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Forecasting Energy Poverty in European Countries: The Effect of Increasing Energy Commodities Prices

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Abstract: The impact of the global COVID-19 pandemic has been devastating in many countries, increasing household energy poverty. Lockdown measures have brought the EU economies into recession phases and forced people to stay confined to their homes, aggravating these issues. From the second half of 2021, when the worst seemed behind us, a new threat has appeared threatening economic recovery: the inflationary process in energy prices. This paper aims to verify the effects on energy poverty in European countries following the economic crisis generated by COVID-19 and the current inflationary scenario due to the increase in energy commodity prices through dynamic factor models, estimating the time it will take for energy poverty to return to levels before the shocks that occurred over the past two years. The outcomes show that the overall rise in energy prices (in particular gas) that unexpectedly affected European countries modifies the forecast scenarios, delaying, at best, the first improvements, initially expected as early as 2021, until after 2022.

Keywords: energy poverty; COVID-19 pandemic; EU energy prices; dynamic factors analysis

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1. Introduction

The lack of domestic energy services has been studied under the term "energy poverty" (or fuel poverty). It is assuming a central role in academic concerns and governmental agendas because of the negative impact on the population. Recently, multidisciplinary researchers have analyzed the effects of inadequate access to energy services on people's health and comfort, suggesting that energy poverty undermines an individual's well-being and social life [1–4].

Although energy poverty (EP) has been studied in low- and high-income countries, various research papers (e.g., [5]) show a dichotomy between accessibility and affordability. In low-income nations, energy poverty is mainly due to the lack of connection to the electrical grid (e.g., [6]). At the same time, in high-income countries, EP is meant as "a situation in which a household lacks a socially and materially necessitated level of energy services in the home" ([7]). It is mainly linked to energy affordability [8,9].

The economic recession following the COVID-19 pandemic, with the reduction in households' disposable income, has amplified, among other effects, the difficulties of European families in maintaining their homes in comfortable climatic conditions. The recent State of the Energy Union Report for 2021 [10] reported that approximately 31 million Europeans live in energy poverty. Therefore, less affordability could delay achieving one of the Sustainable Development Goals (SDGs), which is to ensure that everyone enjoys reliable, modern, and sustainable energy by 2030 [11,12].

Recently, Tundys and Bretyn [13] used a scenario approach, expert research, and mathematical–statistical tools to present possible scenarios related to energy transformation and the transition to renewable energy sources in economies. The authors indicate that these measures can change EP. The recent surge in energy commodity prices is expected to exacerbate the issue of energy affordability. This spike is driving up energy bills, increasing the share of households experiencing EP. Furthermore, the ongoing crisis arising from the conflict between Russia and Ukraine, coupled with international sanctions against Russia, is anticipated to elevate commodity trading prices for energy products, particularly gas, further. This escalation is likely to be reflected in retail tariffs, intensifying the impact of EP on households.

Given that approximately 50% of Europe's gas is imported from Russia, the surge in gas prices in the European Union (EU) will immediately and directly affect wholesale electricity prices. These electricity prices are closely linked to the short-term marginal costs of gas-fired power plants. Consequently, the increase in gas prices will disproportionately affect vulnerable households, and it is expected to have significant repercussions for a segment of families that were not previously considered vulnerable.

In response to the escalating prices of energy products, numerous European countries are taking measures to alleviate the impact, including supporting the most vulnerable households and selling portions of their strategic oil and gas reserves. Additionally, the anticipated decrease in gas supplies is reshaping the energy generation mix, raising the possibility that several European nations may reintroduce coal-fired power plants to meet the rising electricity demands of households and businesses. This shift, however, is expected to have consequences for the ongoing energy transition in European countries.

The EU has connected the issue of EP to the principles of "just and fair" energy and climate transitions. These initiatives aim to ensure that no one is left behind, while striving to reduce greenhouse gas emissions by 55% by 2030 and achieve climate neutrality by 2050. The overarching goal is to position Europe as the first "climate-neutral" continent, emphasizing the importance of inclusive and equitable measures amid the challenges posed by the changing energy landscape [14]. All these aspects, linked to an economic crisis that is affecting, among others, all European countries, require the need to forecast how much the business cycle and the inflationary process triggered by the increasing prices of energy commodities affect energy poverty in European countries, and to estimate how long it will take for energy poverty to return to the levels preceding the shocks that occurred in the last two years (health and energy commodity price crises). In a recent contribution, ref. [15] already studied the effect of the economic crisis following the COVID pandemic. However, one of the limitations highlighted in [15] concerns the assumption of a scenario of stable energy prices for the forecasts. While the pandemic's impact is rapidly waning, the global economy is dealing with rapid inflation—especially in the cost of oil and gas—and geopolitical upheaval generated by the conflict between Russia and Ukraine. This paper aims to add to the discussion about the repercussions of the business cycle and the recent inflationary trend in the price of energy commodities. What is missing from recent studies on the topic is consideration of the price reversal that has occurred in the energy market.

Therefore, to overcome this limitation and, at the same time, assess the effect of the energy and economic crisis on EP in European countries, the method already successfully implemented in the above contribution will be replicated, updating the data with the latest just released by Eurostat (February 2022) and adding the series of energy commodity prices following the projections released by the World Bank. The rest of the paper is organized as follows. Section 2 summarizes the method and data; Section 3 reports the estimates, while Section 4 presents the EP forecasts. Section 5 concludes the study and provides some meaningful policy implications.

2. Data and Methods

2.1. Data

Following various empirical papers (e.g., [15–21]), the outcome variable is the share of the population unable to keep their homes adequately warm, drawn from the EU Statistics on Income and Living Conditions (EU-SILC). Recently, some scholars (e.g., [21]) proposed a multidimensional measure of EP using a composite indicator. However, the proposed method is only useful for carrying out a comparative analysis across countries by estimating the ranking for each country and the possible variation over time, and does not give any empirical measure of the phenomenon that is the main aim of this paper.

Various factors, including socioeconomic factors and housing characteristics, interact with energy poverty in a complex manner [22]. The inability to keep a house adequately warm is considered a measure of energy poverty because it indicates a lack of sufficient financial resources to meet basic energy needs. In many contexts, household heating is essential to ensure the well-being and health of individuals, especially during the colder months. The explicative variables have been selected following the suggestions of EU Energy Poverty Observatory and the scientific literature [23,24], and other aspects (such as time span and data availability for the EU-MS). For the time span 2007–2020, 20 time series have been selected. Data descriptions are in Table 1, while the descriptive statistics are in Table 2. All data are from the Eurostat database.

Table 1. Data definitions of explicative variables (source: Eurostat database).

Eurostat Thematic Area	Dynamic Factor	Series	Description
Demographic and social conditions	psc	pop	Total population
		pov	% of population at risk of poverty
		educ	% of population with tertiary education (lev. 5–8)
		unemp	Unemployment rate
Energy	ene	ren_ sh	% of RES generation
		noren_sh	% of fossils generation
		ren_ele	Gross electricity production from RES
		noren_ele	Gross electricity production from fossils
		ei	Energy intensity (2010)
		imp_sh	Share of imports of fuels on total
		el_imp	Imports of electricity and derived heat
		imp_dep	Energy dependence: net imports/available energy
		opf_imp	Imports of solid fossil fuels—thousand tonnes
		elprice	Electricity prices for household consumers
		elprice_c	Electricity prices for non-household consumers
		en_cons	Final energy consumption
		inve_ren	Electricity production capacities for renewables
Living conditions	liv	arrears	% of population with arrears on utility bills
		hous_cos	Share of housing costs in disposable income
		hous_dep	% of population with severe housing deprivation

The variables used were grouped into three homogeneous areas: (i) demographic and social conditions (*psc*), (ii) living conditions (*liv*), and (iii) energy (*ene*).

Table 2. Descriptive statistics.

Time Series	Median	Standard Deviation	Minimum	Maximum
pop	9,742,867	23,657,074	534,237	81,572,146
pov	23.28	7.32	14.28	45.07
educ	24.43	6.76	13.25	36.11
unemp	0.45	0.07	0.38	0.72
ren_ sh	0.23	0.24	0.07	0.88
noren_sh	0.77	0.24	0.12	0.93
ren_ele	2142	7781	127	28,117
noren_ele	10,156	34,429	521	123,494
ei	156.39	90.10	75.17	466.21
imp_sh	0.13	0.05	0.07	0.26
el_imp	12,002	10,585	1352	46,127
imp_dep	51.18	23.29	−0.20	96.65
opf_imp	17,206	52,586	1701	182,163
elprice	0.15	0.05	0.09	0.29
elprice_c	0.12	0.03	0.09	0.24
en_cons	20.39	54.46	2.90	213.65
inve_ren	5826	19,179	452	80,307
arrears	7.23	8.54	2.25	31.18
hous_cos	20.64	5.11	14.48	36.23
hous_dep	4.43	6.03	0.74	23.06

2.2. Method

The Dynamic Factor Application (DFA [25]) was used to analyze the collected data in [15], and it has been applied in this work via an updated database (February 2022) to obtain a relatively small number of m uncorrelated common dynamic factors. The basic idea behind dynamic factor models is to represent observed variables as a linear combination of unobserved (latent) factors and idiosyncratic (specific) components. In dynamic factor models, both the factors and the loadings can evolve over time, capturing changes in the underlying structure of the data. This allows for a more flexible data representation compared to static factor models. These models are widely used in macroeconomics, finance, and other fields to analyze and forecast economic indicators, such as GDP growth, inflation, or asset prices. They provide a way to extract meaningful information from large datasets, reduce dimensionality, and improve forecasting accuracy by focusing on the common trends shared among the variables. We refer to this paper to describe and define the method used in explaining the three dynamic factors (one for each thematic area) that synthesize the exogenous information used in the model for 2008–2020.

2.3. Empirical Application

The DFA-estimated factors represent a latent country i-trend for each area, accounting for most of the variability in each group.

Furthermore, given that the factors capture a significant portion of the overall variability in the sets of variables from which they are derived, they were incorporated, with a one-year lag, into a panel analysis examining the determinants of EP. This analytical approach seeks to understand and evaluate the factors influencing EP by leveraging the summarized information provided by the lagged factors:

$$enp_{it} = \alpha_i + \sum_{j=1}^{3} \beta_j x_{it-1}^{j} + \gamma r_{it} + \mu \Delta p_{it} + u_{it} \quad (1)$$

where, for t = 2007, . . ., 2020, α_i are the country time-invariant fixed effects, x_{it-1}^{j} represents the three factors extracted (*psc*, *liv*, and *ene*), while the exogenous regressors r and Δp account for the business cycle and the inflationary, respectively, and u_{it} is the disturbance with zero mean. In the empirical implementation of Equation (1), we use the per capita gross domestic product (*gdp*) at market prices (2010 chain-linked volumes) as a proxy for the business cycle, and the purchasing power standard natural gas prices' yearly change ($\text{year}_t - \text{year}_{t-1}$; all taxes and levies included—Δ*gprices*) to detect the effects of the inflationary process on energy poverty.

3. Results

As is known, the dynamic factors resulting from the procedure are autoregressive, but they can also be integrated. For this reason, it is necessary to verify that they are stationary. To this end, we verify the integration order with two different tests: the panel data unit root test proposed by [26] and the cross-sectionally Dependent Panel Unit Root Test (CIPS) proposed by [27]. Cross-sectional dependency among EU countries may arise due to the effects of similar economic development efforts, governance structures, and environmental awareness.

Table 3 summarizes the test statistics used for the unit root tests proposed. Both tests confirm that the dynamic factors and the two exogenous variables are I(0), failing to accept the null.

Table 3. Panel unit root tests statistics.

Time Series	Levin	CIPS
psc	−4.702 ***	−2.812 ***
ene	−10.513 ***	−1.957 **
liv	−10.327 ***	−2.748 *
gdp	−11.124 ***	−4.457 ***
Δ*gprices*	−6.769 ***	−3.073 **

***: 99%. **: 95%. *: 90%.

Coefficients of the model are estimated using the within estimator with a homoscedastic consistence covariance matrix (Table 4). All coefficients are significant and in line with the expected results. The estimates were robust in terms of the slope of coefficients: the Wald-F test led us to reject the null hypothesis that the slope coefficients of the model were jointly equal to zero. Moreover, we tested for significant individual effects through the Breusch–Pagan Lagrange Multiplier Test (BP) and for the presence of cross-sectional correlation among countries through the average absolute correlation test. The results suggest that the null hypothesis of the absence of significant individual (country) effects cannot be accepted. At the same time, the BP test confirms the lack of cross-sectional dependence among countries.

Table 4. Fixed model estimates.

Variable	Coefficient	Std Error	*p*-Value
psc(t−1)	0.572	0.096	0.000
ene(t−1)	0.159	0.082	0.055
liv(t−1)	0.885	0.109	0.000
gdp	−0.333	0.061	0.000
Δ*gprices*	0.443	0.123	0.000
Model tests			
	Wald F		0.000
	BP		0.000
	Average absolute correlation		0.443

The signs and significances of the coefficients of the dynamic factors of the proposed model confirm the results previously obtained by [15]. This ensures the robustness and stability of the model in explaining the EP determinants. In line with previous findings from the literature, EP tends to decrease if energy policies are combined with social policies in the European nations [20], as confirmed by the positive and highly significant dynamic factor that summarizes the demographic and social conditions area (*psc*). Therefore, this factor arises from synthesizing variables that summarize the worsening of social conditions, inequality in access to services, and inefficiencies in the addressing of social needs for families, as shown by [28]. It is linked, among others, to the unemployment rate, population, and the share of the people at risk of poverty.

The coefficient of the dynamic factor associated with the energy area (*ene*) is also positive and significant. The indicator is derived from generation, prices, imports, and energy efficiency variables. Consequently, we have construed this factor as an indicator reflecting domestic energy demand. Recent shifts in climate patterns, particularly in southeast Europe, have notably impacted energy demand. Elevated external temperatures have heightened household vulnerability, resulting in an upsurge in energy demand [29]. Consequently, we interpret the direct and noteworthy correlation of the indicator with EP as an indication of households responding to their vulnerability by increasingly seeking indoor space cooling and air conditioning.

This trend, however, poses challenges, as heightened demand places additional stress on power grids and clashes with goals aimed at reducing carbon emissions. Scholars widely agree that the COVID-19 pandemic has intensified the difficulty of envisioning a low-carbon future, given the strain on efforts to align energy consumption with sustainability objectives [30–32].

The last dynamic factor, *liv*, summarizes three variables. It is in line with the outcomes of previous studies [22,33], and emphasizes the energy inefficiency of buildings, which is an essential determinant of EP for EU households.

Moreover, as previously suggested by [34], income is one of the key factors of EP.

Although the dynamic factors summarize many of the aspects related to energy poverty in European countries, the objectives of the present work remain to be considered, regarding how much the worsening of the economic conditions of the countries following the recent health emergency (one of the tangible aspects of the economic crisis caused by the pandemic was the severe contraction of GDP as a result of the adoption of mitigation measures introduced by the various countries, which led to closures or restrictions being imposed on economic activities) and the growth of electricity prices have increased the share of households in energy poverty, and, above all, what will be the dynamics in the coming years. For this purpose, both GDP at market prices (*gdp*) and gas price variation ($\Delta gprices$) are exogenous regressors. By employing this approach, we captured how EP responds to cyclical fluctuations marked by peaks and troughs. As anticipated, EP exhibited a countercyclical pattern. During periods of economic expansion, it displayed a trend of reduced numbers of households facing energy difficulties.

Conversely, the same indicator tended to increase during economic recession phases. On the other hand, energy prices are directly related to EP. Many of the latest studies revealing that EP can be a result of the rising energy prices both in EU countries [25] and worldwide [35] confirm the empirical result of this analysis, finding that a positive variation (increase) in prices leads to a growth in the energy poverty. From this perspective, we account for the positive and significant coefficient of the $\Delta gprice$ variable. This result is in line with the pre-pandemic analysis of [36], in which the results of a stochastic model used for energy poverty analysis at the country level showed energy poverty being associated mainly with income.

4. Forecasting Energy Poverty in European Countries

Having identified the factors that influence energy poverty, we want to verify, consistent with the aims of the paper, what the effect of the COVID-19 pandemic and the increase in electricity prices will be in the coming years.

For a generic year $t + h$, with h= 1,. . ., n, the expected value of EP, $E(enp_{t+h})$, is conditioned on the set of information, $E(\mathbf{X})$, that is available at time t.

$$E(enp_{t+h}) = \beta' E(\mathbf{X}) + E(u_t) = \beta' E(\mathbf{X}) \quad (2)$$

because $E(u_t)$ = 0 by construction.

The matrix **X** in Equation (2) includes the DF, which, by construction, is autoregressive, the level of GDP and the natural gas price yearly changes, accurate forecasts of which are provided for the former by the EU and for the latter by the World Bank. In this section, using these, we process a medium-term forecast (until 2025) on the expected levels of energy poverty related to modified economic and inflationary frameworks for coming years.

4.1. The World Bank and International Monetary Fund (IMF) Medium-Term Scenario

The October 2021 IMF World Economic Outlook (WEO) predicts that, despite mounting headwinds, the EU economy will keep expanding over the forecast horizon. Most Member States are expected to reach the pre-pandemic volume of output by the end of 2021, while a few others will fully recover in 2022.

The 2025 medium-term outlook for the European countries given by the IMF (Source: https://www.imf.org/en/Publications/WEO/weo-database/2021/October—accessed on 10 January 2022) is forecast to continue to pick up moderately. In fact, in 2021, increase in GDP by 5.1% is expected, with 4.4% in 2022 and 2.3% in 2023 (the latest projections unfortunately do not take into account the effects of international sanctions imposed on Russia), with these growth levels expected to settle by 2025. Nevertheless, the pace of recovery is expected to vary considerably across the EU. The extent of the impact of the pandemic differs among countries, with some experiencing more severe consequences than others. Additionally, certain nations are more reliant on sectors such as tourism, which are likely to persist in a weakened state for an extended period. This diversity in the recovery landscape will also influence the trajectory of EP. After experiencing an increase in 2020, with varying degrees of intensity among countries, EP is projected to decrease, but the speed of this decline will differ significantly among nations.

While economic growth, based on the evidence from the model analysis, is an encouraging factor as regards the expected rates of EP, the other side of the coin that is less encouraging, but which still fits with the model's evidence, is that expected price growth will negatively affect expected levels of EP. The commodities price forecasts for natural gas provided by the World Bank predict in European countries an increase in prices, which, in the years examined, was very steady from 2019, at about 340% until 2021 (it is expected that the price will move from USD 3.2/mbtu to USD 14.6/mbtu) (https://thedocs.worldbank.org/en/doc/ff5bad98f52ffa2457136bbef5703ddb-0350012021/related/CMO-October-2021-forecasts.pdf—accessed on 10 January 2022). This increase will slowly be reabsorbed starting from 2025, at which point the price will still be expected to be more than twice as high as in 2020 (Figure 1). Several factors contributed to the rise in commodity prices in 2021: supply chain disruptions and the positive decline in demand for commodities as consequences of the COVID-19 pandemic are among them. Other factors include the fiscal stimulus proposed by governments, expansionary monetary policies of central banks in many countries, and extreme weather events, such as droughts, floods, and fires. These events have occurred in various parts of the world, affecting agricultural production and causing disruptions in the supply of crops such as grains and oilseeds. This is compounded by speculative trading in commodity markets by investors seeking higher returns.

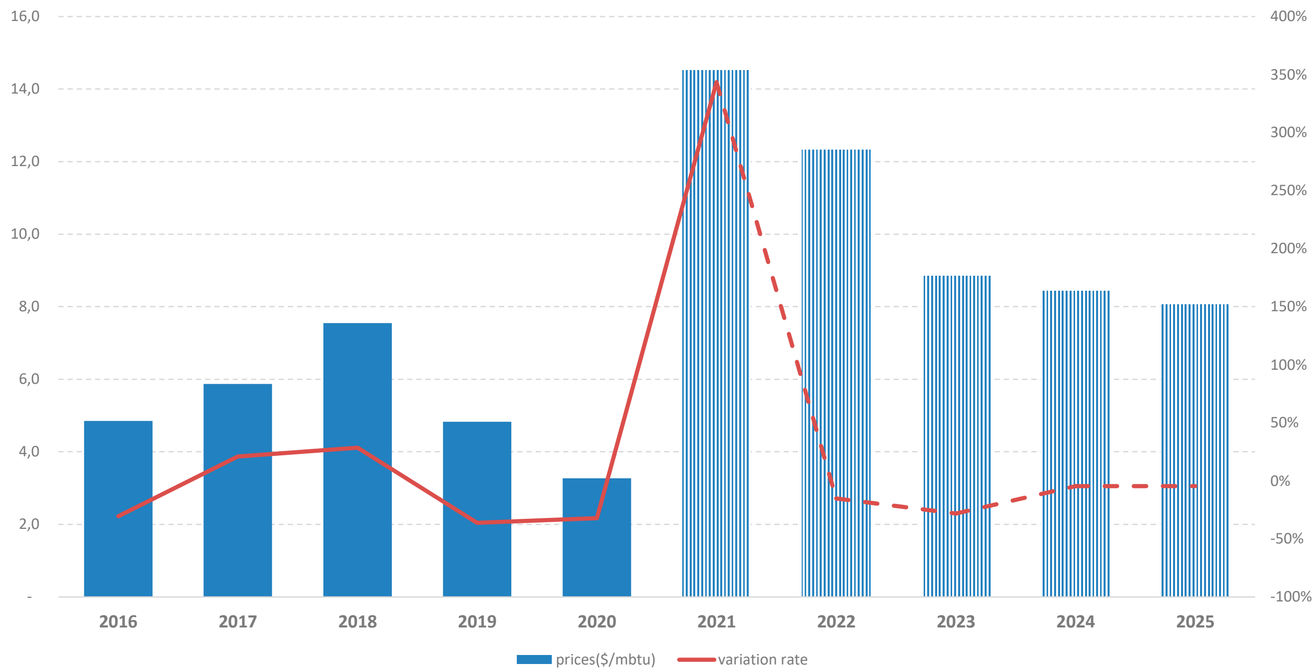

Figure 1. World Bank Commodities Price Forecast (constant USD). Source: World Bank Commodity Markets (October 2021)—price forecasts for natural gas, 2021–2025 forecasted values.

4.2. Forecasting Energy Poverty

The expected levels of EP for 2025 can be obtained by estimating the expected values (from t = 2022 to t = 2025) of the dynamic factors via a stepwise procedure. In the first step, using all the observed variables (until 2020), we can obtain the expected EP values for 2022;

$$E(y_{2022}) = c + \varphi x_{2021}$$

In the second step, the one-year-ahead predicted values of dependent variables, along with the predicted values from one year before the regressors, are used to add another observation to the dataset to obtain the expected EP values for 2021, and so on:

$$E(y_{2023}) = c + \varphi E(x_{2022})$$
$$\ldots$$
$$E(y_{2025}) = c + \varphi E(x_{2024})$$

The procedure stops when the expected EP values for 2025 are obtained.

The stepwise predictions of 2022–2025 dynamic factors, the GDP forecasts, and the price variation rates projected by the World Bank are the predicted exogenous regressors ($\widehat{\Delta gprices}$ and $\widehat{gdp}$) used to cast forward the expected values of EP through the panel model coefficients estimated with Equation (1):

$$\begin{aligned} E(enp_{i2022}) &= \alpha_i + \beta_1 E(psc_{i2021}) + \beta_2 E(ene_{i2021}) + \beta_3 E(liv_{i2021}) + \gamma \widehat{gdp}_{i2022} + \mu \widehat{\Delta gprices}_{i2022} \\ &\vdots \\ E(enp_{i2025}) &= \alpha_i + \beta_1 E(psc_{i2024}) + \beta_2 E(ene_{i2024}) + \beta_3 E(liv_{i2024}) + \gamma \widehat{gdp}_{i2025} + \mu \widehat{\Delta gprices}_{i2025} \end{aligned} \quad (3)$$

Table 5 shows medium-term forecasts (to 2025), restricted to the minimum estimated positive value. They are expressed in terms of differences between the predicted and pre-pandemic (2019) observed values. Figure 2 plots a synthetic comparison between the medium-term forecasts (t = 2025) and the pre-pandemic observed values of the EP indicator (t = 2019).

Table 5. 2022–2025 medium-term forecasts.

	2022	2023	2024	2025
Austria	−2.78	−4.53	−1.04	−1.22
Belgium	0.22	−1.46	0.61	0.21
Bulgaria	9.13	7.86	13.47	13.49
Croatia	−3.67	−6.15	0.07	0.15
Czechia	−1.69	−3.94	0.81	0.60
Denmark	−5.43	−8.24	−3.49	−3.92
Estonia	−2.88	−4.55	−0.58	−0.99
Finland	−5.10	−7.96	−2.90	−3.16
France	−3.06	−4.70	−0.92	−1.33
Germany	−1.64	−3.46	0.00	−0.19
Greece	3.79	1.43	4.70	4.52
Hungary	−0.27	−2.77	2.88	2.71
Ireland	−8.26	−9.98	−7.37	−7.86
Italy	1.63	0.77	3.25	4.06
Latvia	4.13	2.60	6.29	6.63
Lithuania	−1.90	−4.13	0.50	0.60
Luxembourg	−5.26	−7.24	−5.19	−5.94
Netherlands	−5.28	−7.68	−3.72	−3.86
Poland	−1.75	−4.41	2.89	3.09
Portugal	1.65	−0.05	4.63	4.93
Romania	−1.40	−4.22	3.12	3.27
Slovakia	−6.27	−8.89	−3.65	−3.86
Slovenia	−2.94	−5.32	−0.39	−0.58
Spain	−2.11	−3.95	−0.21	−0.36
Sweden	−4.09	−6.44	−2.34	−2.69
United Kingdom	−1.62	−3.76	−0.53	−0.92

Figure 2 and Table 5 show that, in all European countries, the pandemic’s impact and the increase in energy prices will worsen conditions for European households; moreover, forecasts suggest that the amount of households in fuel poverty will increase, albeit at different rates. In 2022, a generalized decrease in EP was expected, by about 1.8 percentage points. This decrease would have been in line with the expected price dynamics. However, the average scenario outlined, of course, is not the same for all countries, and the picture looks very heterogeneous; in countries like Bulgaria, Italy and Greece, EP will continue to rise from 2022, and until 2025, no recovery to the pre-pandemic level (2019) is expected. This evidence is most clearly depicted in Figure 2, where it is evident that only a few countries are above the bisector (Ireland, Denmark, Holland, Sweden, and Slovakia), which means that only a few countries will be at lower EP levels than before the pandemic. On the other hand, countries such as Bulgaria, Hungary, Latvia, Poland, and Italy will suffer more from energy poverty; in these countries, at t = 2025, an increase from 4 to 15 percentage points of households reporting that they are unable to maintain adequate climate conditions in their homes is expected.

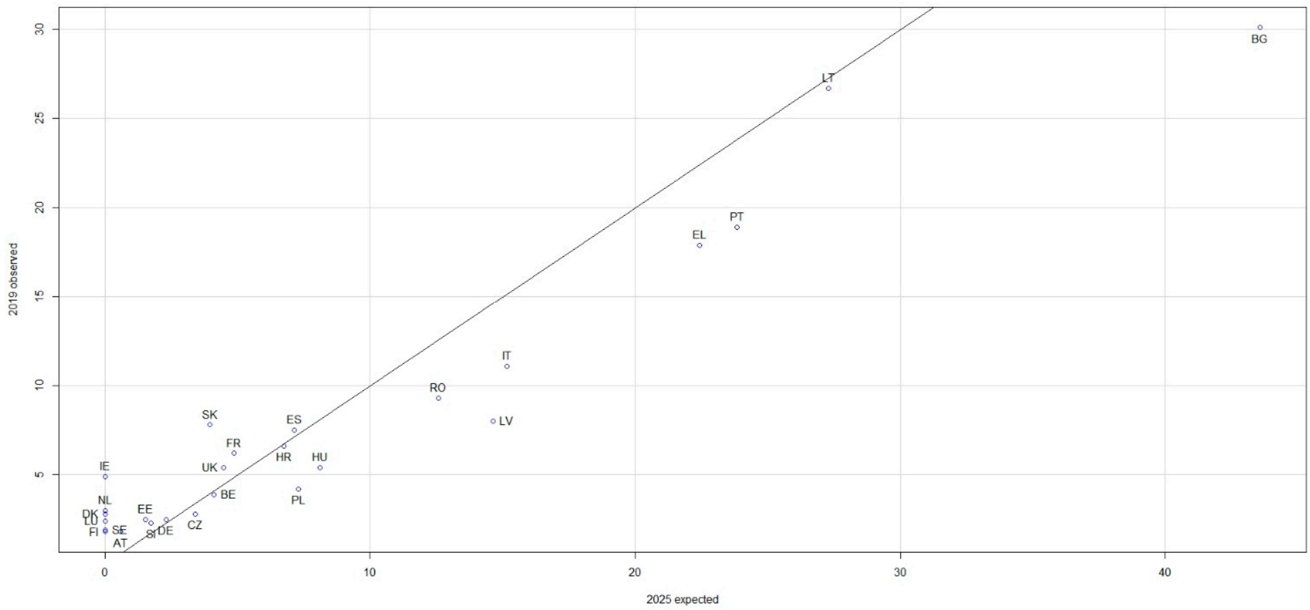

Figure 2. 2019 vs. 2025 (expected) EP levels.

Comparing these results with those obtained in the recent study by [15], it can be observed that, due to the inflationary process of energy product prices, the share of households in energy poverty will increase significantly, worsening the already evident distress linked to the health crisis. While the previous study showed that, some countries would have been able to return to pre-pandemic levels as early as 2023, the inflationary process has caused a further increase in distressed households, and no improvement is expected before 2025. The uncertainty linked to economic recovery, and the substantial increase in the cost of electricity due to the rise in raw materials and the uncertain dynamics related to the current geopolitical context, highlight the weakness of the European supply system and the excessive price sensitivity, which strongly affects the final consumer, risking aggravating the situation further and triggering a spiral that leads to the progressive deterioration of the purchasing power of households and an increase in the share of households in conditions of energy poverty.

5. Conclusions and Policy Implications

The global crisis triggered by COVID-19 has devastated numerous countries, leading to a rise in energy-poor households. This surge is attributed to the deteriorating economic, social, and energy conditions witnessed during the pandemic. Stringent lockdown measures have pushed EU economies into recessions, significantly affecting employment levels and household spending capacity. Although the immediate effects of the pandemic are now diminishing, the global economy is entering a new phase of uncertainty marked by the inflationary surge in energy commodity prices initiated in the second half of 2021. This inflationary trend threatens the anticipated economic recovery, as predicted by international financial organizations.

In light of these circumstances, this paper aims to contribute to the ongoing discussion about the repercussions of the business cycle and the inflationary trends in energy commodity prices, represented by gross domestic product and gas prices, respectively. The focus is on examining their impact on EP in European countries, building upon the work done by [15].

The analysis validates concerns that the economic and price crises will exacerbate energy poverty in European nations. The recovery from the current economic, social, environmental, and energy deterioration is anticipated to be gradual and uneven across countries. Forecasts indicate that Bulgaria, Greece, Lithuania, and Portugal will experience the most severe consequences in terms of EP. Conversely, countries with less dependence on gas-fired generation plants are expected to absorb the price shock swiftly. Notably, Ireland, Slovakia, the Netherlands, and Sweden are projected to witness an improvement in EP conditions in the short term. These countries boast a diversified energy mix, incorporating traditional thermal generation plants alongside nuclear and renewable sources. The diversification of generation sources emerges as a crucial lever for mitigating the impact of exogenous shocks.

Households across Europe are facing the most significant increase in energy prices since World War II. The peak expected in 2022 is due to a global surge in wholesale power and gas prices. These have sky-rocketed due to (i) low gas storage levels, (ii) the carbon price increases in the EU, (iii) the lower supplies of Russian and Asian gas than usual (which suppliers have also moved into other Asian markets with increasing demand) and (iv) the numerous infrastructure outages.

The recent conflict between Russia and Ukraine and international sanctions have triggered widespread concern, leading to an oversupply panic from Europe's primary natural gas provider. This conflict adversely affected economic growth in the first half of 2022, contributing to an increase in inflation. The primary transmission channels for these effects include escalating commodity prices, diminished trade with Russia due to international sanctions, and a shock to consumer and business confidence. With Russia supplying approximately 16% of global natural gas and 11% of oil, concerns regarding a supply shortage have driven up oil and other energy commodity prices.

The war in Ukraine has further implications, as it has seen the halting of the progress of the new Nord Stream undersea pipeline from Russia to Germany, which could have potentially mitigated price increases. Presently, benchmark gas prices in Europe are projected to surge by 330% in 2022 compared to 2021. The short-term scenario of the natural gas future indicates a sharp rise, with a target of USD 5.882/BTU. Expectations, however, suggest a continued increase in the curve, reaching up to USD 6.356/BTU. Despite assurances from some suppliers of increased gas availability and attempts by European policymakers to diversify supplies by reducing reliance on Russia, shifting to imports from other countries, and boosting domestic supplies, prices are not expected to decrease significantly in the coming years.

To curb this phenomenon, governments have announced measures and the taxation of extra profits for companies that are not suffering from the increase in upstream prices during the raw material supply phase or as subsidies, removing levies or VAT from bills and price caps. Countries such as Italy and the UK, which rely heavily on gas for heating, announced that they will introduce price caps on energy supply charges in 2022 to end what some have called the "rip-off" prices. However, these measures are unlikely to make an impact if they are taken in a spread out manner by individual countries. It is strongly recommended that supply and price control policies be decided at the community level to avoid imbalances between countries. However, all these measures will have repercussions.

With the implementation of these measures, there is a risk of weakening the contribution of energy generated from renewable sources, and of resources being taken away from different sectors of the economy. Therefore, there is a risk of slowing down both the progress of the energy transition that is being attempted with much effort, and the economic recovery, now that the projections regarding the end of the pandemic are more optimistic and could see benefits to households via reducing energy poverty conditions. This price upheaval in the energy market, which was completely unexpected until the first half of 2021, has had significant implications for energy poverty. Many households will be deprived of the opportunity to get a sufficient energy supply to keep their homes climatically adequate. For this reason, we have updated the model by including the changed exogenous contingencies that have arisen, inserting, for example, one that took into account the expected inflationary process.

With this in mind, the results of this upgrade, which affect not only the qualitative dimension (with the introduction of a new exogenous factor) but also the quantitative one (with the extension of another year of observation), can guide policymakers in tackling energy poverty. The model preserves the ability to identify and describe the determinants of energy poverty, along with its predictive accuracy and robustness in terms of the fulfillment of econometric requirements, but it also provides scenarios for the evolution of energy poverty that indicate that, in the medium term, the hardship for European households will remain high.

Thus, new policy measures are necessary, especially for countries wherein EP was already structurally prevalent, and for those whom previous forecasts indicated would be in worse conditions in the medium term than in the pre-pandemic phase.

A first step that could be taken is linked to the diversification of the generation option, which will reduce European countries' energy dependence by enforcing Administrative Simplification requirements and outlining considerable support measures for new investments in renewable sources. Policymakers seem to be moving in this direction, promoting generation from renewable sources and reinvesting in nuclear energy.

For these purposes, an upgrade of the so-called "Recovery Plan" in light of the changing international energy landscape is needed, with part of the funds used to reduce households' energy bills and improve living conditions. The development of renewable energy to stimulate economic growth and reduce energy poverty within the next few decades has been proven to be the most effective method of promoting economic growth and reducing EP within a medium-term trajectory. We contend that numerous households in the EU suffer from inadequate insulation, a condition exacerbated by the effects of climate change. Addressing this issue requires a multifaceted approach that not only focuses on demand-side measures, but which also explores opportunities on the supply side. To help reduce the cost of energy, encouraging the use of green providers and promoting the utilization of green energy can play a pivotal role, ultimately making environmentally friendly options more appealing and reducing the reliance on fossil fuels.

However, the ongoing energy crisis and inflationary pressures pose risks to the new post-COVID-19 era. Stimulus measures, if not carefully guided and considered, may fall short of approaching the underlying causes of the inflationary process disrupting the energy price system. Moreover, there is a risk of these measures running counter to sustainability goals seeking to combat climate change and eliminate unsustainable practices. Striking a balance between economic recovery and environmental sustainability is crucial to avoid unintended consequences and to ensure a resilient and sustainable post-pandemic era.

In this case, the adverse scenario envisaged in this study will have the most acute and severe consequences for the groups already emerging as the most vulnerable among European citizens.

Future research on energy policy forecasts could focus on several key areas, such as energy storage technologies, transportation electrification, and government strategies for reducing greenhouse gas emissions and adapting to climate impacts. These will be helpful in addressing emerging challenges and opportunities in the energy sector, and will contribute to the development of evidence-based policies and strategies to address energy access disparities and promote energy equity.

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