specification was formulated in the third set of procedures (Model 2), taking into consideration that some SDG variables may have an intertemporal influence on the dependent variable. The analysed function was transformed into the following form for Model 2:

$$d_GHG_{it} = \alpha + \beta_k \cdot d_C_{it} + \gamma_k \cdot (d_C_{it})^2 + \lambda_k \cdot d_C_{it-1} + \phi_k \cdot (d_C_{it-1})^2 + v_i + \varepsilon_{it} \quad (2)$$

Table 1

Model 1 - Basic specification of relationship between various SDG indicators and GHG

Pooled OLS; 250 observations; cross-section units = 25; time series length = 10. Beck-Katz standard errors. Note: all SDG variables are in the form of first differences; prefix 'sq_' denotes quadratic function.

indicators	Coefficient	p-value	indicators	Coefficient	p-value
constant	0.016495	0.54982	sq_SDG01.30	0.00138614	0.20188
SDG01.30	-0.0226046	0.01774**	sq_SDG01.40	6.50308e-05	0.98508
SDG01.40	0.0362523	0.00126***	sq_SDG01.50	-0.00155444	0.08882*
SDG01.50	0.01612	0.00031***	sq_SDG02.30	-0.000544024	0.81812
SDG02.30	-0.00297161	0.72819	sq_SDG02.60	-0.00276634	0.38829
SDG02.60	0.00164644	0.87352	sq_SDG03.10	-0.0162003	0.87496
SDG03.10	0.179812	0.00049***	sq_SDG03.40	-0.0787836	0.00577***
SDG03.40	-0.00263802	0.93024	sq_SDG03.60	-0.00300823	0.44698
SDG03.60	-0.0248627	0.01949**	sq_SDG04.20	-0.00105129	0.33289
SDG04.20	0.0237099	0.00973***	sq_SDG04.50	0.000891451	0.09321*
SDG04.50	0.00313767	0.37568	sq_SDG05.50B	-0.000529673	<0.0001***
SDG05.50B	0.00530973	0.00108***	sq_SDG7.10	1.09584	0.00038***
SDG7.10	2.05907	<0.0001***	sq_SDG7.11	-2.89037	0.00043***
SDG7.11	-0.140544	0.50538			
SDG07.30	-0.206166	0.00004***			
SDG07.40	0.0129116	0.39433***	sq_SDG07.40	0.0112593	0.04258**
SDG07.60	0.0223981	0.00401***	sq_SDG07.60	0.00087429	0.06052*
SDG08.10	0.0875365	0.00010***			
SDG8.11	0.00844453	0.10582	sq_SDG8.11	-0.000838885	0.08330*
SDG09.10	-0.178272	0.07014*	sq_SDG09.10	-0.802373	0.04151**
SDG09.20	0.00857809	0.68651	sq_SDG09.20	-0.0553057	0.00002***
SDG09.40	-0.00251464	0.00183***	sq_SDG09.40	1.62348e-05	0.35199
SDG09.60	0.0215902	0.00252***	sq_SDG09.60	0.000433594	0.54223
SDG10.20	0.0514145	0.02424**	sq_SDG10.20	0.0417354	0.02036**
SDG10.30	-0.0224765	0.00002***	sq_SDG10.30	0.00100829	0.57182
SDG11.10	-0.0007228	0.93580	sq_SDG11.10	0.00079118	0.09668*
SDG11.40	0.0403499	0.04485**	sq_SDG11.40	-0.00351301	0.63846
SDG13.20	0.0829038	<0.0001***	sq_SDG13.20	-0.00134677	<0.0001***
SDG16.10	-0.242666	0.0001***	sq_SDG16.10	-0.0623318	0.20362
SDG16.20	0.0105142	0.07562*	sq_SDG16.20	0.00138323	0.43948
SDG16.61	-0.00644073	0.00374***	sq_SDG16.61	6.68319e-06	0.97157
SDG16.63	0.00897778	0.00010***	sq_SDG16.63	-8.59247e-05	0.65472
SDG17.30	0.0276779	0.01865**	sq_SDG17.30	0.0015655	0.62613
SDG17.50A	-0.0864178	0.00040***	sq_SDG17.50A	-0.00408133	0.87250
R-squared		0.938317	Adjusted R-squared		0.916977
F(64,185)		43.97158	P-value(F)		2.40e-84
Log-likelihood		147.3140	Akaike criterion		-164.6280
Autocorrelation of resid.-rho1		-0.183380	Durbin-Watson stat.		2.105666

White's test statistics: LM = 150.617; $p = P(\text{Chi2}(97) > 150.617) = 0.000400138$.Test statistics of the normal distribution of residuals: Chi2(2) = 15.2413; $p = 0.000490232$.Residuals variance: $3.98777/(250-89) = 0.0247687$.Total significance of group mean inequalities: $F(24,161) = 0.869224$ with $p = 0.643085$.Breusch-Pagan test: LM = 2.39429 with $p = \text{prob}(\text{chi2}(1) > 2.39429) = 0.121779$.

Source: own calculations.

where:

 d_GHG_{it} —the dependent variable (GHG), a first difference; d_C_{it-1} —set of explanatory variables (d_C_{it}), lagged by one time period – first differences; λ —the structural parameters for respective lagged explanatory variables in d_C_{it-1} set (1, ..., k); φ —the structural parameters for respective lagged explanatory variables in $(d_C_{it-1})^2$ set (1, ..., k);

The description for other variables and parameters are the same as in Equation (1).

The results of modelling are presented in Table 2. Similarly to Model 1, the pooled OLS panel data specification was the most appropriate. Model 2, supplemented with lagged variables, is characterized by an increased number of statistically significant coefficients than in Model 1 and better fitness. Its adjusted R^2 ratio amounts to 94.5 %. Model 2 exhibits several desired statistical properties, namely it does not have heteroscedasticity of residuals (i.e. constant variance of the errors) and the errors are normally distributed.

The presented results of Model 2 are supplemented with the beta coefficients (see Table 2, the last column), which reflect the magnitude of impact of each SDG variable on dependent variable, measured with

standardized regression coefficients.

Since the mathematical formulas describing behaviour of individual variables are relatively complex, a helpful approach is to use graphical analysis for understanding their joint influence on the GHG variable. The marginal effects of selected variables, i.e. their isolated impact on the GHG variable, are depicted in Fig. 3. The charts are constructed for the typical variation ranges of particular SDG indicators, in order to illustrate their most probable effect on the dependent variable. The charts show the variables with the largest beta (excluding SDG 03.40 and SDG 16.10, which are related to the death rates) as well as the variables, on which we focus in our analysis from the perspective of the implementation of socio-economic goals. The obtained results are analysed in the discussion section in a subsequent part of this article.

The variables SDG7.10 and SDG13.20 play the largest role in explaining the dependent variable according to the beta metric. Their behaviour, predicted by Model 2 (see Fig. 3, chart A & B), is fully in line with theoretical expectations. This additionally validates the correctness of the obtained econometric results.

As the literature shows, the link between environmental indicators and socio-economic policies is often country-specific – see e.g. Refs. [50–52]. Thus, we tested a possible heterogeneous impact of

Table 2

Model 2 – Enhanced model specification of relationship between various SDG indicators and GHG.

Pooled OLS; 225 observations; cross-section units = 25; time series length = 9. Robust standard errors (robust HAC). Note: all SDG variables are in the form of first differences, prefix 'sq_' denotes a quadratic function, suffix '_1' denotes a lagged variable (t-1).

indicators	Coefficient	p-value	beta	Indicators	Coefficient	p-value	beta
constant	0.0214978	0.34007					
SDG01.30	0.0005368	0.93517	.0019524	sq_SDG01.30	0.00138857	0.02420**	.027796
SDG01.30_1	−0.0079146	0.12511	−.026969				
SDG01.40	0.0427862	0.0001***	.1084634	sq_SDG01.40	−0.0019226	0.66687	−.012316
SDG01.40_1	−0.0031148	0.75307	−.008242				
SDG01.50	0.00968102	0.0039***	.0387373	sq_SDG01.50	−0.00131342	0.03558**	−.030153
SDG01.50_1	0.0055966	0.14294	.0239727				
				sq_SDG02.30	−0.00588381	0.00011***	−.051208
SDG02.30_1	0.00207171	0.70425	.0050005				
SDG02.60	0.00808001	0.25944	.014602	sq_SDG02.60	−0.0129188	0.00005***	−.049583
SDG02.60_1	−0.0020677	0.70533	−.004384	sq_SDG02.60_1	0.00711953	0.00346***	−.049583
SDG03.10	0.212725	<0.001***	.1196816	sq_SDG03.10	−0.125533	0.05597*	−.036753
SDG03.10_1	−0.0711299	0.04015**	−.041913				
SDG03.40	0.103913	0.0019***	.0913165	sq_SDG03.40	0.0527694	0.05127*	.067532
SDG03.40_1	−0.158921	<0.001***	−.151109	sq_SDG03.40_1	−0.0976825	0.00239***	−.162279
SDG03.60	−0.0334946	0.0004***	−.076930	sq_SDG03.60	−0.00365228	0.20097	−.025252
SDG03.60_1	0.0165255	0.03852**	.0402346	sq_SDG03.60_1	0.00804934	0.00102***	.059166
SDG04.20	0.0133582	0.03534**	.0438812	sq_SDG04.20	−0.00084202	0.20313	−.020595
SDG04.20_1	−0.003585	0.48732	−.011307				
SDG04.50	−0.0008469	0.73115	−.005728	sq_SDG04.50	0.000851912	0.06073*	.033097
SDG04.50_1	0.0121304	<0.001***	.0940137	sq_SDG04.50_1	0.0014407	0.00004***	.079505
SDG05.50B	0.0016739	0.11843	.0235079	sq_SDG05.50B	−0.00048847	<0.0001***	−.123203
SDG05.50B_1	−0.0037041	0.0019***	−.052834	sq_SDG05.50B_1	−0.00014878	0.03265**	−.037707
SDG7.10	1.87457	<0.001***	.5739955	sq_SDG7.10	0.939905	0.06065*	.094739
SDG7.10_1	0.341869	0.04576**	.1154462	sq_SDG7.10_1	0.706619	0.01049**	.078768
SDG7.11	−0.0229329	0.92061	−.004253	sq_SDG7.11	−2.16599	0.00773***	−.078998
SDG7.11_1	−0.248706	0.27976	−.053537	sq_SDG7.11_1	−1.08258	0.07508*	−.048514
SDG07.30	−0.220636	<0.001***	−.178472				
SDG07.30_1	0.193596	<0.001***	.1587777	sq_SDG07.40	0.019314	0.00014***	.082109
SDG07.40	−0.0109823	0.35506	−.020962				
SDG07.40_1	−0.0204672	0.02131**	−.044509	sq_SDG07.60	0.000395612	0.26861	.023430
SDG07.60	0.014755	0.0033***	.0680599	sq_SDG07.60_1	−0.00156499	0.00010***	−.093012
SDG07.60_1	−0.0074189	0.17997	−.034916				
SDG08.10	0.0716126	0.0015***	.1241164				
SDG08.10_1	0.0244871	0.13149	.049889	sq_SDG8.11	−0.00772239	<0.0001***	−.160093
SDG8.11	0.0168965	0.01413**	.0561947				
SDG8.11_1	0.0137362	0.0027***	.0598567	sq_SDG09.10_1	−0.801495	0.00159***	−.066274
SDG09.10	−0.122425	0.04431**	−.029519	sq_SDG09.20	−0.0113304	0.25777***	−.016282
SDG09.10_1	0.099181	0.26514	.0242854	sq_SDG09.20_1	0.0208791	0.00153***	.064622
SDG09.40	−0.0014259	0.01240**	−.042887				
SDG09.40_1	0.00143298	0.01201**	.0458976	sq_SDG09.60	0.00174352	0.00007***	.065590
SDG09.60	0.011069	0.0008***	.0481098				
SDG09.60_1	−0.0092516	0.0099***	−.042225				
SDG10.20	0.0390113	0.02966**	.0404229				
SDG10.20_1	−0.0580513	0.03940**	−.068142	sq_SDG10.30	0.00303056	0.04433**	.050559
SDG10.30	−0.0225029	0.0002***	−.094782				
SDG10.30_1	0.00132111	0.76785	.0053254				
SDG11.10	−0.005789	0.05132*	−.040290				
SDG11.10_1	0.00319506	0.39883	.0204625	sq_SDG11.40	−0.00575737	0.66552	−.011378
SDG11.40	0.0167087	0.29541	.0235965	sq_SDG11.40_1	−0.0176838	0.00212***	−.072255
SDG11.40_1	−0.0344304	0.03791**	−.058876	sq_SDG13.20	−0.00097975	0.00016***	−.13907
SDG13.20	0.0883594	<0.001***	.6953579	sq_SDG13.20_1	0.000485864	0.01615**	.067888
SDG13.20_1	0.00111988	0.77506	.0086292	sq_SDG16.10	0.0326988	0.51625	.020066
SDG16.10	−0.208839	0.0000***	−.123257	sq_SDG16.10_1	−0.170818	0.00049***	−.125624
SDG16.10_1	−0.1764	0.0051***	−.115441	sq_SDG16.20	−0.00282132	0.05567*	−.031706
SDG16.20	0.010977	0.0005***	.0377855				
SDG16.20_1	0.0144532	0.0085***	.0557601	sq_SDG16.61	0.0000412	0.78585	.004552
SDG16.61	−0.0058344	0.0049***	−.070338				
SDG16.61_1	0.0019702	0.28858	.0238866	sq_SDG16.63	−0.0000419	0.79648	−.003743
SDG16.63	0.00444217	0.01276**	.0498204				
SDG16.63_1	−0.000348	0.85283	−.003946	sq_SDG17.30	0.0186392	0.00223***	.054006
SDG17.30	0.00321946	0.79928	.0051332				
SDG17.30_1	−0.0286345	0.0013***	−.060033	sq_SDG17.50A	0.0589688	0.00543***	.036089
SDG17.50A	−0.044905	0.009***	−.035585				
SDG17.50A_1	−0.0295681	0.13733	−.026584				
R-squared			0.970136	Adjusted R-squared			0.944714
F(103,121)			38.16193	P-value(F)			1.55e-61
Log-likelihood			238.8089	Akaike criterion			−269.6178
Autocorrelation of resid.-rho1			−0.037202	Durbin-Watson stat.			1.817173

White's test statistics: $LM = 165.368$; $p = P(\text{Chi}^2(169) > 165.368) = 0.564593$.
 Test statistics of the normal distribution of residuals: $\text{Chi}^2(2) = 1.47802$; $p = 0.477586$.
 Residuals variance: $1.36765 / (225 - 128) = 0.0140995$.
 Total significance of group mean inequalities: $F(24, 97) = 0.61844$ with $p = 0.910823$.
 Breusch-Pagan test: $LM = 3.18764$ with $p = \text{prob}(\text{chi}^2(1) > 3.18764) = 0.0741969$.
 Source: own calculations.

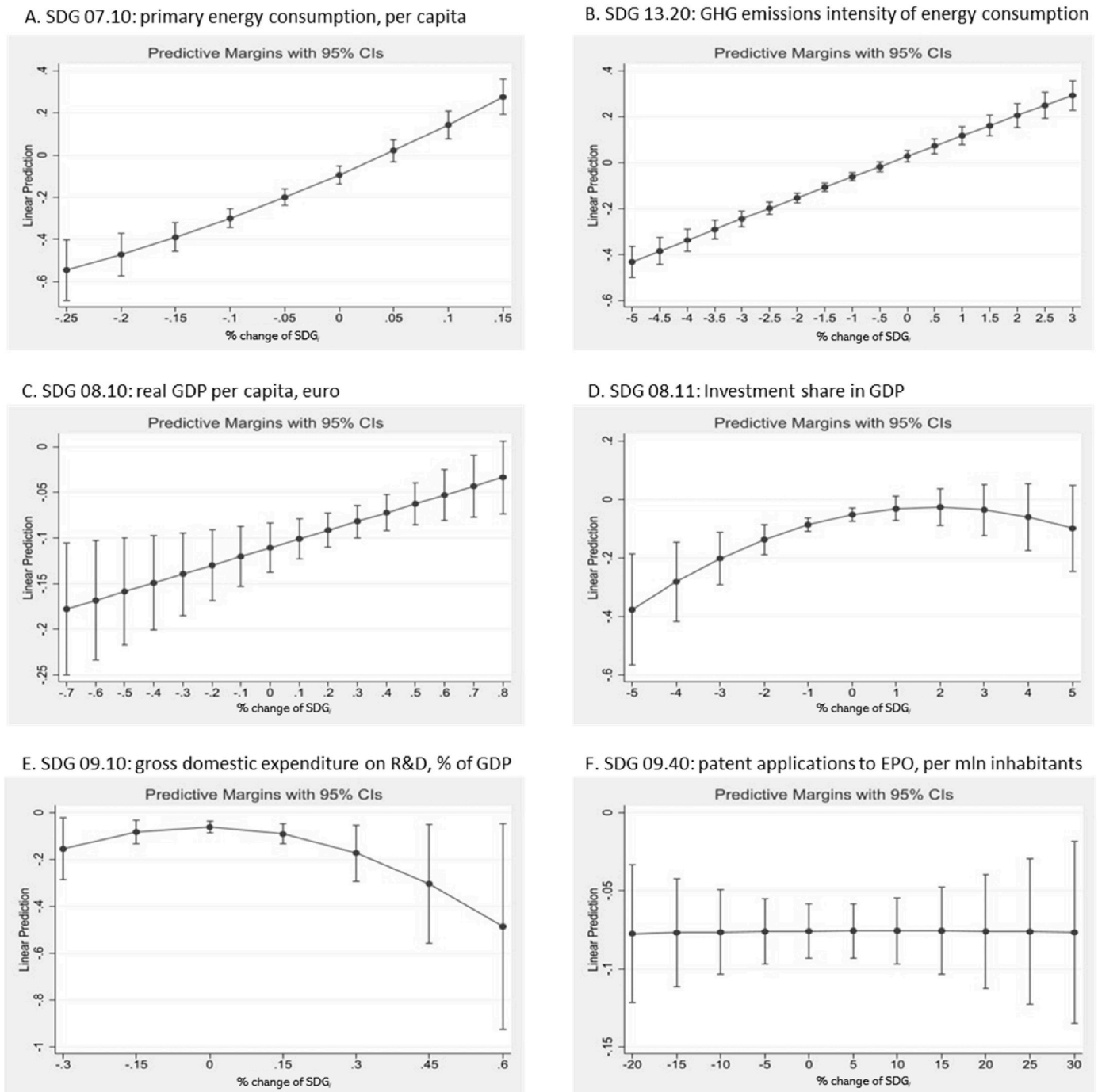
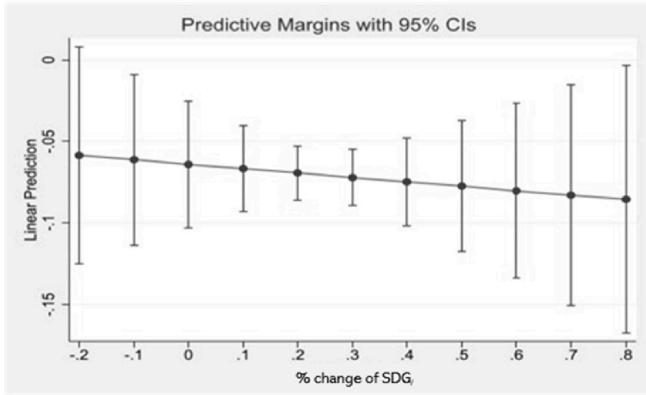


Fig. 3. Marginal effects of selected SDG indicators in Model 2.
 Source: own elaboration.

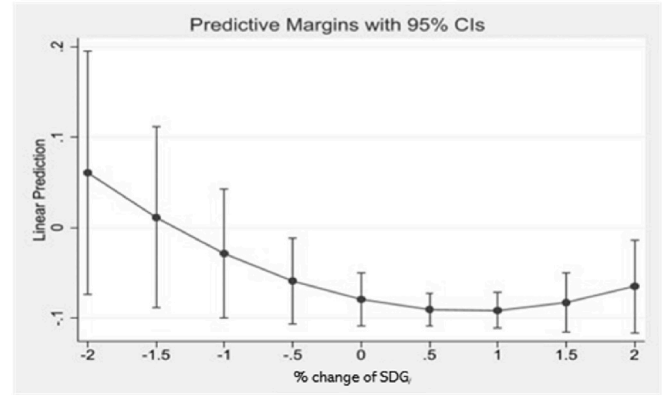
independent variables from the geographic dimension. The countries were grouped into three distinctive categories—Western and Northern Europe (WNE: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Netherlands, Sweden, United Kingdom), Mediterranean and

Southern Europe (MSE: Greece, Italy, Portugal, Spain) and Central and Eastern Europe (CEE: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia). The variable describing the geographic characteristic is referred to as *Cluster*.

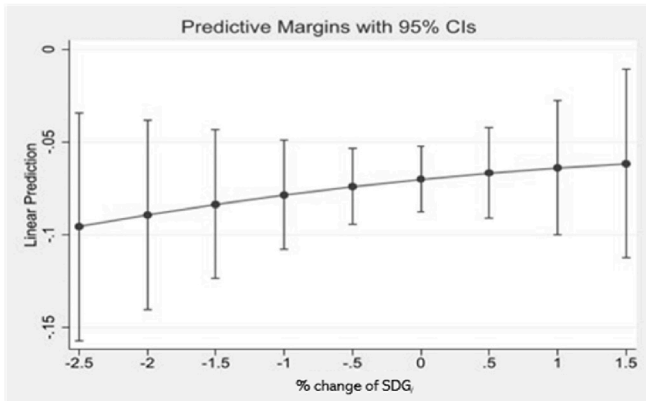
G. SDG 07.30: energy productivity, per kg of oil equivalent



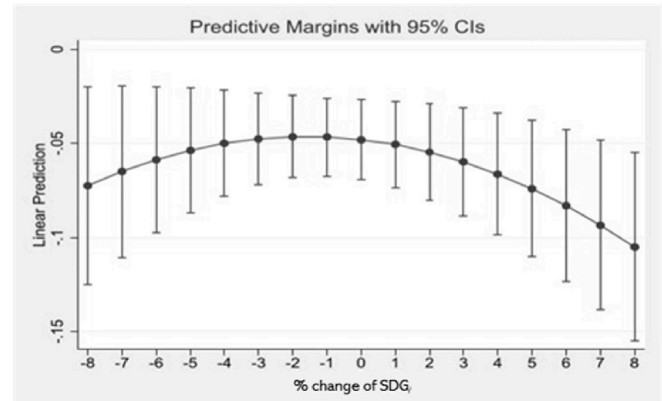
H. SDG 07.40: Share of renewable energy in final energy consum.



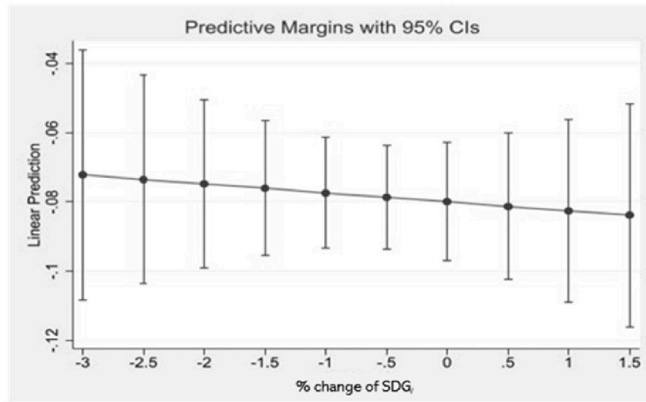
I. SDG 07.60: Population unable to keep home adequately warm



J. SDG 05.50B: seats held by women in national governments, %



K. SDG 11.10: Overcrowding rate, % of population



L. SDG 17.50A: Share of environmental taxes in total tax revenues

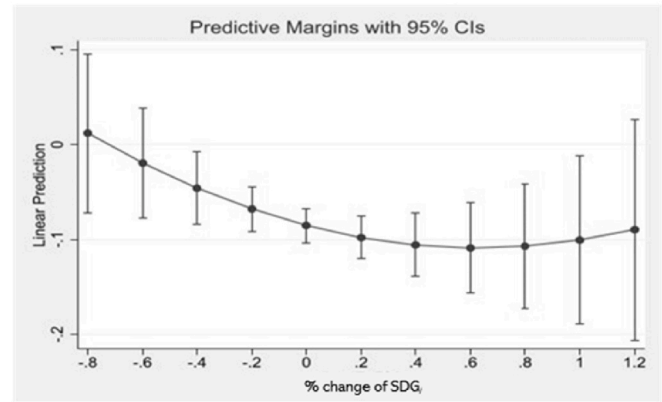


Fig. 3. (continued).

This group of procedures in the modelling is based on the design of the experiment concept. Their aim is to identify how possible interactions between *Cluster* and selected *SDG_i* variables affect the behaviour of the *GHG* dependent variable. The methodology of this factorial analysis is widely described by Ref. [53]. In general, the following regression problem is solved (Equation (3) depicts a 2-way full factorial model with quadratic main effects and non-lagged variables):

$$y = \eta_0 + \eta_1 x_1 + \eta_2 x_2 + \dots + \eta_k x_k + \eta_{11} x_1^2 + \eta_{22} x_2^2 + \dots + \eta_{kk} x_k^2 + \eta_{12} \times I \times 2 + \dots + \eta_{k-1,k} x_{k-1} x_k + \epsilon \quad (3)$$

where:

y —experiment yield; in our case the *GHG* variable;
 x_k —independent variables, in our case sustainable development

goals indicators ($d_{C_{it}}$) and *Cluster* variables;

η_k —coefficients for independent variables;

$x_{k-1}x_k$ —interactions between $k-1$ and k -th variables;

$\eta_{k-1,k}$ —coefficients representing two factor interaction effects.

In this study, we limit ourselves to an analysis of only 2-way interactions of the given SDG indicator and the categorical *Cluster* variable. We isolate these interaction effects in such a way that we check each interaction separately instead of introducing them simultaneously in one joint equation. It means that several independent regressions are carried out to grasp the impact of geographical categories on a specific SDG indicator. The formulation of the relationship being modelled is presented in Equation (4).

$$d_GHG_{it} = \alpha + \beta_k \cdot d_C_{it} + \gamma_k \cdot (d_C_{it})^2 + \lambda_k \cdot d_C_{it-l} + \varphi_k \cdot (d_C_{it-l})^2 + \eta_l \cdot Cluster \cdot d_C_{it} + \eta_2 \cdot Cluster \cdot (d_C_{it})^2 + \eta_3 \cdot Cluster \cdot d_C_{it-l} + \eta_4 \cdot Cluster \cdot (d_C_{it-l})^2 + \varepsilon_{it} \quad (4)$$

where:

d_C_{it} and d_C_{it-l} —a selected independent variable (one per each regression) from the set of all d_C_{it} variables, for which the factorial effects with the *Cluster* variable are examined;

Cluster—the categorical variable representing a geographic area to which an individual country belongs to; it is comprised of three categories (WNE, MSE, CEE);

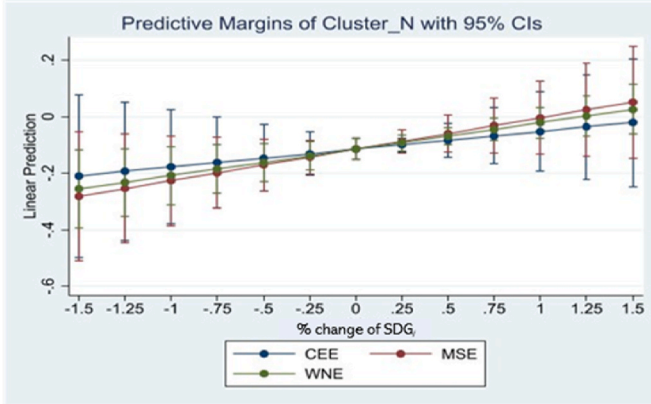
η_l —the structural parameters for a respective explanatory variable d_C_{it} and/or d_C_{it-l} ; $l = (1, 2, 3, 4)$;

The description for other variables and parameters are the same as in

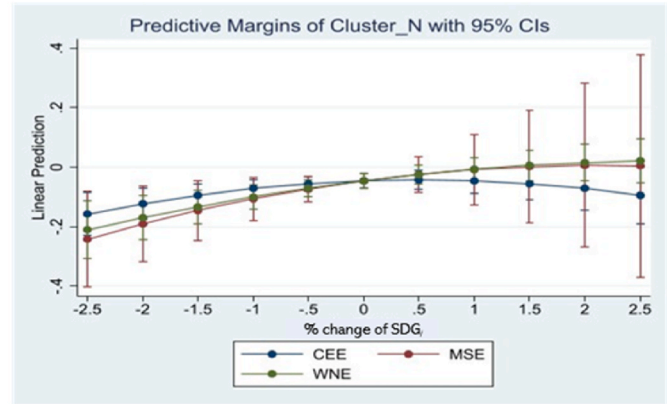
Equation (1).

In this article, the analysis of geographical differentiation of a given variable impact on GHG was conducted for a small group of variables selected by the authors to deepen their view on the specific phenomena. Namely, it included following SDG indicators: 5.50B, 7.40, 8.10, 8.11, 9.10, 17.50A. The full results of these models are not presented in this article due to their large size. The variables' behaviour, illustrated by their marginal effects, is depicted in Fig. 4. This should be treated as some supplementary evidence – indicating some promising observations but still at the early stage of research, specifically due to the relatively short time horizon of such an analysis. In short, two clusters delivered some statistically significant estimates. Namely, the separation of WNE

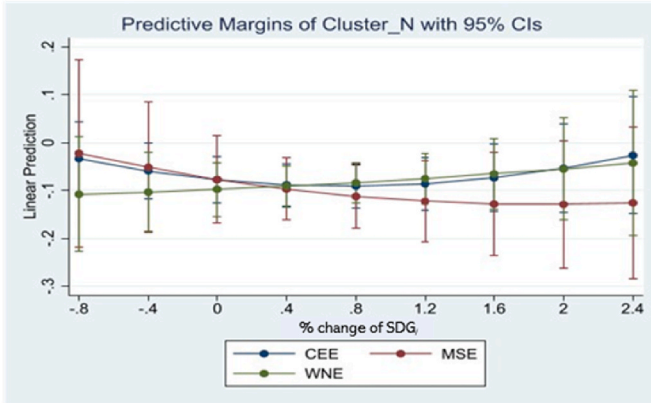
A. SDG 08.10: real GDP per capita, euro



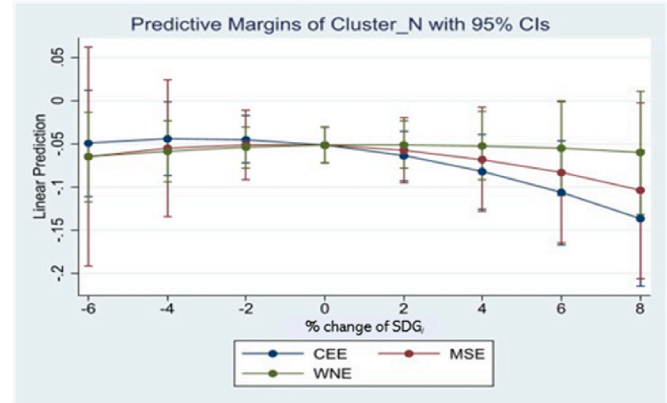
B. SDG 08.11: Investment share in GDP



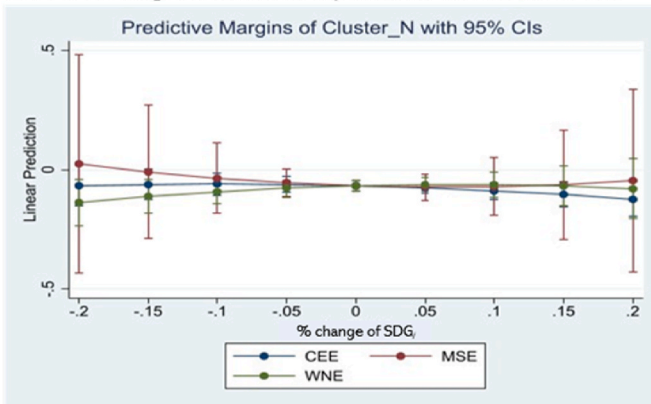
C. SDG 07.40: Share of renewable energy in final energy consum.



D. SDG 05.50B: seats held by women in national governments, %



E. SDG 09.10: gross domestic expenditure on R&D, % of GDP



F. SDG 17.50A: Share of environmental taxes in total tax revenues

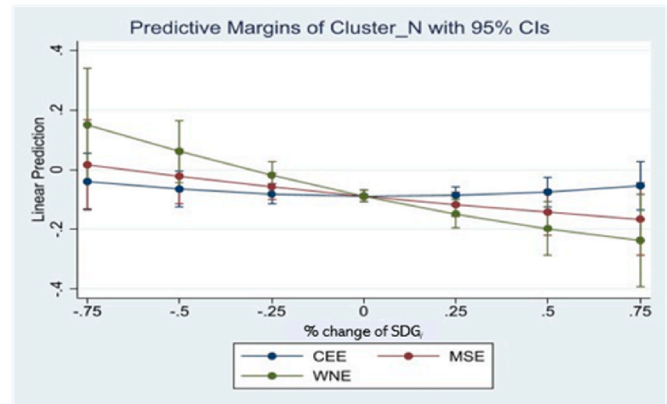


Fig. 4. Marginal effects of selected SDG indicators modelled with 2-way interactions with geographical clusters. Source: own elaboration.

and CEE cluster proved to be moderately significant for the following SDG indicators: 8.10, 8.11, 9.10, 17.50A (only WNE), 5.50B (only CEE).

4. Discussion

This research has shown that the most significant impact on climate policy development comes not only from a direct factor, SDG13.20: greenhouse gas emissions intensity of energy consumption, but also from semi-direct factors such as SDG07.10: primary energy consumption (per capita) and SDG07.30: energy productivity. Significant influence, either positive or negative, is also exerted by remarkably indirect factors which reflect various economic and social policies such as SDG08.11: investment share of GDP, SDG05.50B: seats held by women in national governments, SDG07.60: population unable to keep home adequately warm by poverty status. Indicator SDG08.10: real GDP per capita is also an important but very general factor with a differentiated impact depending on country characteristics (see Fig. 4). Indicators SDG17.50A: shares of environmental taxes in total tax revenues and SDG09.40: patent applications to the European Patent Office have a relatively modest impact. It is significantly lower than the impact of more general indicators of related policy areas, such as SDG07.40: share of renewable energy in gross final energy consumption and SDG09.10: gross domestic expenditure on R&D.

Identification and appropriate analysis of the links between the natural environment, economy and society are essential to making effective systemic decisions aimed at building sustainable solutions. Accurate interpretation and valuation of the natural environment's contribution to human functioning in various dimensions is one of the most important objectives carried out in the context of sustainable development policy. Our research on the impact of GDP per capita on greenhouse gas emissions in the EU countries has shown that the increase in the wealth of society causes an increase in air pollution. These results are consistent with studies that confirm that the relationship between CO₂ emissions and economic growth is negative [54,55], or that it is initially positive but then turns negative [56,57], although some papers report instead a positive relationship [58–60]. However, from the perspective of sustainable development, it is important to investigate whether the pursued economic policy is continuous, intelligent and sustainable growth influencing the implementation of a climate policy, measured by the reduction of greenhouse gas emissions, and not only growth measured by the GDP-based indicators. For this purpose, as part of the conducted study, it was decided to analyse the environmental impact of other economic factors such as the following: gross domestic expenditure on R&D; patent applications to the European Patent Office, investment share in GDP and share of environmental taxes in total tax revenues.

In the first step, it was decided to analyse the impact of the investment share in GDP level on greenhouse gas emissions, assuming that new investments should create pro-ecological behaviour, e.g. energy-saving, and it is important to note here the inverse relationship between these variables. However, the results turned out to be different, i.e. the increase in the share of investments in GDP does not significantly affect a reduction of greenhouse gas emissions. Such results may arise from the fact that new investments generate higher economic growth, which in turn requires additional energy, thus leading to increased greenhouse gas emissions. It is noted in the literature that investments are related to the dynamic development of human populations, cities and unlimited satisfaction of ever new human needs, and above all, that these processes impact the quality of the environment. Therefore, it is important to increase the share of pro-ecological investments in the pool of all investments that are being implemented.

The results obtained during the research confirmed that expenditure on research and development in European Union states effectively reduces greenhouse gas emissions. The growing share of R&D spending results in the development of low-carbon technologies and supports responsible climate policy in the medium-term. In the literature, many

authors, such as [61–63] came to similar conclusions, i.e. that R&D positively affects technological capabilities in environmental protection technology at the company level. On the other hand, Cuerva et al. [64] show that R&D stimulates green innovation to a lesser extent than conventional innovation. Further, in their article, Chengshi and Zhenyi [65] showed that technological innovations significantly influence environmental policies, and are the basis for formulating adaptive environmental policies as well as the promotion of sustainable environmental development. Results indicating no influence of patent applications to the European Patent Office on climate policy as measured by the greenhouse gas reduction index came as a certain surprise. Such results may probably be due to the fact that the patent itself is one of the elements that, without spending on its development and implementation as part of R&D, is only a tool that must be used to be able to observe the results in improving the environment. The literature devoted to the analysis of the changes taking place in the global economy in the face of constant technological progress, counteracting climate change, dwindling resources and the pursuit of a low-emission economy, emphasizes the growing importance of eco-innovation [66–68] and not the patents themselves, which are considered to be only one element of a larger whole. Therefore, any actions of authorities within the framework of expenditure or tax policy (tax breaks) supporting R&D expenditure, in particular eco-innovation, which favour sustainable development, are in line with the results we have obtained.

The tax system can be a facilitating tool for conducting climate policy, not only in the case of supporting R&D spending. In recent years, taxes for environmental protection, which have experienced a renaissance at the European Commission level, can also be an effective way to reduce greenhouse gas emissions, depending, however, on their scope and broader economic context. The results obtained from our research in this area condition the effectiveness of the increasing share of environmental taxes in total taxes, *inter alia*, on the wealth of countries and the general level of taxes in relation to GDP, i.e. environmental taxes are a more effective tool in reducing emissions of greenhouse gases in wealthy countries. Since they constitute an additional burden for entrepreneurs, environmental taxes in underdeveloped or developing countries may result in the limitation of development activities, e.g. R&D expenditure, or force other savings that may adversely translate into the broadly understood state of the environment. In such cases, it is important to adapt the introduced solutions to the national conditions, because they may achieve the opposite environmental effect to the one assumed. In the literature, many scientists believe that levying an environmental tax is beneficial for the environment in terms of reducing pollution and carbon dioxide emissions [69]. show that an ecological tax may not only favour the effects of pollution control, but also reduce the losses to the natural environment. Piciu and Tric [70] prove that an ecological tax can be returned to the polluters, i.e. the ecological tax can, under certain conditions, reduce pollution and protect the environment. Tamura et al. [71] believe that an ecological tax is effective for total control of carbon dioxide emissions only if a sufficiently high-elimination and low-cost technology is developed [72,73]. state that environmental tax shocks can lead to a reduction in carbon dioxide emissions.

Among the factors affecting GHG emissions, an important role, which is emphasized in the literature [74], is played by variables from SDG7 (Ensure access to affordable, reliable, sustainable and modern energy). In particular, a key role here is played by three variables – energy productivity, primary energy consumption and share of renewable energy in gross final energy consumption. The choice of these variables is consistent with the actions of the European Union aimed at achieving climate neutrality by 2050. The decarbonisation processes and activities consisting in replacing traditional energy sources based on fossil fuels with renewable sources are key to achieving this goal. This is one of the assumptions of the European Green Deal. The research results confirm the positive relationship between GHG emissions and the growing share of renewable energy sources in gross final energy consumption. The research results show that the share of renewable energy

in gross final energy consumption contributes to a reduction of greenhouse gas emissions. The higher the share, the more the emission level decreases. Karimi et al. [74] analysed the relationship between economic growth, consumption of renewable energies and CO₂ emissions in Iran between 1975 and 2017. They assume that renewable energies, CO₂ emissions and economic growth are related in the short term. They pointed out that using renewable energy as a solution is still being hampered by rising investment costs in new technologies. Khan et al. [75] concluded that renewable energy sources are reusable, which can reduce CO₂ emissions as well as ensure the sustainable economic development of Pakistan.

Akdag and Yildirim [76] confirm that there is a causal link between energy efficiency and greenhouse gas emissions in many European countries. They used datasets from 29 European countries between 1995 and 2016 and the result suggests that there is a long-term inverse relationship between energy efficiency and GHG emissions. Amponsah et al. [77] in their study, taking into account renewable energy sources, waste treatment and dedicated biomass technologies, potentially high greenhouse gas emissions were identified based on the raw material, selected limits and the inputs required for their production. The study confirms additional impacts of renewable electricity and heating technologies, shows the effectiveness of life cycle analysis as a tool for evaluating the environmental impact of renewable energy sources and declares potential for future improvements. According to the study conducted by Gielen et al. [78], renewable energies and energy efficiency in combination with the electrification of end uses make up 94 % of the emission reductions.

Owusu et al. [79] revealed opportunities related to renewable energy sources which consists of the following: energy security, access to energy, social and economic development, and mitigating climate change and reducing environmental and health impacts. According to their research, there are challenges that usually hamper the sustainable development of renewable energy sources and their ability to limit climate change. These challenges are market failure, lack of information, access to raw materials for the future use of renewable resources and, above all, human way of using energy inefficiently. Another factors with the positive impact on the reduction of GHG emissions are primary energy consumption and energy productivity [80–82]. pay attention to similar dependencies. Li et al. [80] found that the amount of CO₂ emissions in different countries was closely related to the amount and type of energy consumed by them. Their research results highlight the importance of improving energy efficiency and adjusting the energy structure to decrease energy consumption and ensure sustainable development. According to Ref. [81] research carried out for USA confirmed that total non-renewable, industrial and residential energy consumption has a positive impact on CO₂ emissions, while renewable energy consumption has a negative relationship with CO₂ emissions. Zou and Zhang [82] found that there is a mutual relationship between energy consumption and CO₂ emissions. Energy consumption and carbon dioxide emissions are interrelated, which has a negative spatial impact on carbon dioxide emissions in the surrounding provinces and cities.

GHG emissions are also influenced by social aspects, e.g. poverty. In countries with a high proportion of the population suffering from poverty, environmental degradation is higher. Countries with high poverty rates experience high levels of energy poverty and environmental degradation at the same time. Awad and Warsame [83] analysed the poverty-environment nexus in developing countries and came to the conclusion that while the bidirectional causality relationship between poverty and ecological footprint is discovered for the global panel and Africa, no causality is detected for the developing countries in Asia, Latin America, and Caribbean.

According to Ref. [84], poor people live in an unsustainable way and impact on environmental degradation based on natural resources (for example deforestation). The other problem is lack of fuel-efficient/green vehicles and green practices in poor societies, which results in greater

GHG emissions. The research results presented in this paper fit into the discussion and the published research results (especially [84]). The analysis of SDGs leads to the conclusion that poverty has an impact on environmental degradation, resulting in excessive exploitation of natural resources and the use of heat sources negatively affecting the environment. The study confirms this relationship for the EU countries based on the analysis of SDG7 (Population unable to keep home adequately warm).

Women are strongly affected by climate risk and are therefore more concerned about climate change [85]. In this context, the possibility of women influencing decision-making processes and influencing the shaping of climate policy becomes more important. This article examines this issue through the SDG5 analysis (women participation in national governments). The research results are in line with the results published in Ref. [86], who assume the representation of females in parliament results in lower carbon dioxide emissions.

5. Conclusion

The importance of climate policy is growing in the context of the impact of environmental risk on business, society and the economy. The article analyses the relationship between SDGs and climate policy development, obtaining a broader approach than previously used (climate policy versus sustainable development). The research results indicate for the EU countries that the implementation of the climate policy goals might be achieved by pursuing SDGs from the economic, environmental and social groups. It is crucial from the point of view of climate policy enactment, which should integrate the objectives of environmental protection policy, social policy and redistribution, according to obtained research results.

The aim of the paper is to analyse the interactions between climate policy development and various SDGs. The new approach and, at the same time, the strength of the article manifests itself in analysing climate policy development at the level of individual SDGs. Previous research and their results referred to the general relationships between climate policy and sustainable development. The original contribution is to connect climate action included in climate policy with the perspective of each SDG; it is the study's novelty compared to the research results published so far. One of the limitations of the study is the data set. Eurostat currently uses 100 different indicators to monitor progress in the implementation of the 2030 Agenda; some of them are updated less than once a year (12 indicators) and in the case of a further 23, information on them is only available in an aggregated form on a European basis level. Another limitation of the study stems from its focus on the EU countries. Research conducted for other regions of the world may potentially produce different results.

The general results of the study confirm that there are statistically significant interactions between SDG 13.10 (GHG) and several SDGs. Specific variables from the SDG7, SDG13 goals have the greatest normalized influence on the dependent variable. The study argues that GHG is linked to the environmental, social and economic pillar of sustainable development represented by SDG1, SDG3, SDG4, SDG5, SDG7, SDG8, SDG11, SDG 13, SDG16, SDG17.

The article indicates that interactions between particular SDGs support the implementation of climate policy development. The implementation of SDG7 and SDG13 has the strongest impact on climate policy development because both SDG7 and SDG13 relate to energy consumption, which has an impact on the amount of GHG emissions. SDG7 additionally refers to renewable energy sources, the share of which is systematically growing in EU countries as a result of public policies supporting the energy transformation, e.g. through systems of discounts and subsidies for renewable energy sources.

SDG7, SDG9, SDG17 support climate policy development because they influence the behaviour of market entities that contribute to the reduction of GHG emissions. Environmental taxes included in SDG17 support the reduction of GHGs by influencing the decisions of taxpayers

(dirty business ceases to pay off as "polluters pay"). Environmental taxes can facilitate a reduction of greenhouse gas emissions, depending on their scope and the general policy context. R&D spending effectively reduces greenhouse gas emissions. R&D expenditure included in SDG9 through support for green innovations is another example of a positive impact on climate policy development through the implementation of SDG9. Technological solutions and industrial innovation can help reduce greenhouse gas emissions. The patent application variable requires further investigation.

The research results show that social factors also influence the amount of GHG emissions, in addition to economic ones. In particular, the level of society's wealth and living conditions have an impact on consumption patterns which, for countries with high levels of poverty, lead to unsustainable consumption increasing environmental degradation. Poor living conditions result in unsustainable consumption and an increase in environmental degradation. Also, the position of women and their influence on decisions, in other words, gender issues, are important. Women will feel the effects of climate change more strongly than men, hence they are more sensitive to these changes and make more environmentally friendly decisions. The participation of women in parliament is therefore important for GHG emissions and the implementation of climate policy.

The study confirms that the energy efficiency which may be achieved by SDGs brings a number of environmental benefits. In particular, it reduces greenhouse gas emissions, both direct emissions from combustion or the consumption of fossil fuels and indirect emissions from electricity generation. Future work will focus on two fields: cluster analysis with respect to country affluence, location etc. and multiway factorial analysis of variables in order to extract indirect effects/impacts between particular SDGs.

The research results have significant theoretical, practical, and managerial implications. From the perspective of the conducted research, to obtain comprehensive knowledge about the SDG's impact on climate policy, it is necessary to look at the assumptions and implementation of climate policy, considering the importance and impact of all SDGs, not only those that directly relate to climate but also interactions between SDGs. Research shows that each of the SDGs can may have an effect on achieving climate neutrality and contributes to climate improvement. Therefore, environmental goals from the perspective of climate policy research should not have an absolute higher priority in research than social goals. The practical and managerial perspective should consider the energy transformation's role in achieving climate policy goals. Thus, governments should provide support programs for enterprises and households in this area through direct instruments, e.g., subsidies, and indirect fiscal instruments, particularly tax ones. At the same time, interventionist tools should include incentives for companies to implement innovations in energy sources and for researchers to conduct research in energy transformation. From the perspective of non-environmental goals, it is essential to organize such a decision-making policy at the level of companies and public entities to include fairly represent women in the decision-making process on the directions of the green transformation, e.g., by providing quotas on the boards of companies operating in the energy industry.

Author contributions

All authors contributed to the study conception and design. Data collection and analysis were performed by Krzysztof Kluza. The first draft of the manuscript was written by Krzysztof Kluza, Marta Postula, Magdalena Ziolo and all authors participated in revision of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Data availability

Dataset used in this research is freely available in the OSF repository; direct link: <https://osf.io/j5amr>. No registration is required.

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