IMPLICATIONS OF THE TRANSITION TO THE CIRCULAR ECONOMY ON ENERGY POVERTY AT EUROPEAN LEVEL

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Abstract:

The COVID-19 pandemic has brought into question the issue of housing space and decent living and working conditions. With the outbreak of the war in Ukraine, the problem has worsened due to the ever-increasing costs of energy products (especially oil and gas) at the European level. For the most vulnerable citizens, seriously exposed to the risk of energy poverty, solutions vary in the scope of restricting consumption, using dangerous non-compliant materials for heating and cooking, postponing bill payments, but also reducing spending on essential goods, such as food and medicine. Against this background, the increasingly important climate ambitions of European Union officials regarding the reduction of greenhouse gas emissions and the transition to a circular economy worsen the situation, through necessary investments in key infrastructure (e.g. energy, transport, etc.), which lead, through successive implications, to the support of these costs at the citizen level. In this context, the article analyzes, through an econometric model, with panel data, for the period 2015-2024, the implications of the circular economy transition captured by circular economy indicators on some energy poverty indicators at the EU27 level.

Keywords: *energy poverty, circular economy, correlations, feedback*

JEL classification: *C23, I31, P46*

Introduction

The multifaceted nature of poverty can make addressing specific types of poverty - such as energy poverty - extremely interesting. Addressing energy poverty is vital for economic development, having close links with income poverty, but also with structural problems in areas such as construction and energy. Energy poverty, especially for the most vulnerable categories

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of the population, can be viewed from a climate perspective as an enhancer of climate problems, by exposing the vulnerable population to the use of more polluted and more dangerous heating sources and resources for human health and the environment. Thus, not only the reduction of costs and the clear benefits for humans such as combating diseases (respiratory, mental, cardiac, etc.), improving educational performance and general well-being, but also the protection and conservation of the environment.

At the same time, the increased need to accelerate climate reform in all areas of economic and social life may put increased pressure on combating energy poverty issues, especially if the vulnerable groups affected by the two types of phenomena (energy poverty and economic reforms to comply with the EU27 climate commitments) are not identified or they are not identified correctly and clearly enough or they are not protected by effective measures. For this reason, the link between the circular economy and energy poverty deserves increased interest in investigation.

Thus, this article explores the implications of some circular economy indicators on energy poverty indicators on at the European Union (EU27) level. The article uses a panel econometric model to analyze the impact of circular economy on variables such as Arrears on utility bills, At risk of poverty or social exclusion, Energy import dependency, Electricity prices for household consumers, Final consumption expenditure of households, Share of renewable energy in gross final energy consumption for the period 2015-2024. The data sources are extremely different, mainly based on Energy Poverty Advisory Hub (EPAH), Eurostat, and European Commission documents. Although the circular economy is an important climate and environmental objective, it should not be seen as an end in itself and as a target on a limited time horizon, but as an integrative way of perceiving reality with serious implications in all aspects of life, including the issue of energy poverty. That is why it is important to see not only the short-term advantages or disadvantages, but as a way in which problems combine, become complicated, but can also express the potential for mutual problem-solving. Only in this way can circularity propose valid, medium- and long-term solutions to energy poverty.

Literature Review

The issue of energy poverty has received increasing attention in the academic literature over the past two decades, being closely linked to economic inequalities, unequal access to resources, and shifts in energy policies at both national and European levels. According to recent studies, energy poverty is defined not only by the lack of physical access to energy sources but also by households' inability to meet their basic energy needs in a safe, healthy, and affordable manner (Bouzarovski & Petrova, 2015; Boardman, 2010).
Following the outbreak of the COVID-19 pandemic, numerous studies have highlighted a worsening of these problems, particularly among vulnerable groups, due to social isolation, reduced income, and increased household energy consumption (Sovacool et al., 2020; Middlemiss & Gillard, 2021). In parallel, the literature has underlined the indirect impact of climate policies on these groups, in the context of the green transition and the rising costs associated with its implementation (Jenkins et al., 2021). At the same time, the concept of the circular economy has become central to debates on sustainable development, being promoted as an alternative to the traditional linear economic model. Specialist studies indicate that a well-implemented circular economy can help reduce pressure on natural resources, diminish waste,

and create new job opportunities (Kirchherr et al., 2017; Geissdoerfer et al., 2017). However, few studies have directly examined how this transition affects energy poverty or the living conditions of the most vulnerable citizens.
Several authors have warned of the risk that transition policies may generate additional inequalities if not accompanied by compensatory measures and adequate social protection mechanisms (Simcock & Walker, 2020). It is also noted that the investments required for green infrastructure—such as in transport or energy efficiency—may lead, at least in the short term, to increased costs borne indirectly by the population (Sorrell, 2015).
As for the empirical analysis of the relationship between the circular economy and energy poverty, the literature is still in an emerging phase. Some recent research attempts to establish links between circularity indicators and population well-being, but the results are often contextual and difficult to generalize (Ritzen & Sandström, 2017). In particular, comparative data at the EU member state level are rarely analyzed using panel econometric models, leaving room for further scientific contributions exploring this research direction.

Methodology and Data

In terms of methodology, the analysis refers to the relationship between a series of circular economy indicators and some energy poverty indicators. The study period is 2015 - 2024, and the method is estimation by the ordinary least squares method. Where the data stop in the previous period, for example 2022 or 2023, they are extended by extrapolation, and where they are missing from the series, there has been used interpolation methods. Thus, the results should be viewed with reservations.

Below there are the variables selected for analysis; so the first six represent indicators of the energy poverty and the last four represent indicators of circular economy.

Table 1: The indicators used and their description

Variables name	Acronym	Unit of measure	Data source
Arrears on utility bills - No disaggregation	UBA	% of households	EPAH
At risk of poverty or social exclusion - Total	RPSE	% of population	EPAH
Energy import dependency by products	EID	%	Eurostat [sdg_07_50]
Electricity prices for household consumers - bi-annual data (from 2007 onwards), second semester	EPH	Euro/kWh	Eurostat [nrg_pc_204]
Final consumption expenditure of households - Total	FCE	k€/capita	EPAH
Share of renewable energy in gross final energy consumption by sector	SRE	%	Eurostat [sdg_07_40]
Consumption footprint - single weighted score	CFP	Planetary Boundary	Eurostat, [sdg_12_31]
Circular material use rate	CMUR	Percentage	Eurostat, [sdg_12_41]
Gross value added in environmental goods and services sector	GVAEG	Percentage of GDP	Eurostat, [sdg_12_61__custom_17563732]
Consumption of Raw material	CRM	Tonnes per capita	Eurostat, [sdg_12_21]

Source: EPAH and Eurostat, authors' selection.

The geographical area of analysis is the European Union with 27 countries. The final number of observations obtained is 270, the volume of data can be considered relatively small. Although there are studies that place the share of renewable energy in gross final energy consumption within the framework of circularity indicators, we use it in this study as an indicator of energy poverty. This is due to the fact that the energy sector is a central factor in the evolution of energy poverty.
The option for the regression model is justified by the fact that the panel data econometric model combines multiple observations for the same entities (e.g. countries) over multiple time periods compared to other econometric models.

Results

In order to identify the link between the evolution of the independent indicators and the dependent variable, a series of specific indicators of EPAH, and Eurostat were selected. The descriptive statistics are presented in Table 2. Thus, the mean, median, standard deviation, Skewness and Kurtosis were highlighted. The standard deviation is kept relatively close to the mean and below it, which means low variability, a high degree of consistency and relatively low dispersion within the data set. The mean and median are generally close to each other suggesting a relatively symmetrical distribution, which may suggest that the data may be normally distributed.
The data shows a Skewness with values generally lower than two, except for the UBA indicator, which can be considered acceptable for evaluating the normality of the data series. Regarding Skewness, most indicators are positive, so it is possible that outliers are positioned at the top of the data set, pulling the mean to the right in relation to the median. Only the EID indicator has a negative Skewness, which indicates a frequency distribution that presents an asymmetric tail in the area of values lower than the mean, pulling the mean to the left in relation to the median.

Table 2: The Statistics description of the selected variables

	UBA	RPSE	EID	EPH	FCE	SRE	CFP	CMUR	GVAEG	CRM
Mean	8.6908	21.4941	57.6365	0.1489	15.4898	23.6218	3.3757	9.4009	2.5697	19.1749
Median	6.5000	20.0500	58.9800	0.1260	14.5928	19.7913	3.3800	8.0500	2.3200	16.5365
Maximum	42.2000	46.0000	103.0520	0.4590	39.8500	68.3260	4.8500	31.7667	6.3850	49.3110
Minimum	1.2000	10.7000	1.2290	0.0771	4.2900	4.9870	2.0700	1.2333	0.4700	8.8570
Std. Dev.	7.5787	6.1056	22.8537	0.0650	6.7844	12.3430	0.6226	6.5433	1.2310	7.8922
Skewness	2.1891	1.2524	-0.2228	1.9086	0.7679	1.1293	0.0016	1.0880	0.8535	1.4638
Kurtosis	8.0314	5.0758	2.5603	7.4733	3.7423	4.2141	2.4390	3.7034	3.6722	5.2277
Jarque-Bera	500.4363	119.0651	4.4090	389.0448	32.7327	73.9723	3.5402	58.8342	37.8634	152.2582
Probability	0.0000	0.0000	0.0110	0.0000	0.0000	0.0000	0.0170	0.0000	0.0000	0.0000
Sum	2.346.522	5.803.41	15561.87	40.2115	4.182.257	6.377.880	911.4267	2.538.233	693.8275	5.177.223
Sum Sq. Dev.	15450.32	10028.02	140496.5	1.137281	12381.62	40982.03	104.2676	11517.17	407.6182	16755.18
Observations	270	270	270	270	270	270	270	270	270	270

Source: EPAH and Eurostat, authors' calculation in EViews9.

Regarding Kurtosis, positive values indicate a distribution with a “peak” higher than the normal distribution, thus for most of the studied variables the Kurtosis is substantially above 3 (except EID and CFP, with values below 3, and FCE, CMUR and GVAEG, with values above, but closet to 3), indicating that the distribution is leptokurtic, producing more values than a normal distribution.

To better elucidate the consistency of the normal distribution of the data set, additional tests are developed such as a unit root test - ADF (Augmented Dickey-Fuller).

In Table 3, in order to reduce the number of ADF tests from 10 to 1, the clustered unit root summarization test was used. Using a common unit root method, the study observed that all the statistical methods mentioned in Table 3 regarding Levin, Lin & Chu T*, IM, Pesaran and 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 159.206 and a probability of 0.0000. In other words, the selected indicators are presented as a stationary series, that all the variables used in this investigation are stationary at order 0.

Table 3: Augmented Dickey-Fuller unit root test for the selected variables

Group unit root test: Summary				
Series: UBA, RPSE, EID, EPH, FCE, SRE, CFP, CMUR, GVAEG, CRM				
Date: 09/19/25, Sample: 1 270, Exogenous variables: Individual effects, individual linear trends				
Automatic selection of maximum lags, Automatic lag length selection based on SIC: 0				
Newey-West automatic bandwidth selection and Bartlett kernel, Balanced observations for each test				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.06058	0.0000	10	2690
Breitung t-stat	-11.3656	0.0000	10	2680
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-10.7854	0.0000	10	2690
ADF - Fisher Chi-square	159.206	0.0000	10	2690
PP - Fisher Chi-square	162.068	0.0000	10	2690
** Probabilities for Fisher tests are computed using an asymptotic Chi				
-square distribution. All other tests assume asymptotic normality.				

Source: EPAH and Eurostat, authors’ calculation in EViews9.

Table 4 shows the correlation matrix between the independent variables and the dependent variables. The dependent variables are UBA, RPSE, EID, EPH, FCE, SRE. Thus, it can be observed that the most values are below 0.70, which suggests a low risk of collinearity. But in order to have a more accurate picture, in the appendix, the tolerance or variance inflation factor (VIF) is also analyzed, which clearly shows, with great reliability, that there is no collinearity problem for the variables selected (see Annex).

From the correlation matrix it is observed that the links between the dependent and independent variables are either positive or negative. For example, for the dependent variables UBA and RPSE the correlations for the selected independent variables are negative while for FCE, EPH it is predominantly positive while for others EID and SRE it is mixed.

Interpretation is difficult, in the sense that many energy poverty indicators have negative significance (except the share of renewable energy - SRE), while circularity indicators have

mixed significance, generally going in the direction of improvement, so the inverse correlation between the two types of indicators should theoretically be interpreted positively. However, there is a bidirectionality and interconditioning that is difficult to detect based on the correlation matrix alone.

Table 4: Correlation matrix of the variables

	UBA	*RPSE*	*EID*	*EPH*	*FCE*	*SRE*	*CFP*	*CMUR*	*GVAEG*	*CRM*
UBA	1									
RPSE	0.6280	1								
EID	0.0126	-0.0794	1							
EPH	-0.1578	-0.1464	0.2556	1						
FCE	-0.4359	-0.4055	0.3328	0.4761	1					
SRE	-0.0957	-0.0208	-0.5368	0.0091	0.0784	1				
CFP	-0.4611	-0.4122	0.3444	0.3913	0.8324	-0.0048	1			
CMUR	-0.4479	-0.3285	0.0617	0.2071	0.3128	-0.2228	0.2873	1		
GVAEG	-0.2131	-0.0669	-0.4388	0.1230	0.2889	0.6763	0.1707	0.0852	1	
CRM	-0.2267	-0.1610	-0.3422	-0.0585	0.3444	0.3756	0.2905	-0.0089	0.6671	1

Source: EPAH and Eurostat, authors' calculation in EViews9.

Based on the correlation matrix, the regression equations constructed are as follows:

$$UBA = f(CFP, CMUR, GVAEG, CRM) \quad (1)$$

$$RPSE = f(CFP, CMUR, GVAEG, CRM) \quad (2)$$

$$EID = f(CFP, CMUR, GVAEG, CRM) \quad (3)$$

$$EPH = f(CFP, CMUR, GVAEG, CRM) \quad (4)$$

$$FCE = f(CFP, CMUR, GVAEG, CRM) \quad (5)$$

$$SRE = f(CFP, CMUR, GVAEG, CRM) \quad (6)$$

The equations are represented by the form:

$$Y=\alpha+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_4x_4+\varepsilon$$

Where: Y = the dependent variable, chosen successively: Arrears on utility bills - No disaggregation – UBA, At risk of poverty or social exclusion – Total – RPSE, Energy import dependency by products – EID, Electricity prices for household consumers - bi-annual data (from 2007 onwards), second semester – EPH, Final consumption expenditure of households – Total – FCE, Share of renewable energy in gross final energy consumption by sector – SRE.

α= Constant; β_{1-4} = slope of variables x_1–x_4 – coefficients; x_1–x_4 = regression coefficients or independent variables, more precisely: Consumption footprint - single weighted score – CFP, Circular material use rate – CMUR, Gross value added in environmental goods and services sector – GVAEG, Consumption of Raw material – CRM; ε = error term.

Thus, it can be observed (see Table 5) that for UBA, RPSE and EID, R-squared and adjusted R-squared are not considerable, with values below 0.50, they can still be considered relevant. The probability (F statistic) is adequate for all equations, being well below 0.05. And for all equations the coefficients are generally negative, except for equation 3 in table 5, in which the coefficient of CFP is considerable and positive. Also, according to the probabilities, from the first equation the variables GVAEG and CRM should be eliminated, from the second equation, GVAEG and CRM and from the third equation CMUR.

Table 5: Regression equation results for UBA, RPSE and EID in relation with climate change variables

Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	UBA	Independent Variables	C	28.50255	13.36325	0.0000
R-squared	0.340627		CFP	-3.92606	-5.88024	0.0000
Adjusted R-squared	0.330674		CMUR	-0.40567	-6.62667	0.0000
F-statistic	34.22418		GVAEG	-0.41549	-0.99766	0.3194
Prob(F-statistic)	0.000000		CRM	-0.08748	-1.30210	0.1940
Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	RPSE	Independent Variables	C	34.964150	18.801900	0.0000
R-squared	0.227759		CFP	-3.123185	-5.365208	0.0000
Adjusted R-squared	0.216102		CMUR	-0.230225	-4.313460	0.0000
F-statistic	19.53928		GVAEG	0.497023	1.368834	0.1722
Prob(F-statistic)	0.000000		CRM	-0.106397	-1.816477	0.0704
Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	EID	Independent Variables	C	29.040270	4.758163	0.0000
R-squared	0.406278		CFP	18.074580	9.460560	0.0000
Adjusted R-squared	0.397316		CMUR	-0.182211	-1.040177	0.2992
F-statistic	45.33421		GVAEG	-6.501804	-5.455923	0.0000
Prob(F-statistic)	0.000000		CRM	-0.729935	-3.797048	0.0002

Source: EPAH and Eurostat, authors' calculation in EViews9. Variables that should be accepted according to the adequacy of the probability (below 0.05) are marked in gray.

In Table 6 it can be seen that for SRE and FCE, R-squared and adjusted R-squared are considerable, with values above 0.50, and can be considered highly relevant.

The probability (F statistic) is adequate for all equations, being well below 0.05. For the first two equations the coefficients are generally positive, except for equation 3 in table 6, where the coefficients are generally negative, except for the coefficient of GVAEG which is considerable and positive.

This is perfectly explainable, a higher gross value added from environmental goods implies that alignment with European standards stimulates the increase in the share of renewable energy. Also, according to the adequacy of the probabilities, the CMUR variable should be eliminated from the first equation in table 6, CRM from the second equation and CFP from the third equation.

Table 6: Regression equation results for EPH, FCE and SRE in relation with climate

change variables

Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	EPH	Independent Variables	C	0.010068	0.512957	0.6084
R-squared	0.241491		CFP	0.045633	7.427298	0.0000
Adjusted R-squared	0.230042		CMUR	0.000521	0.924662	0.3560
F-statistic	21.09238		GVAEG	0.015925	4.155517	0.0000
Prob(F-statistic)	0.000000		CRM	-0.003181	-5.145560	0.0000
Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	FCE	Independent Variables	C	-16.26188	-13.08823	0.0000
R-squared	0.720792		CFP	8.478525	21.79920	0.0000
Adjusted R-squared	0.716577		CMUR	0.081763	2.292761	0.0226
F-statistic	171.0282		GVAEG	0.694467	2.862578	0.0045
Prob(F-statistic)	0.000000		CRM	0.030139	0.770129	0.4419
Method: Least Squares, Included observations: 270				**Coefficient**	**t-Statistic**	**Probability**
Dependent Variable	SRE	Independent Variables	C	13.58451	4.748297	0.0000
R-squared	0.552756		CFP	-0.236777	-0.264388	0.7917
Adjusted R-squared	0.546005		CMUR	-0.547465	-6.667197	0.0000
F-statistic	8.316607		GVAEG	8.163281	14.613500	0.0000
Prob(F-statistic)	0.000000		CRM	-0.260458	-2.890380	0.0042

Source: EPAH and Eurostat, authors' calculation in EViews9. Variables that should be accepted according to the adequacy of the probability (below 0.05) are marked in gray.

At the same time, if we also apply a Granger causality (Table 7), and select only the relationships that have a probability value below 0.05 or in its proximity, we observe an important element in the modeling of the relationship, namely that the electricity price is influenced and dramatically influences the final consumption of households.

At the same time, if we refer to the influence of the dependent variables on the independent one, we also observe a bidirectionality between variables, especially between Consumption footprint (CFP) and Electricity prices for household consumers (EPH). This once again says that there is much to be done in the energy field in order to break the electricity price (especially by decreasing it) from the Consumption footprint.

Table 7: Variables Granger Causality Test Results

Pairwise Granger Causality Tests, Date: 09/19/25, Sample: 1 270, Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
EPH does not Granger Cause UBA	268	2.89274	0.0572
EPH does not Granger Cause RPSE	268	5.20453	0.0061
FCE does not Granger Cause EPH	268	4.15308	0.0168
EPH does not Granger Cause FCE	268	5.17892	0.0062
CFP does not Granger Cause EPH	268	2.46525	0.0869
EPH does not Granger Cause CFP	268	2.49793	0.0842
EPH does not Granger Cause CRM	268	2.39881	0.0928

Source: EPAH and Eurostat, authors' calculation in EViews9. Variables that should be accepted according to the adequacy of the probability (below 0.05) are marked in gray.

Conclusions

Energy poverty is one of the many forms of poverty that affect the daily lives of citizens, but also of the private environment and institutions. Although it is mainly observed at the population level, it describes numerous shortcomings of the general social and economic sphere.

At the same time, although it influences environmental parameters and especially the population's relationship to nature, energy poverty is also influenced by the transition to a green economy and a circular economy.

Ideally, the transition to a circular economy should be borne mainly by companies and public institutions, but in reality the transition is often reflected through prices at the population level, worsening energy poverty. Thus, this article highlights how circularity influences energy poverty and the results indicate the need for a greater effort to break economic growth and well-being from resource consumption, including through fairer control over energy prices.

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Annex

Table 8: Additional tests and robustness checks for UBA

Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			49.05139	0.0000
Heteroskedasticity Test: Breusch-Pagan-Godfrey			10.40527	0.0000
LM test			325.8203	0.0000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
C	4.549286	NA	VIF<10	No interconnectivity of independent variables
CFP	0.445783	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	0.003748	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	0.173441	1.839002	VIF<10	No interconnectivity of independent variables
CRM	0.004513	1.967084	VIF<10	No interconnectivity of independent variables

CUSUM test

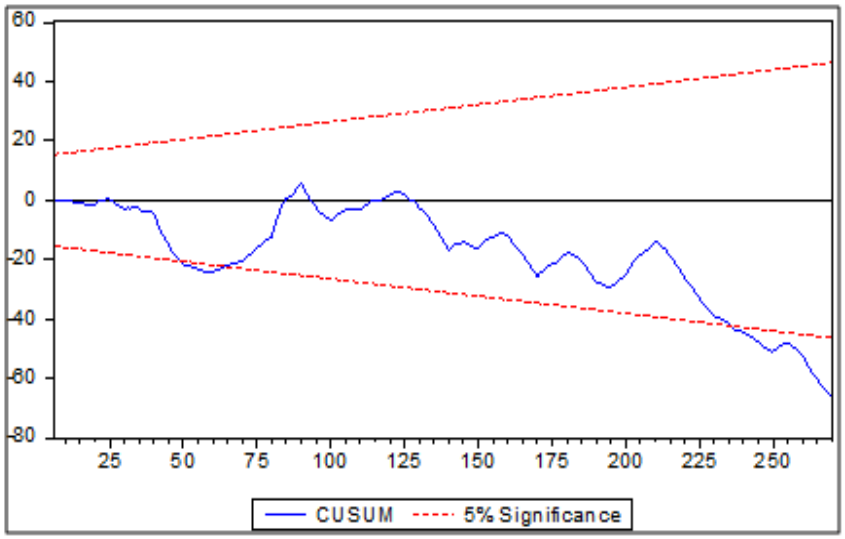


Table 9: Additional tests and robustness checks for RPSE

Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			94.75471	0.0000
Heteroskedasticity Test: Breusch-Pagan-Godfrey			28.17543	0.0000
LM test			427.6292	0.0000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
C	3.458138	NA	VIF<10	No interconnectivity of independent variables
CFP	0.338862	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	0.002849	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	0.131841	1.839002	VIF<10	No interconnectivity of independent variables
CRM	0.003431	1.967084	VIF<10	No interconnectivity of independent variables

CUSUM test

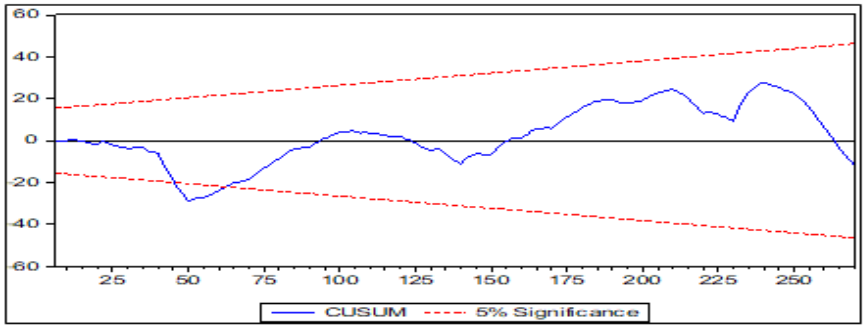


Table 10: Additional tests and robustness checks for EID

Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			0.242279	0.6230
Heteroskedasticity Test: Breusch-Pagan-Godfrey			17.8176	0.0000
LM test			347.5038	0.0000
Multi-Collinearity test for initial equation	Coefficient variance	Centered VIF	Result analysis	Observations
C	37.24970	NA	VIF<10	No interconnectivity of independent variables
CFP	3.65008	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	0.03069	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	1.42014	1.839002	VIF<10	No interconnectivity of independent variables
CRM	0.03696	1.967084	VIF<10	No interconnectivity of independent variables

CUSUM test

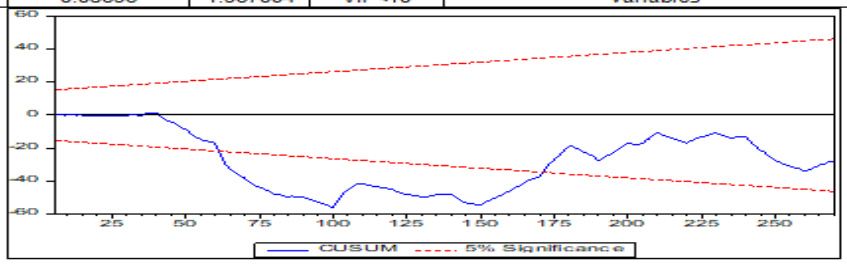


Table 11: Additional tests and robustness checks for EPH

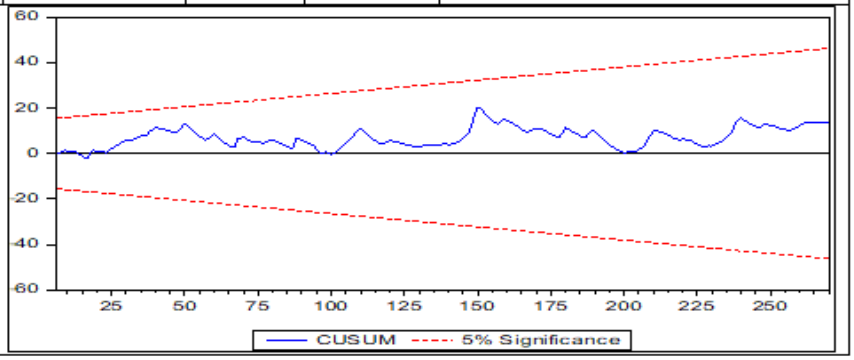
Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			10.72494	0.0012
Heteroskedasticity Test: Breusch-Pagan-Godfrey			2.576689	0.0380
LM test			65.9956	0.0000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
C	0.000385	NA	VIF<10	No interconnectivity of independent variables
CFP	3.77E-05	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	3.17E-07	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	1.47E-05	1.839002	VIF<10	No interconnectivity of independent variables
CRM	3.82E-07	1.967084	VIF<10	No interconnectivity of independent variables
CUSUM test				

Table 12: Additional tests and robustness checks for FCE

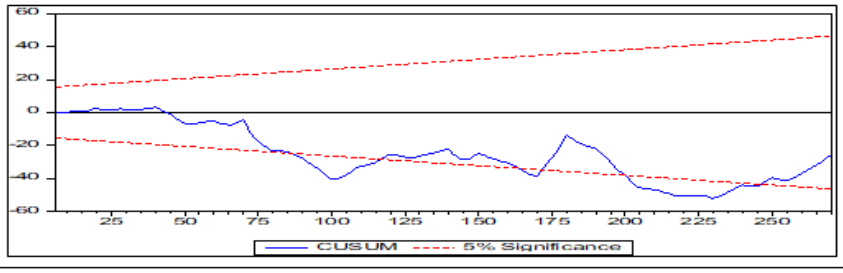
Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			40.596	0.0000
Heteroskedasticity Test: Breusch-Pagan-Godfrey			13.23708	0.0000
LM test			346.8124	0.0000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
C	1.54376	NA	VIF<10	No interconnectivity of independent variables
CFP	0.151272	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	0.001272	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	0.058856	1.839002	VIF<10	No interconnectivity of independent variables
CRM	0.001532	1.967084	VIF<10	No interconnectivity of independent variables
CUSUM test				

Table 13: Additional tests and robustness checks for SRE

Fact-finding checks			F - Statistics	P-value
Ramsey RESET -Stability test			0.116104	0.7336
Heteroskedasticity Test: Breusch-Pagan-Godfrey			4.255929	0.0024
LM test			307.7315	0.0000
Multi-Collinearity test for initial equation	**Coefficient variance**	**Centered VIF**	**Result analysis**	**Observations**
C	8.184884	NA	VIF<10	No interconnectivity of independent variables
CFP	0.802033	1.209064	VIF<10	No interconnectivity of independent variables
CMUR	0.006743	1.122739	VIF<10	No interconnectivity of independent variables
GVAEG	0.312048	1.839002	VIF<10	No interconnectivity of independent variables
CRM	0.008120	1.967084	VIF<10	No interconnectivity of independent variables
CUSUM test