ARE ENVIRONMENTAL EXPENDITURES A REFLECTION OF CLIMATE CHANGE FOR ROMANIA?

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ABSTRACT: Are Environmental Expenditures a Reflection of Climate Change for Romania?
Climate change is debated on a daily basis in the press and in specialized literature. Although the natural calamities caused by them can be seen at every step in all the countries of the world and on all the continents, nevertheless the authorities are seriously postponing the introduction of concrete methods of prevention and especially an appropriate budget financing that should take into account these challenges. But not only the extreme phenomena, difficult for the authorities to foresee, but especially the subtle and gradual changes of climate change must be taken into account. In this context, the article aims to highlight the impact of some indicators that highlight climate changes such as Cooling and heating degree days on Environmental Expenditures at the level of Romania. The panel analysis is based on Eurostat data at NUTS3 level but also on the national statistics of the Romanian Ministry of Finance on the period 2011-2023. The results show that although there is a connection between the elements tracked for Romania, nevertheless climate changes, taken into account through weather-based technical indexes designed to describe the need for the heating and for the cooling energy requirements of buildings, do not emphasize the due importance, at the level of budget expenditures.

Keywords: *Firms survival, performance, macroeconomic factors, impact, climate change.*

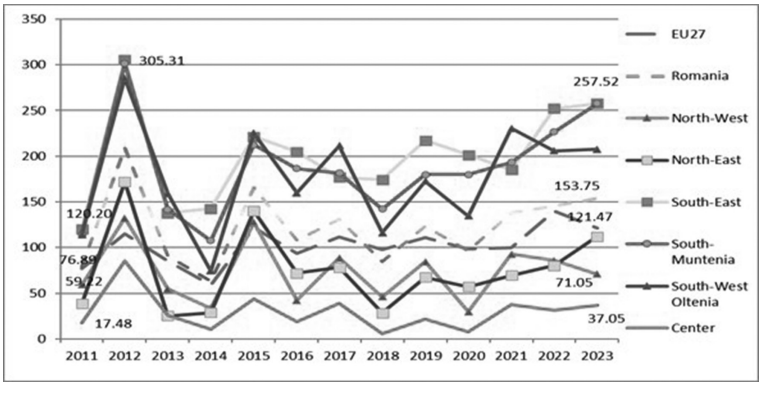
Introduction

Heating degree day (HDD) index and Cooling degree day (CDD) index are weathner-based technical indices designed to describe the need for the

heating energy and respectively for the cooling (air-conditioning) requirements of buildings. The Joint Research Centre's AGRI4CAST Resources Portal publishes this monthly dataset and Eurostat calculates on the basis of monthly data the annual data and republishes them. Weather conditions influence the consumption of energy, and in periods of extreme winters the need for natural gas or heating oil will be greater, therefore the bills for instance will be considerably higher. Thus, temperatures influence the need for cooling or air conditioning of buildings, affecting the daily life of citizens, increasing the price of bills and influencing not only comfort, but also the smooth running of daily activities at the community level. Thus, the article aims at the local level, at the NUTS-3 level, to study whether, at the level of Romania, local expenses are increased or not by the need for heating or cooling buildings. In this way, by assuming that climate change is having its say more and more by increasing temperatures and therefore consuming energy for thermal regulation, the article tries to raise an alarm signal regarding a more correct budgetary programming of environmental expenses so I am pleased to see a connection between these expenses and the ever-increasing need for thermal adjustment of buildings at the local level.

Thus, if we analyze the data processed by Eurostat, we notice that the Cooling degree days average index for Romania is above the average of the European Union with 27 states (EU27), with a generally increasing trend given by the regions in the south of the country (South-East, South-Mutenia, South-West Oltenia) (see Figure 1).

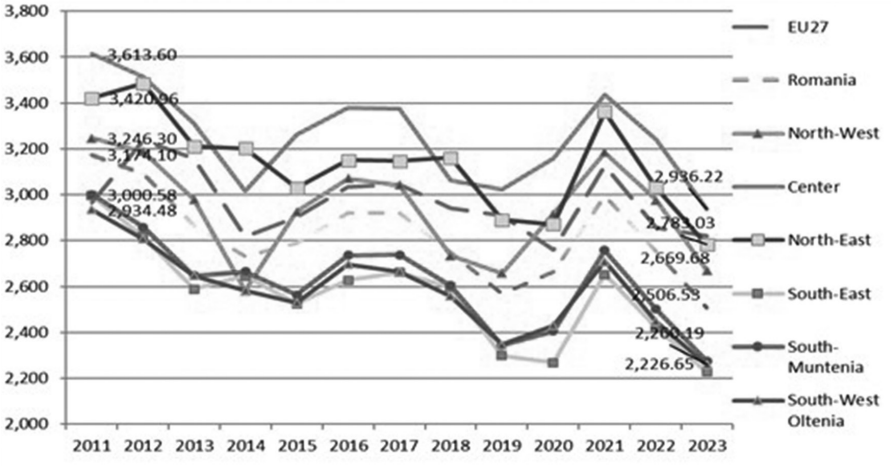
Figure 1 - Cooling degree days by major regions for Romania for the period 2011-2023



Source: Eurostat, Cooling degree days by NUTS 3 regions - annual data [nrg_chddr2_a__custom_12150174]

Regarding the Heating degree days index, looking at the Eurostat data, we notice that the average for Romania is below the EU27 average, with a general downward trend, and the most affected regions of Romania are in the Center, North East and North West. Thus, *the phenomenon of global warming certainly has its say in Romania, with a general need for cooling rather than heating* (although the index remains extremely consistent in terms of value compared to the cooling one!) throughout the year, with regions and respective counties more and more affected in the south for building cooling needs and in the centre and north for building heating needs.

Figure 2 - Heating degree days by major regions for Romania for the period 2011-2023



Source: Eurostat, Heating degree days by NUTS 3 regions - annual data [nrg_chddr2_a__custom_12150162]

Regardless of what specific needs the region has in preventing the freezing and cooling of buildings, the local authorities will have to understand quickly enough what actions must be taken at the county level, so that the needs of the citizens are covered as much as possible and therefore, local expenses will have to better adjust to these needs.

Research significance and purpose

Climate change is very much addressed in specialized literature, but it is very rarely treated on specific regions of the world, with a high level of specialization. For example, Central and Eastern Europe, although it is increasingly facing extreme phenomena, the conceptual and applied approach is precarious. Looking at the impact of the degree of climate change shown especially through the relatively increasingly extended periods of warming, requiring increased involvement in reducing temperatures, including through a reforestation especially at the urban level, the study also tries to show the connection with financing, through budget expenditures local environment. At the same time, with regard to the atmospheric cooling, requiring heating for the population and companies, although the periods seem rather to decrease from year to year, nevertheless the connection with the environmental expenditures can also be justify here if and how they are important for the public interest.

Thus, the novelty of the study is reflected in the fact that the study presents an analysis with Eurostat data for the period 2011-2023 for the NUTS 3 analysis level for Romania, an unprecedented analysis at this structural level.

Literature review

Climate change has had its say especially in recent decades and this trend is expected to continue until the end of the century (Eurostat, 2024). Identifying climate-related impacts is important for future climate risk management, and weather-related energy consumption for cooling and heating buildings can help to correctly identify and monitor this energy demand (Eurostat, 2024).

Numerous studies from around the world demonstrate high correlations between degree days and modeled building energy demand, adequately describing the influence of climate change on the need for heating and cooling of buildings (Badescu and Zamfir, 1999, Conradie, Van reenen and Bole, 2015; Bhatnagar et al. , 2018; Harvey, 2020, etc.). But not everywhere in the world the effects are found in a negative sense, there is evidence for example that for some areas of the world, climate change has so far contributed to the net decrease in weather-related en-

ergy consumption of households (Pangsy-Kania et al., 2024). However, the emphasis is rather on HDD (Heating degree days) than on CDD (Cooling degree days), although it should be the other way around, at least for continental Europe, for example for Switzerland there is a significant relative HDD decrease, between 11% and 18% depending on building quality and location, over the period 1901–2003 (Christenson, Manz and Gyalistras, 2006).

However, the connection between changes in temperatures, climate change and the economic expenditures necessary to mitigate the negative effects of climate change are rarely captured in the literature, especially regarding government expenditures (Flavin, 2019; Combes et al., 2018; Feng et al., 2022; Caglar and Yavuz, 2023; Niu, 2024). In this sense, our study aims to make its own contribution regarding the integration of information on HDD and CDD as an impact on the government environmental expenditures at the local level (NUTS3) for Romania.

Methodology

The analysis refers to the relationship, at county level, between environmental expenditures and a couple of climate change indexes such as cooling degree days and heating degree days. Also, some control variable where added to analysis such as Gross domestic product (GDP) at current market prices (% national GDP) and Population on 1 January (as % of the country level), all date being systematized at NUTS 3 regions level. The study period is 2011 - 2023, and the method is ordinary least squares estimation.

At the same time, using the panel technique, one must take into account the rather large heterogeneity of information between different counties of the country, but taking into account that it strictly refers to Romania, this heterogeneity is rather the internal structure and does not affect the general idea of adjustment at the level national and therefore neither the conclusions at the national level. The final number of observations obtained is 546, the extension of the series for the future being necessary to strengthen the conclusions. Also, taking into account a larger number of countries and other regions of the world as well as the introduction of other variables can complete and improve the conclusions of the study in the future. Below are the indicators used for this study.

Table 1. Used indicators and their description

Indicators' acronym	Indicators's description	Unit of measure	Source (for initial indicators)
CSEE	County Share of Environmental Expenditures in total county expenditures	%	The Romanian Ministry of Finance, to be exact: http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html
CCDD	County Cooling degree days (index)	number	Eurostat, [nrg_chddr2_a__custom_12150174]
CHDD	County Heating degree days (index)	number	Eurostat, [nrg_chddr2_a__custom_12150162]
CSGDP	County Gross domestic product (GDP) at current market prices by NUTS 3 regions- % national GDP	%	Eurostat, [nama_10r_3gdp__custom_12151782]
CSP	County Population on 1 January by broad age group, sex and NUTS 3 region (as % of the country level)	%	Eurostat, [demo_r_pjanaggr3__custom_12150075]

Source: http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html and Eurostat indicators. Authors' systematization

Discussion (Findings and Implications)

In the discussion section, we present some aspects of the statistical description, we continue to present the results of the Augmented Dickey-Fuller unit root test, the results of the correlation matrix, the regression equation, and the regression equations results, as well as the results of Granger causality (we only considered links with a probability below 5%).

Thus, to analyze the interrelationship between the independent indicators and the dependent variable - County Share of Environmental Expenditures in total county expenditures (CSEE), we first study the statisti-

cal properties of the variables, such as the mean value, standard deviation, skewness and kurtosis (see Table 2).

Table 2. Variables statistics description

	CSEE	CCDD	CHDD	CSGDP	CSP
Mean	5.76280	131.13080	2803.12400	2.37885	2.43245
Median	5.35653	116.41500	2768.70500	1.57939	2.14707
Maximum	15.63199	458.83000	4096.16000	25.10436	9.59164
Minimum	1.49312	0.00000	1979.44000	0.62094	0.98797
Std. Dev.	2.30849	97.02301	403.07710	3.61057	1.30371
Skewness	0.77148	0.64490	0.53963	5.42644	3.26854
Kurtosis	3.93177	2.72225	3.11005	33.26063	18.03592
Jarque-Bera	73.91258	39.60159	26.77488	23511.91000	6115.47700
Probability	0.00000	0.00000	0.00000	0.00000	0.00000
Sum	3146.488	71597.410	1530505	1298.850	1328.118
Sum Sq. Dev.	2904.36900	5130338	88546791	7104.75300	926.31890
Obser-vations	546	546	546	546	546

Source: Author's calculations, EViews12 processing; Eurostat and *http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html* initial data

For all the studied variables, the closeness between the average value and the median value, leads to the conclusion of a relatively symmetrical distribution. In most situations, the standard deviation, with some exceptions, appears to be close to the mean, suggesting gathering around the mean.

We notice that some variables are some subunits, being moderately deformed, and the variables above the value of 1 (e.g. CSGDP and CSP) indicates that they are distorted (deformed) substantially and positively. For almost all variables studied (except CCDD) the kurtosis is often substantially above 3, indicating that the distribution is leptokurtic, producing more values than a normal distribution.

On the basis of the above information, an Augmented Dickey-Fuller (ADF) unit root test can be constructed. Table 3 demonstrates that all variables used in this investigation are stable at order 0, not being necessary to go to the first difference.

Table 3. Selected variables Augmented Dickey-Fuller unit root test

Variables tested for ADF	T-statistic	Mackinnon critical value at 5%	P-value	Order of integration	Observation
CSEE	-8,9685	-3,4181	0.0000	I(0)	Stationary
CCDD	-3,8387	-3,4183	0.0153	I(0)	Stationary
CHDD	-4,8044	-3,4183	0.0005	I(0)	Stationary
CSGDP	-3,6571	-3,4183	0.0261	I(0)	Stationary
CSP	-3,7619	-3,4183	0.0193	I(0)	Stationary

Source: Authors' calculations, EViews processing; Eurostat and http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html initial data

Table 4 shows the correlation matrix between the dependent variable and the independent variables. The results could be considered somehow interesting, despite the fact that we can observe that although the correlation values are not quite significant, suggesting that there is no autocorrelation between the data. Somewhat higher levels in explaining the environmental local expenditures (CSEE) are recorded in the case of the GDP, population and cooling degree days (CCDD).

Table 4. Correlation matrix of the variables

	CSEE	CCDD	CHDD	CSGDP	CSP
CSEE	1				
CCDD	0.1069	1			
CHDD	0.0024	-0.6729	1		
CSGDP	0.1536	0.2816	-0.1886	1	
CSP	0.1309	0.1986	-0.1321	0.8790	1

Source: Authors' calculations, EViews processing; Eurostat and http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html initial data

It is interesting that the environmental expenditures correlate positively with all the proposed independent variables and the correlation of these expenses, both with the cooling and heating periods, reflects the fact that in principle, although insignificant, they are taken into account at the local county level within these expenditures. At the same time, at county level, it should be emphasized that the control variables such as CSGDP and CSP (that is, those related to GDP and population) are negatively correlated, but not significantly, with CHDD, the cooling of atmospheric temperatures still generating at the level of Romanian counties losses in relation to population but also GDP.

To better understand what is happening, we proceed to develop a regression equation.

The generic equations are represented as follows:

$Y= \alpha+ \beta1x1+ \beta2x2+ \beta3x3+ \beta4x4+\varepsilon$

Where:

Y= the chosen dependent variables such as the County Share of Environmental Expenditures in total county expenditures (CSEE);

α = constant;

β1-4=Slope or coefficients of x1-x4;

x1-x4= regression coefficients or independent variables;The x1-x4 are County Cooling degree days (index)(CCDD), County Heating degree days (index)(CHDD), County Gross domestic product (GDP) at current market prices by NUTS 3 regions- % national GDP (CSGDP), County Population on 1 January by broad age group, sex and NUTS 3 region (as % of the country level) (CSP). The ε is the error term.

Table 5 shows, in a systematized way, the regression equation results.

Table 5. Regression equation results

Dependent Variable: CSEE				
Method: Least Squares		Sample: 1 546, Included observations: 546		
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.893189	1.083402	2.670468	0.0078
CCDD	0.003812	0.001393	2.737452	0.0064
CHDD	0.000776	0.000326	2.378413	0.0177
CSGDP	0.087704	0.058087	1.509882	0.1317
CSP	-0.006345	0.157495	-0.040289	0.9679
R-squared	0.038048	Mean dependent var		5.762799
Adjusted R-squared	0.030935	S.D. dependent var		2.308488
S.E. of regression	2.272501	Akaike info criterion		4.488754
Sum squared resid	2793.865	Schwarz criterion		4.528156
F-statistic	5.349463	Hannan-Quinn criter.		4.504157
Prob(F-statistic)	0.000313	Durbin-Watson stat		1.131256

Source: Authors' calculations, EViews processing; Eurostat and http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html initial data; grey shades for unaccepted variables

Thus, we observe that for the chosen indicators they do not seem to significantly explain the desired indicator, having low coefficients and the R-squared and adjusted R-squared are very low, but the probability (F-statistic) is being adequate. However, the indicators revealing the evolution of the cooling and heating degree days (CCDD and CHDD) indicate some

impact on the environmental expenditures (CSEE), and the probability for the two variables is relatively adequate, well below 0.05. Thus, these variables can be accepted with confidence in the model, properly verifying the connection with the County Share of Environmental Expenditures in total county expenditures (CSEE). The CSGDP and CSP variables are not good enough to explain the model, so we rewrite the regression equation without these two control variables. Table 6 presents the results of the chosen final equation.

Table 6. Regression of the chosen final equation results

Dependent Variable: CSEE				
Method: Least Squares	Sample: 1 546, Included observations: 546			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.964035	1.054661	2.810416	0.0051
CCDD	0.004718	0.001365	3.455350	0.0006
CHDD	0.000778	0.000329	2.366485	0.0183
R-squared	0.02152	Mean dependent var		5.762799
Adjusted R-squared	0.017916	S.D. dependent var		2.308488
S.E. of regression	2.287715	Akaike info criterion		4.498463
Sum squared resid	2841.866	Schwarz criterion		4.522104
F-statistic	5.971290	Hannan-Quinn criter.		4.507705
Prob(F-statistic)	0.002722	Durbin-Watson stat		1.112026

Source: Authors' calculations, EViews processing; Eurostat and http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html initial data; grey shades for unaccepted variables

Based on the information presented previously, we can also perform a Granger causality test. Thus, taking into account only the connection between the dependent and independent variables with a p-value below 5%, we observe the following situations presented in table 7.

Table 7. Variables Granger Causality Test Results

Pairwise Granger Causality Tests			
Sample: 1 546, Lags: 2			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
CSEE does not Granger Cause CCDD	544	3.43360	0.0330
CSGDP does not Granger Cause CSEE	544	3.23525	0.0401
CHDD does not Granger Cause CCDD	544	61.98200	6.E-25
CCDD does not Granger Cause CHDD	544	26.48740	1.E-11
CSP does not Granger Cause CCDD	544	3.39718	0.0342
CSP does not Granger Cause CHDD	544	7.82111	0.0004
CSP does not Granger Cause CSGDP	544	110.16700	8.E-41

Source: Authors' calculations, EViews processing; Eurostat and *http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html* initial data; only date with a p-value under 0.05 are presented

Granger causality tells us that environmental expenses are rather influenced by the evolution of GDP at the county level, and cooling and heating do not seem to be variables that have a substantial effect in explaining environmental expenses (for example, rather cooling is explained by environmental expenses).

Conclusions

Extreme weather phenomena haunt the entire European continent more and more substantially in the last decades, and the changes can also be seen in the increase in general temperatures from year to year throughout a calendar year for almost all EU27 countries. In this sense, also in Romania, annual temperature increases are recorded for all seasons of the year and the need for cooling speaks more and more often, especially for the regions in the south of the country. In this context, the article tries to treat at the local, county level, based on Eurostat NUTS 3 data, the impact of climate

changes, noticeable also through the cooling and heating degree days' indicators, on environmental expenses at the local level.

Although the results, from the perspective of the econometric analysis, are not substantial, nevertheless it can be observed that the impact of climate change is somewhat integrated at the environmental expenditure local budget level. Thus, additional efforts are needed for a better understanding of the phenomena and a better integration at the budgetary level of the efforts to adjust to climate change in Romania.

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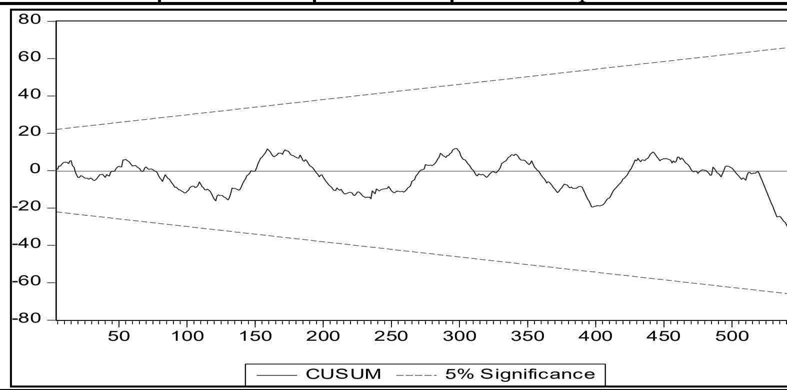
Annex

Table 8. Additional tests and robustness checks

Fact-finding checks	F - Statistics			P-value
Ramsey RESET -Stability test	4.19195			0.00601
Heteroskedasticity Test: Breusch-Pagan-Godfrey	3.57650			0.02863
LM test	67.52779			0.00000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
CCDD	1.86E - 06	1.827412	VIF<10	No interconnectivity of independent variables
CHDD	1.08E - 07	1.827412	VIF<10	No interconnectivity of independent variables
CUSUM test				

Source: Authors' calculations, EViews processing;
Eurostat and http://www.dpfbl.mdrap.ro/sit_ven_si_chelt_uat.html initial data