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An Analysis of the Impact of Fiscal Instruments on Energy Poverty in EU27

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Abstract

The war in Ukraine has exposed a number of problems of the advanced economies of the European Union (EU27), including: dependence on energy resources provided by Russia, increased pressure on the need to find alternative sources of energy independence, including through better exploitation of renewable, innovative or advanced storage means, the need to increase the interoperability of energy networks at European level, the consolidation of energy-efficient residential and public building structures that put less and less pressure on the European energy infrastructure. In this context, we can talk about energy poverty and the means to combat it. Beyond general economic methods, there is a part of the public toolkit that can be used effectively in combating energy poverty. Therefore, the objective of the article is to analyze the impact of some fiscal-budgetary instruments on energy poverty for the period 2010-2024 for 27 EU countries. The methodology envisages a panel analysis at a general level, but also with detail on fixed and random effects. At the same time, an interesting division is made into three groups of countries (North-eastern countries -NEC, South-western countries SWC, and Central countries - CC) to help us better discern the heterogeneities at the EU27 level regarding energy poverty. The results prove that the fiscal-budgetary instrument is more intensively used in the case of Central and South-western countries, this also against the background of some delays in identifying and solving the problem, compared to the Nordic countries. At the same time, the implications are given by the fact that the results confirm the economic theory regarding fiscal instruments to combat energy poverty, in the sense that both environmental taxes on energy, as well as VAT and subsidies, can play an active and important role in controlling and combating the phenomenon, which requires measures to refine the panoply of instruments and each individual instrument, as well as a more coherent interconnection between fiscal instruments at the European level.

Keywords: Energy Poverty, Fiscal Instruments, Public Policies, Fiscal Infrastructure.

Introduction

Energy poverty beyond the imminent aspect of deprivation represents a real element of the international and regional geopolitical game at the EU27 level, especially following the outbreak of the war in Ukraine in 2022. Energy poverty, despite the divergences of definitions, has captured the attention of society due to the fact that the phenomenon of lack of access to energy entails a series of extremely adverse social, environmental, educational, labour and health phenomena with implications in all areas of life for affected households, thus combating it having numerous benefits [1-6]. Taking into account the proportions of the phenomenon, both in terms of area in space and in terms of depth in society (there are various forms of energy poverty), the European Union has committed itself to combating the phenomenon both at the EU and national levels [7-11].

Literature Review

At the same time, at the EU27 level there is a process of increasing awareness and involvement of Member States in addressing the problem, including from the perspective of improving energy efficiency [12-16]. In the Balkan region, the largest allocations of funds to combat energy poverty are in Poland, the Czech Republic and Romania [10]. Given that the effects are extremely broad and mixed, with causes in various areas (housing infrastructure, buildings and energy system), a series of measures have focused on improving the stock and energy efficiency of the residential system, through financial incentives for renovation, and another on improving the financial capacity to cope with energy poverty (especially in Slovakia, Portugal and Estonia, in disadvantaged groups such as the Rom) [10, 17].

In addition to the classic instruments that are more aimed at subsidizing, bank loans, impact bonds, green bonds, technical assistance, citizen-based mechanisms, fiscal incentives, on property tax, crowdfunding, energy efficiency mortgages, the establishment of energy communities, energy efficiency feed-in tariffs, one-stop shops are several other instruments that can offer a wide range of options for financing and supporting the fight against energy poverty, including at the local level [9, 10, 16, 18, 19]. Despite the analyses in recent years that have helped to unravel the field of energy poverty, the instruments used so far still lack an integrative vision, with policies at European and national level still being disjointed between action plans (e.g. regional - state - local), incomplete and lacking a long-term vision [20-22].

Methodology

The fiscal instruments to combat energy poverty (FICEP) are extremely varied, with partial coverage on various aspects, therefore for a good structuring and operability of the information in a relatively coherent form, a centralization of the various instruments is necessary. Usually, the amounts are global, projected on a calendar of several years, being difficult to systematize in a concrete form at the annual level. Also, there is no compact period, of data coverage, clearly identifiable for all instruments. The years 2020-2023/2024 are better covered with data and information, while an analysis over a longer period, for example starting with 2010, makes the comparability and relevance of the information quite difficult. For example, energy subsidies are generally linked to crisis measures for consumer protection, such as government subsidies to moderate the increase in bills, provided either through direct contributions or through various measures to control or reduce energy prices, and households are generally the direct beneficiaries of these measures. However, it is difficult to identify whether price reductions/adjustments or benefits come from direct subsidies, vouchers, social tariffs or other instruments. At the same time, it is difficult to identify which subsidies have general effects and which are strictly related to vulnerable consumers, as specific programmes can overlap with general ones, and there are also funds provided at country level and funds provided through EU programmes, thus creating data fragmentation and different reporting for the same information. At the same time, although the vast majority of countries have introduced forms of support for vulnerable consumers, the reporting of values differs, in the sense that some countries include support measures in social budgets and others in energy budgets. These aspects are just some of the limitations of the analysis.

We can start with a description of the macroeconomic variables that we will use in the analysis:

Table 1: Presentation of variables for FICEP impact analysis

Variable name	Acronym	Unit of measurement	Data source
Standardized energy poverty index (SEPI)	SEPI	Index	Eurostat and EPAH, calculated by the previous author
Implicit tax rate on energy	ITE	Euro per tonne of oil equivalent (TOE)	Eurostat, [ten00120__custom_18477083]
V.A.T. Electricity prices for household consumers - bi-annual data (from 2007 onwards)	VATEPHC	Euro/Kilowatt-hour	Eurostat, [nrg_pc_204__custom_18494201]
Environmental subsidies and similar transfers from general government to households, by environmental activity, sector of recipient and ESA category of transfer, Current and capital transfers (including services), of which EP services, Subsidies, Tax abatements	ES	Million euro	Eurostat, [env_esst_gg__custom_18490460]
Environmental taxes by economic activity (Energy taxes)	EET	Million euro	Eurostat, [env_ac_taxind2__custom_18494911]

From a methodological perspective, the article focuses on identifying the impact of fiscal-budgetary instruments to combat energy poverty. The analysis is with panel data for the period 2010-2024, and the geographical area monitored is the European Union with 27 countries. Where data were missing, interpolation was made, or proxies were used, and where the data set stopped in previous periods, extrapolation was performed for the missing periods, especially for 2023 and 2024. The systematization of information is panel, taking into account all countries of the European Union with 27 countries (EU27). The lack of data but also the presence of adjustments may make the results of the study be viewed with caution.

Results and Discussions

Descriptive statistics are presented, and to test normality the Jarque-Bera statistical test is analyzed. The null hypothesis (H0) is that the selected variables have a normal distribution, and the alternative hypothesis (H1) is that they do not have a normal distribution. According to Table 2, the Jarque-Bera information for all selected variables is highly statistically significant at a significance level of 5%, confirming the normal distribution. But if we assume that the null hypothesis requires that the Skewness be 0 and the kurtosis be 3, this is not true for all the chosen variables. Thus, the Skewness is generally below 1, except for the ITE, ES,EET indicators, and the kurtosis is positive and extremely high (above 3) for most indicators, indicating a leptokurtic distribution. If we consider that for a normal distribution the mean and median values are close, suggesting a relatively symmetric distribution of the series, the null hypothesis is confirmed for most of the analyzed indicators. At the same time, the standard deviation also oscillates around the mean and median values, which indicates that the values are spread in an interval close to the mean.

Table 2: Descriptive statistics for FICEP indicators

	SEPI	ITE	VATEPHC	ES	EET
Mean	0,446228	220,0892	0,022959	41,190190	9171,384
Median	0,419379	205,2000	0,017700	0,400000	3598,280
Maximum	1,000000	625,8800	0,155000	3089,370000	83174,480
Minimum	0,000000	79,4400	-0,225200	-8.88E-16	92,720
Dev. Std.	0,197107	86,6046	0,039196	207,94870	14625,700
Skewness	0,687690	1,016988	-0,540625	2,82317	2,446978
Kurtosis	3,646206	4,067354	11,124030	14,15640	8,564660
Jarque-Bera	38,968640	89,037610	1133,477000	325357,4	926,7119
Prob.	0,000000	0,000000	0,000000	0,000000	0,000000
Sum.	180,722400	89136,12	9,298400	16682,03	3714410
Sum Dev. Sq.	15,695920	3030144	0,620684	17470043	8.64E+10
Obs.	405	405	405	405	405

Source: Eurostat and EPAH data, author's calculations in Eviews9

According to the correlation matrix table, most of the correlation coefficients of the macroeconomic variables are less than 0.5 and have a relatively weak positive and negative linear correlation, thus eliminating questions related to collinearity. Only, for example, EET is positively and more strongly correlated with ITE (0.446852) and VATEPHC (0.3517746), confirming the information that is also validated by theory in the sense that budgetary fiscal instruments sometimes overlap and potentate each other.

The implicit energy tax rate (ITE) can influence energy poverty by increasing energy prices, which can lead to an adverse effect in combating the phenomenon, burdening low-income households in particular. If tax revenues are used to support vulnerable households in particular, the implicit rate can help reduce energy poverty. Therefore, analyzing the correlation matrix, it is not clear whether the implicit energy tax rate can really contribute to combating the phenomenon. On the other hand, if we look at the VAT component of the energy price, we observe that it is directly correlated with the SEPI composite index, although relatively weakly. Subsidies granted to households, probably also through the complex form of aggregation, do not seem to contribute to the reduction of energy poverty, but rather have an adverse effect, they should rather have a negative sign. Regarding the environmental energy tax (EET), its decrease should be accompanied by the reduction of the SEPI index, which corresponds to the evolution in the matrix, but the correlation is extremely weak.

Table 3: Correlation matrix for FICEP indicators

	SEPI	ITE	VATEPHC	ES	EET
SEPI	1				
ITE	-0,0222	1			
VATEPHC	0,1681	0,3458	1		
ES	0,1743	0,0553	0,0332	1	
EET	0,0751	0,4469	0,3518	-0,0495	1

Source: Eurostat and EPAH data, author's calculations in Eviews9

Environmental taxes on electricity can aggravate energy poverty by increasing energy costs at household level, exposing low-income social groups in particular to the risk of energy poverty. At the same time, a high environmental tax on electricity can lead to greater difficulties for more vulnerable groups in accessing clean energy transition programs. However, beyond the financial support for low-income households, if the revenues from these taxes are directed to finance measures such as energy efficiency programs and for better access to renewable energy, the effect can be positive in combating energy poverty at household level.

In addition to the correlation matrix, the stationarity of the series was also checked by applying a clustered unit root sum test to calculate and compare statistical values with p-values. In order to reduce the number of ADF tests, the clustered unit root sum test was used.

Table 4: Unit root test for selected FICEP indicators

Group unit root test: Summary Series: SEPI, ITE, VATEPHC, ES, EET, Sample: 1 405 Exogenous variables: Individual effects, individual linear trends Automatic selection of maximum lags, Automatic lag length selection based on SIC: 0 to 2 Newey-West automatic bandwidth selection and Bartlett kernel				
Method	**Statistic**	**Prob.****	**Cross-sections**	**Obs**
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5,84469	0,0000	5	2017
Breitung t-stat	-9,19649	0,0000	5	2012
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-10,28240	0,0000	5	2017
ADF - Fisher Chi-square	132,66300	0,0000	5	2017
PP - Fisher Chi-square	166,53400	0,0000	5	2020
** Probabilities for Fisher tests are calculated using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.				

Source: Eurostat and EPAH data, author's calculations in Eviews9

Using a common unit root method, the study observed that all the statistical methods mentioned in the table above regarding Levin, Lin & Chu T*, IM, Pesaran & Shin W-Stat, ADF-FISHER Chi-Square and PP-Fisher Chi-Square have significant statistics and probabilities. For example, ADF - Fisher Chi-Square has a statistical value of 132.663 and a probability of 0.0000. So, the selected indicators are presented as a stationary series.

Based on the correlation matrix, the constructed regression equation is:

SEPI = C (1) + C (2) *ITE + C (3) *VATEPHC + C (4) *ES + C (5) *EET

Where: SEPI = dependent variable, Standardized Energy Poverty Index (SEPI)

C (1) = Constant; C1-5 = slope of the variables ITE, VATEPHC, ES, EET, these being coefficients or independent variables, more precisely the fiscal-budgetary instruments proposed previously.

Thus, if we analyze the result of the regression equation, it can be observed (see Table 5) that for the standardized energy poverty index, R-squared and adjusted R-squared are not considerable, with values below 0.50, and cannot be considered relevant. More precisely, R-squared has a value of 0.070193 and adjusted R-squared 0.060894. The probability (F statistic) is adequate for the above equation, being well below 0.05, more precisely having a value of 0.000007. The coefficients are generally positive (except for the ITE variable), but insignificant. Also, according to the probabilities, the EET variable should be eliminated from this equation.

Table 5: Result of the regression equation with panel systematization for the dependent variable SEPI in relation to FICEP

Dependent Variable: SEPI, Method: Panel Least Squares Sample: 2010 2024, Periods included: 15, Cross-sections included: 27, Total panel (balanced) observations: 405				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0,473569	0,026563	17,82811	0,0000
ITE	-0,000294	0,000126	-2,33061	0,0203
VATEPHC	0,901196	0,266006	3,38788	0,0008
ES	0,000170	4.60E-05	3,70041	0,0002
EET	1.06E-06	7.50E-07	1,41398	0,1581
R-squared	0,070193	Mean dependent var		0,446228
Adjusted R-squared	0,060894	S.D. dependent var		0,197107
S.E. of regression	0,191012	Akaike info criterion		-0,460696
Sum squared resid	14,594180	Schwarz criterion		-0,411265
Log likelihood	98,290890	Hannan-Quinn criter.		-0,441130

F-statistic	7,549149	Durbin-Watson stat	0,058748
Prob(F-statistic)	0,000007		

Source: Eurostat and EPAH data, author's calculations in Eviews9

The result can be presented as follows:

SEPI = 0.473569454487 - 0.000294269668233*ITE + 0.901195758777*VATEPHC + 0.000170062143059*ES + 1.0607874643e-06*EET

The analysis can be performed on fixed effects and random effects, and the results are shown in table six.

Table 6: The result of the regression equation with panel systematization for the dependent variable SEPI with fixed and random effects on the cross-sectional variable or per period in relation to FICEP

Model	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Effect on Cross-Section	**F**	**R**	**-**	**-**	**F**	**R**	**R**	**F**
Effect on Period	**-**	**-**	**F**	**R**	**F**	**R**	**F**	**R**
R-squared	0,9177	0,0185	0,1263	0,0702	0,9744	0,0464	0,6785	0,9632
Adjusted R-squared	0,9111	0,0087	0,0855	0,0609	0,9713	0,0368	0,6635	0,9602
Prob (F-statistic)	0,0000	0,1119	0,0000	0,0000	0,0000	0,0008	0,0000	0,0000
C, coef. (p-val.)	0,4026 (0,0000)	0,4050 (0,0000)	0,4760 (0,0000)	0,4736 (0,0000)	0,4440 (0,0000)	0,4358 (0,0000)	0,4425 (0,0000)	0,4368 (0,0000)
ITE, coef. (p-val.)	0,0002 (0,0825)	0,0002 (0,1016)	-0,0003 (0,0146)	-0,0003 (0,0187)	0,0002 (0,066)	0,0002 (0,0168)	0,0002 (0,0079)	0,0002 (0,0052)
VATEPHC, coef. (p-val.)	-0,1604 (0,1652)	-0,1467 (0,2026)	1,1160 (0,0001)	0,9012 (0,0007)	0,0939 (0,1913)	0,0539 (0,5037)	0,1000 (0,1636)	0,0483 (0,4947)
ES, coef. (p-val.)	1,85E-05 (0,2970)	2,01E-05 (0,2567)	0,0001 (0,0027)	0,0002 (0,0002)	-1,41E-05 (0,1676)	-7,92E-06 (0,4963)	-1,36E-05 (0,1846)	-8,46E-06 (0,4074)
EET, coef. (p-val.)	8,62E-07 (0,4339)	8,73E-07 (0,3939)	7,23E-07 (0,3328)	1,06E-06 (0,1527)	6,53E-07 (0,0000)	-2,92E-06 (0,0001)	- 3,68E -06 (0,0000)	-3,13E-06 (0,0000)
Test Hausman, Chi-Sq. Statistic (p-val.)	-	4,1241 (0,3895)	-	22,7354 (0,0001)	-	0,0000 (1,0000)	6,7405 (0,1503)	124,2014 (0,0000)

Source: Eurostat and EPAH data, author's calculations in Eviews9. Notations: F – fixed effects, R- random effects, with gray marking where values can be selected as appropriate, coefficients are passed as value, and in parentheses are p-values.

The Hausman test can tell us whether a random effects model or a fixed effects model is more appropriate. At the same time, for clarification of the option, a fixed effects test can also be performed that can guide us whether a test can go more in the direction of accepting a panel model or one with fixed effects. Thus, from the table above, if we also analyze the results of the Hausman test, we observe that where the probability of the Hausman test is below 0.05, we must reject the null hypothesis (namely, that the random effects model is more appropriate) and validate the hypothesis that the fixed effects model is more appropriate. Thus, from the analysis, we can see that the random effects option is also selectable. At the same time, if we strictly analyze the R squared and the adjusted one, where we also test the option for fixed effects on the cross-section, we observe that the results are clearly in favor of this option, with values of R squared and adjusted R squared well above 90 percent. Equally, if we also look at the probabilities of the independent variables, we observe that models 1 and 2 can be excluded, with inadequate probabilities for the independent variables, models 3 and 4 can allow the ITE, VATEPHC and ES variables as acceptable, model 5 can allow the EET variable as acceptable, and models 6-8 allow the ITE and EET variables as acceptable. Models 3 and 4, however, have a low R-squared, which allows us not to consider them the most appropriate, model 5 leaves us with a single explanatory variable, model 6 also has an insignificant R-squared, and between models 7 and 8, the R-squared is considerably significantly higher in model 8, and the probabilities of the acceptable variables are better (lower) in model 8 compared to model 7.

Therefore, the most appropriate equation seems to be:

SEPI = C (1) + C (2) *ITE + C (3) *VATEPHC + C (4) *ES + C (5) *EET + [CX=F, PER=R]

The results with the appropriate coefficients are of the form:

SEPI = 0.436777177806 + 0.000170127906637*ITE + 0.0482761618629*VATEPHC - 8.45746475002e-06*ES - 3.13499790435e-06*EET + [CX=F, PER=R]

We thus observe that the solution is consistent with the theory, so that the implicit energy tax rate goes in the same direction as energy poverty (tracked by the SEPI indicator), the VAT contribution to the energy price also goes in the same direction as the SEPI indicator, the subsidies granted to households if they increase contribute to poverty reduction, having an inverse effect on the SEPI variable, but relatively imperceptible, while the environmental tax on energy contributes in the opposite direction to energy poverty, but also, the coefficient of this variable is imperceptible from a value point of view. The VAT contribution to the energy price thus seems to be the value element that can bring the best correction to the phenomenon of energy poverty from the panoply of instruments analyzed. Based on the previous tables and information, we can also proceed with a Granger-type analysis. Thus in table 7 we select only the relationships that have a probability value below 0.05 or in its proximity. We note an important element in the modelling of the relationship, namely that the environmental energy tax (EET) Granger conditions the standardized composite energy poverty index (SEPI), and the VATEPHC instruments Granger conditions the ITE, and the ES Granger conditions the VATEPHC.

Table 7: Granger causality test results for FICEP

Pairwise Granger Causality Tests, Sample: 2010 2024, Lags: 2			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
ITE does not Granger Cause SEPI	351	2,49930	0,0836
SEPI does not Granger Cause ITE	351	2,81959	0,0610
SEPI does not Granger Cause VATEPHC	351	2,89887	0,0564
EET does not Granger Cause SEPI	351	7,10103	0,0009
VATEPHC does not Granger Cause ITE	351	3,94422	0,0202
ITE does not Granger Cause VATEPHC	351	2,67678	0,0702
ES does not Granger Cause VATEPHC	351	4,13237	0,0168
VATEPHC does not Granger Cause ES	351	2,41022	0,0913

Source: Eurostat and EPAH data, author's calculations in Eviews9; Note: bolded items are selectable as appropriate

If we look at the analysis by country group, the result is quite different from one group to another. The country groups are the Nordic and Eastern Countries (NEC), the Southern and Western Countries (SWC) and the Central Countries (CC). The country groups are the Nordic and Eastern Countries (NEC) - Denmark, Finland, Sweden, Latvia, Lithuania, Estonia, Ireland, the Netherlands, and Belgium. Southern and Western Countries (SWC): France, Portugal, Spain, Italy, Greece, Cyprus, Malta, Croatia and Slovenia. Central Countries (CC): Luxembourg, Germany, Poland, Czech Republic, Austria, Slovakia, Hungary, Romania and Bulgaria.

Thus, returning to the panel analysis, we observe that for the NEC countries, the result of R squared and adjusted R squared is extremely modest and the only variable that could be kept as explanatory is VATEPHC, for the group of SWC countries, R squared and adjusted R squared are relatively substantial, still below 50%, and all central instruments are under fiscal R squared and adjusted R squared are relatively significant and close to their SWC conditions, and only ITE and ES are suitable as explanatory variables. If we analyze the new equation by country groups, by fixed and random effects, we observe that for each group of countries they are different and extremely interesting.

Thus, if we analyze the results for the North-eastern countries (NEC) we observe that models 3, 4 and 6 are excluded, having inadequate probabilities, model 2 has a rather small R-square, so we could also give up on this equation, model 8 can also be excluded, having inadequate probabilities for the independent variables, therefore the best choices could be made between models 1, 5 and 7.

Model 1 proposes acceptable explanatory variables from the perspective of the p-value on ITE and EET, but the sign of the ITE coefficient is not the desired one, therefore, the best options could be equations 5 and 7. Although the value of R-square is clearly higher in equation 5, however, if we also look at the coefficients of the selected variables, we should rather prefer equation or model 7.

Table 8: Result of the regression equation with panel systematization for the dependent variable SEPI in relation to FICEP, by group of countries

Method: Panel Least Squares Method, Total Panel Observations (Balanced): 135				**Coefficient**	**t-statistic**	**Probabilitate**
Dependent variable	SEPI_NEC	Independent variables	C	0,587820	9,130580	0,0000
R-squared	0,051172		ITE	-0,000204	-0,468516	0,6402
Adjusted R-squared	0,021978		VATEPHC	1,270570	2,468031	0,0149
F-statistic	1,752799		ES	-0,000102	-0,408300	0,6837
Prob(F-statistic)	0,014233		EET	2,27E-06	0,352457	0,7251
Method: Panel Least Squares Method, Total Panel Observations (Balanced): 135				Coefficient	t-Statistic	Probabilitate
Dependent variable	SEPI_SWC	Independent variables	C	0,472710	17,42241	0,0000
R-squared	0,406242		ITE	-0,000686	-6,81751	0,0000
Adjusted R-squared	0,387972		VATEPHC	-0,966215	-3,53675	0,0006
F-statistic	22,236100		ES	-0,000374	-0,47127	0,6382
Prob(F-statistic)	0,000000		EET	4,79E-06	8,68809	0,0000
Method: Panel Least Squares Method, Total Panel Observations (Balanced): 135				Coefficient	t-Statistic	Probabilitate

Dependent variable	SEPI_CC	Independent variables	C	0,162604	3,643754	0,0004
R-squared	0,329666		ITE	0,001528	5,28413	0,0000
Adjusted R-squared	0,309040		VATEPHC	0,028095	0,057217	0,9545
F-statistic	15,983280		ES	0,000114	3,288011	0,0013
Prob(F-statistic)	0,000000		EET	-1,04E-06	-1,021585	0,3089

Source: Eurostat and EPAH data, author's calculations in Eviews9; with gray marked the best options from the perspective of p-value.

Table 9: Result of the regression equation with panel systematization for the dependent variable SEPI for NEC with fixed and random effects on the cross-sectional variable or per period in relation to FICEP

Model_NEC	1	2	3	4	5	6	7	8
Effect on Cross-Section	F	R	-	-	F	R	R	F
Effect on Period	-	-	F	R	F	R	F	R
R-squared	0,9350	0,0899	0,1451	0,0512	0,9838	0,0278	0,7701	0,9616
Adjusted R-squared	0,9286	0,0619	0,0124	0,0220	0,9799	-0,0021	0,7350	0,9578
Prob (F-statistic)	0,0000	0,0150	0,3672	0,1423	0,0000	0,4488	0,0000	0,0000
C coef. (p-val.)	0,5592 (0,0000)	0,5670 (0,0000)	0,5638 (0,0000)	0,5878 (0,0000)	0,5878 (0,0000)	0,5778 (0,0000)	0,5864 (0000)	0,5772 (0,0000)
ITE coef. (p-val.)	-0,0006 (0,0141)	-0,0006 (0,0251)	-5.64E-05 (0,8983)	-0,0002 (0,6418)	0,0002 (0,1476)	-0,0002 (0,4488)	0,0002 (0,1538)	-0,0002 (0,2693)
VATEPHC coef. (p-val.)	-0,1283 (0,5011)	-0,1298 (0,4952)	1,8617 (0,0011)	1,2706 (0,0154)	0,3996 (0,0007)	0,1653 (0,2785)	0,4034 (0,0006)	0,1632 (0,1372)
ES coef. (p-val.)	-3,96E-05 (0,6554)	-3,39E-05 (0,7008)	-0,0003 (0,1997)	-0,0001 (0,6852)	-0,0001 (0,0123)	-9,09E-05 (0,1841)	-0,0001 (0,0125)	-9,16E-05 (0,0634)
EET coef. (p-val.)	3,21E-05 (0,0007)	2,76E-05 (0,0016)	2.89E-07 (0,9647)	2,27E-06 (0,7263)	-1.09E-05 (0,0563)	7, 15E -06 (0,3265)	-1,04E-05 (0,0605)	7,63E-06 (0,1560)
Test Hausman, Chi-Sq. Statistic (p-val.)	-	3,1760 (0,5288)	-	12,1546 (0,0162)		0,0000 (1,0000)	1,0838 (0,8968)	129,3316 (0,0000)

Source: Eurostat and EPAH data, author's calculations in Eviews9; with gray marked the best options from the perspective of p-value.

We can also do a similar analysis for the South-Western Countries flank (SWC) of the EU27. Thus, equations with an inadequate p-value should be eliminated, namely 1,2,6,7 and 8. Model 5, although it has an extremely good R-squared, has only one acceptable explanatory variable, namely EET, therefore we should rather go for models 3 or 4, and considering that model 3 has a slightly better R-squared and adjusted R-squared, this could be the best option.

Finally, we also analyze the perspective of the Central Countries (CC) in combating energy poverty. We observe that all models from the probability perspective are good and very good and have the implicit energy tax rate (ITE) as an explanatory variable. Two models 3 and 4 propose as selectable explanatory variable only the subsidy instrument (ES), and equations 1 and 2, only the ITE variable, therefore we may not consider them the best options. Equations 5-8 remain selectable, and equation 8, proposing as acceptable three fiscal-budgetary instruments for managing energy poverty instead of two, seems to be the most appropriate. However, the sign of the coefficient for VAT (VATEPHC) and for the Environmental Energy Tax (EET) is not necessarily an expected and desirable one. Therefore, it is possible that other elements, other taxes and duties or fiscal-budgetary instruments (or other nature) better explain and counterbalance the phenomenon of energy poverty at the level of the central countries [23].

Table 10: Result of the regression equation with panel systematization for the dependent variable SEPI for SWC with fixed and variable effects on the cross-sectional variable or per period in relation to FICEP

Model_SWC	1	2	3	4	5	6	7	8
Effect on Cross-Section	F	R	-	-	F	R	R	F
Effect on Period	-	-	F	R	F	R	F	R
R-squared	0,8106	0,0294	0,5573	0,4118	0,9355	0,0251	0,6328	0,9068
Adjusted R-squared	0,7920	-0,0004	0,4886	0,3937	0,9200	-0,0048	0,5758	0,8976
Prob (F-statistic)	0,0000	0,4180	0,0000	0,0000	0,0000	0,5041	0,0000	0,0000
C coef. (p-val.)	0,3304 (0,0000)	0,3419 (0,0000)	0,4961 (0,0000)	0,4743 (0,0000)	0,3804 (0,0000)	0,3725 (0,0000)	0,3835 (0,000)	0,3690 (0,0000)

ITE coef. (p-val.)	2,44E-05 (0,8833)	-0,0001 (0,3215)	-0,0008 (0,0000)	-0,0007 (0,0000)	-2,49E-05 (0,8392)	-0,0001 (0,2786)	-0,0002 (0,1708)	-3,79E-06 (0,9745)
VATEPHC coef. (p-val.)	-0,0404 (0,8372)	-0,1354 (0,4800)	-1,2021 (0,0000)	-0,9817 (0,0002)	-0,1488 (0,3102)	-0,1909 (0,2080)	-0,2232 (0,1232)	-0,1201 (0,3951)
ES coef. (p-val.)	0,0007 (0,1535)	0,0006 (0,2208)	-0,0008 (0,3086)	-0,0004 (0,5779)	5,06E-05 (0,8761)	9,85E-05 (0,7779)	-1,18E-05 (0,9710)	0,0002 (0,6181)
EET coef. (p-val.)	-6,97E-07 (0,7752)	2,05E-06 (0,1968)	4,94E-06 (0,0000)	4,80E-06 (0,0000)	-3,33E-06 (0,0324)	-4,19E-07 (0,7552)	-6,46E-07 (0,6019)	-2,93E-06 (0,0577)
Test Hausman, Chi-Sq. Statistic (p-val.)	-	5,5567 (0,2348)	-	26,6938 (0,0000)	-	0,0000 (1,0000)	10,8768 (0,0280)	21,7259 (0,0002)

Source: Eurostat and EPAH data, author's calculations in Eviews9; with gray marked the best options from the perspective of p-value.

Table 11: Result of the regression equation with panel systematization for the dependent variable SEPI for CC with fixed and variable effects on the cross-sectional variable or per period in relation to FICEP

Model_CC	1	2	3	4	5	6	7	8
Effect on Cross-Section	F	R	-	-	F	R	R	F
Effect on Period	-	-	F	R	F	R	F	R
R-squared	0,8791	0,2256	0,3946	0,3297	0,9664	0,1997	0,7701	0,9327
Adjusted R-squared	0,8672	0,2017	0,3006	0,3090	0,9583	0,1751	0,7344	0,9261
Prob (F-statistic)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
C coef.(p-val.)	0,2088 (0,0000)	0,2097 (0,0016)	0,1670 (0,0005)	0,1626 (0,0004)	0,3690 (0,0000)	0,3055 (0,0001)	0,3596 (0,0000)	0,3108 (0,0000)
ITE coef.(p-val.)	0,0012 (0,0000)	0,0012 (0,0000)	0,0015 (0,0000)	0,0015 (0,0000)	0,0006 (0,0000)	0,0008 (0,0000)	0,0006 (0,0000)	0,0008 (0,0000)
VATEPHC coef. (p-val.)	-0,4161 (0,0721)	-0,4133 (0,0737)	0,1282 (0,8157)	0,0281 (0,9547)	-0,2355 (0,1066)	-0,3196 (0,0708)	-0,2363 (0,1052)	-0,3206 (0,0233)
ES coef.(p-val.)	2,82E-05 (0,1292)	2,93E-05 (0,1143)	0,0001 (0,0045)	0,0001 (0,0014)	-1,09E-05 (0,3245)	4,35E-06 (0,7480)	-9,29E-06 (0,3975)	3,40E-06 (0,7524)
EET coef.(p-val.)	1,47E-06 (0,2295)	1,31E-06 (0,2534)	-1,37E-06 (0,1960)	-1,04E-06 (0,3118)	-3,90E-06 (0,0000)	-1,93E-06 (0,0343)	-3,58E-06 (0,0000)	-2,10E-06 (0,0052)
Test Hausman, Chi-Sq. Statistic (p-val.)	-	1,1267 (0,8900)	-	10,1721 (0,0376)	-	0,0000 (1,0000)	4,5347 (0,3385)	81,2551 (0,0000)

Source: Eurostat and EPAH data, author's calculations in Eviews9; with gray marked the best options from the perspective of p-value.

Conclusion

In conclusion, the analysis of the impact of fiscal-budgetary instruments at EU27 level on energy poverty is one with interesting results. On the one hand, due to inherent data limitations, only a part of the previously identified instruments was included in the analysis, therefore the results should be viewed with caution. On the other hand, despite the limitations, the study nevertheless confirms the explanatory power of fiscal instruments in combating energy poverty, an important place being given to the contribution of VAT to the price of energy and environmental taxes on energy.

Thus, if we analyze the result of the regression equation with panel data for all EU27 countries, it can be observed that for the standardized energy poverty index, R-squared and adjusted R-squared are not considerable, with values below 0.50, and cannot be considered relevant, but the probability can be considered adequate, being well below 0.05. The coefficients are generally positive (except for the variable Implicit energy tax rate), but insignificant. Also, according to probabilities, the environmental tax variable on economic activities should be eliminated from this equation. The analysis also aimed to study fixed and random effects in adjusting the model. The preferred solution may lean more towards model 8, in which the fixed effect on the cross-section and the random effect on the period were tested. For this model variant, R squared and adjusted R squared had values of 0.9632 and 0.9602, respectively. The chosen solution is consistent with the theory, so that the implicit energy tax rate goes in the same direction as energy poverty (tracked by the Standardized Energy Poverty Index - SEPI), the VAT contribution to the energy price also goes in the same direction as the SEPI indicator, subsidies granted to households if they increase contribute to the reduction of energy poverty, having an inverse effect on the SEPI variable, but the effect is relatively imperceptible, while the environmental tax on energy contributes in the opposite direction to the evolution of the Standardized Energy Poverty Index, but also, the coefficient of this variable is imperceptible from a value point of view. However, the VAT contribution to the energy price seems to be the value element that can bring the best correction to the phenomenon of energy poverty from the panoply of instruments analysed.

The same type of analysis is carried out on groups of countries, first at a general level with panel data, then on combinations of types of effects: fixed and random. Without further detailing the results for fixed and random effects, regarding the panel analysis, we note that: - for the Nordic and Eastern Countries (NEC), the result of R squared and adjusted R squared are extremely modest and the only variable that could be kept as an explanatory variable is VATEPHC, - for the group of countries Southern and Western Countries (SWC), R squared and adjusted R squared are relatively substantial, but still below 50%, and all fiscal instruments are appropriate, except Environmental Subsidies and Similar Transfers from Public Administration to Households (ES), and for the group of countries Central Countries (CC), R squared and adjusted R squared are relatively significant and close to the value of the SWC countries, and as suitable explanatory variables are only the Implicit Energy Tax Rate (ITE) and ES. This confirms once again that the Nordic countries have treated and solved the problem of energy poverty more seriously, and the fiscal instruments are more evolved, relying on more refined elements such as VAT or environmental taxes or taxes on excessive profits, while the Central and Southern and Western Countries of the EU27 face substantial energy poverty problems, and the chosen instruments are coarser, still focusing on subsidies and direct support.

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