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Energy Poverty in Southern and Eastern Europe: Peculiar Regional Issues

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Abstract: Conceptual and methodological divergence in defining the issue of energy poverty (i.e. the inability of households to afford adequate access to energy services) has made it difficult to assess the problem at a European level using a standardized approach. Moreover, existing research raises concerns with regard to socio-economic and environmental differences between European states that may have a significant impact on this phenomenon. The current paper builds upon a set of newly proposed econometric methods for the trans-national measurement of energy poverty and for the study of its determining factors – the Compound Energy Poverty Indicator. The research shows that Southern and Eastern European countries present peculiar socio-economic traits that distort the impact of predicting variables, such as the tenure status of households. The results imply that a cautious approach is needed when attempting to measure and predict energy poverty at a trans-national level based on macroeconomic indicators. Regionally specific policy measures and indicators may be needed in order to assess the problem in a truly functional, accurate and more efficient.

Keywords: energy poverty; Compound Energy Poverty Indicator; sustainability; tenure status

1. Introduction

Over the last decades, households throughout Europe (as well as other economically developed areas of the World) have been observing an increase in living costs. Based on data from Eurostat (2016a), an overall analysis of household consumption expenditures across the European Union (EU) shows a compound annual growth rate of 0.2% (EU-28 weighted average, with prices adjusted for inflation; per capita values are considered) between 1996 and 2012. This figure is the result of several factors, among which we consider to include the diversification of supply, the liberalization of markets and higher incomes.

However, over the same period, household expenditure with "housing, water, electricity, gas and other fuels" has increased at a rate of 1.2%. The figure jumps to 2.4% when considering only expenditure on "electricity, gas and other fuels". The result is surprising considering the fact that per capita demand for such utilities tends to remain stable over time, especially when compared to the consumption of services or various other goods (e.g. recreation). In fact, when looking at total residential consumption of energy over the period 1996-2012, the EU-28 consumption per capita had a compound annual growth rate of -0.6%.

This suggests that the cost of purchasing the energy to insure adequate living conditions in the EU has been rapidly increasing over the last two decades. Chester and Morris

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(2012) provide empirical evidence to show the link between energy price hikes and market liberalization in several countries across the globe. Furthermore, Fiorio and Florio (2013) demonstrate that a clear connection exists between some energy market reforms (such the privatization of state-owned companies) and an increase in prices within the EU.

Regardless of the reasons behind this phenomenon, it contributes to an increased prevalence of a socio-economic condition that affects households across the Globe: energy poverty (EP), also known as fuel poverty. The problem refers to instances in which households need to spend a disproportionately higher share of their income on energy services. Because it has received increased attention from researchers, the topic has become an integral part in energy market reforms and policies across the EU (Stefan Bouzarovski, Petrova, & Sarlamanovb, 2012; Liddell, 2012). This issue is not directly related to the concept of "poverty", although studies have shown that a strong correlation exists between material deprivation and energy poverty. The current work does not discuss the topic of 'energy poverty' in developing nations, in which case it would refer to a lack of access to modern electricity services.

As part of a previous study, we proposed a new method of measuring EP across the EU. After providing an assessment of EP, we sought to identify potential pressure factors that may lead to a higher level of EP. Some of the proposed variables demonstrated an unexpected relationship with the proposed EP indicator, such as the tenure status being negatively correlated with energy poverty (i.e. countries where people are predominantly home owners suffer from higher EP than countries where the population predominantly rents homes). These results, combined with the specific geo-historical context of Southern and Eastern (SE) European states, encouraged us to pursue a deeper analysis of the particularities of EP in these regions.

Thus, the aim of this paper is to provide an analysis and discussion of the peculiarities of energy poverty in Southern and Eastern EU member states. This is based on reviews of existing literature, a deeper look at the results of our previous cross-country analysis of EP and an analysis of some specific factors affecting poverty and energy poverty in these regions.

In Section 2 of the paper, several methods and issues regarding the measurement and definition of EP are discussed based on existing literature and examples. The final subsection provides an overview of the construction and implementation of a newly developed measure of EP applied at the EU level by the authors: the Compound Energy Poverty Indicator (CEPI). In Section 3, discusses several issues and circumstances specific for SE European countries, which need to be taken into consideration when assessing the issue of EP at an overall EU level. Next, the peculiar results of the CEPI analysis are presented and possible implications and solutions are proposed. These discussions provide the academic added value of the current paper and complement the existing research connected to CEPI – paving the way for a more accurate and streamlined method for generating high-level assessments of EP at the European level. Finally, Section 4 provides a conclusion for the study.

2. Defining and measuring energy poverty across the EU

2.1. The energy poverty threshold and 'vulnerable consumers'

EP is a complex socio-economic problem that is proving difficult to outline. The essential question that researchers and policy makers are seeking to answer is: "what constitutes an energy poor household?" As discussed above, EP, as it is understood today, refers to instances in which a family 'needs to spend a disproportionately high share of their income on energy services'. But establishing with sufficient precision what "needs", "disproportionately high" and even "income" mean has been a controversial issue.

In order to determine whether a household is suffering from EP, a certain threshold needs to be set, below which EP is considered to exist (similar to the concept of a 'poverty line'). But the complex nature of the problem makes it difficult to provide such a clear-cut reference. Among the first proposals for defining EP is the one provided by Isherwood and Hancock (1979) "households with high fuel expenditure as those spending more than twice the median (i.e., 12%) on fuel, light and power", where the median refers to the fuel expenditure of the United Kingdom (UK) households. In her extensive studies on the topic, Boardman (1991) proposed a definition which became widely accepted and was used in designing EP abatement policies in the UK. Similar to the one provided by Isherwood and Hancock (1979), the Boardman definition considered households which spent more than 10% of their income on all energy services as being fuel poor (the 10% threshold was established based on the same 'twice the median expenditure' reference point). One of the limitations of such a definition is that those who cannot afford to purchase all the energy that they need may decide to restrict their consumption of lighting or heating below a level that would be considered acceptable from a social and human health standpoint. For this reason, the notion of '*need* to spend x% of income', rather than simply 'spend x% of income' was included in the UK policies on EP. However, even the concept of *need* can vary from one community to another (and especially among countries), based on what kind of living conditions are considered socially acceptable or normal.

Further research showed several problems that may arise from using the above mentioned definition and numerous revisions or alternatives were proposed. These include the exclusion of housing costs (e.g. rent, maintenance) from income (as these costs are not optional and cannot be substituted), the use of equivalized incomes, the use of budget standards or the use of household expenditure rather than income. A more widely accepted definition was proposed by Hills (2012), which considers households to be suffering from EP if their required fuel costs are above the national median and if spending that amount would result in a residual income (after housing costs) that is below the official poverty line. More extensive discussions on the various definitions and their limitations are provided by Heindl (2013), Hills (2012) and Moore (2012).

From a policy standpoint, the issue of EP has become increasingly more relevant for governing authorities across the EU (Maxim et al., 2016). Many policy reports and directives regarding energy markets do address EP and include specific goals for protecting 'vulnerable consumers'. However, the term itself is not explicitly defined (this task is left up to each member state), so it is not clear if all households that are affected by EP are covered by it. Thus, without the adoption of an objective energy poverty

threshold that is applicable and accepted across the EU, EP may be assessed differently from one country to another and the term 'vulnerable consumers' may understandably vary significantly among member states (since it can include households affected by other types of locally specific socio-economic risks).

2.2. Methods for measuring energy poverty

In the absence of a clear and effective definition of 'energy poverty' and/or 'vulnerable consumer', policies that seek to reduce the phenomenon of EP cannot be effective. Clarity is required in order to allow policymakers to better target the problem and quantify the effectiveness of policy implementation. Several specialists in the field, including Dubois (2012), provide discussions on the difficulties of identifying fuel poor households and the need for accurate targeting in order to achieve a successful implementation of abatement policies. The existing body of literature on this topic relies on methods which could be largely grouped into four categories (Maxim et al., 2016; Waddams Price, Brazier, & Wang, 2012): objective measures, subjective measures, direct monitoring and macro assessments.

Objective measures of EP rely on the use of a pre-defined energy poverty threshold (such as the ones discussed in the previous section). Due to the fact that energy poverty measurement research conducted outside of the UK and Ireland is predominantly exploratory, 'comparative' objective assessments seem to be one of the most common approaches used. These are based on analyses of data regarding household energy expenditure and income patterns collected from secondary sources. Energy poverty is defined and measured according to several definitions, most of which are selected from the set discussed in Section 2.1. The resulting EP figures at the national level are then compared across definitions and adequate policy measures are then proposed. When possible, researchers also assess the structural distribution of the problem (usually based on socio-demographical data, if available). This is done in order to provide a qualitative assessment of whether a certain definition is effective in the local context, but also to help improve the targeting and identification of energy poor households (Heindl, 2013; Maxim et al., 2016; Sergio Tirado Herrero & Ürge-Vorsatz, 2012).

I an officially accepted definition and measurement of energy poverty does exist in Great Britain. Given the ongoing debate regarding the establishment of a revised definition, some UK focused comparative assessments have also been conducted in order to add scientific arguments to the discussion (ACE, CSE, & Moore, 2012; Stefan Bouzarovski, 2014; Moore, 2012). However, in spite of the criticism, the high cost/low income definition proposed by Hills has become an official reference for the UK government (GOV.UK, 2016).

An alternative approach in measuring EP involves the use of self-reported subjective assessments made by the households themselves. A subjective measurement is obtained in the form of 'EP proxy indicators' by directly asking residents, for example, whether they feel that they can afford to purchase a sufficient amount of energy services in order to cover their cooking, lighting and environmental needs (heating and/or cooling). Survey data, such as that provided by the EU-SILC (Eurostat, 2016b) or the Eurobarometer, can be used to provide an overview of national levels of EP that can be directly compared across European countries. Subjective measures are affected by the limitations specific to all survey studies

(including reliability issues). However, they do have some specific advantages, such as cross-country comparability (for large standardized surveys) and a potential for a higher effectiveness in identifying EP compared to objective measures, as discussed by Maxim et al. (2016). In addition, the use of microdata can help identify the degree of EP affecting households within each country (e.g. unable to afford sufficient energy for adequate heating, cooling as well as cooking vs. not being able to light the home satisfactorily).

Direct monitoring of living conditions are mentioned by Stefan Bouzarovski (2014) and rely on active measurement of light levels and temperatures in the home over a period of time and comparing them to acceptable standards. By collecting data from samples of representative households in various geographical areas across a region or country (as suggested by Dubois (2012)), the approximate level of intensity and incidence of EP can be estimated. While this approach could yield the most objective, precise and concrete measurement of the phenomenon, the logistical requirements for the successful implementation of such a study make it very unlikely to be adopted by researchers and policymakers at a large scale.

Finally, in order to gain high-level understanding of the issue at a national level, a multidimensional macro assessment can be conducted. Such an analysis would be based on a set of diverse macro indicators (e.g. social, economic, technical, medical etc.), serving as proxies to be combined as part of a multifaceted measurement of EP in a specific country or group of countries. This type of approach outlines the problem from various perspectives, an outcome that can prove to be useful given the cross-sectorial impact of EP. Examples of studies using this method are provided by Chester and Morris (2012), Sergio Tirado Herrero and Bouzarovski (2014) and Wang, Wang, Li, and Wei (2015).This method does not incur high monetary or temporal costs, as it makes use of readily available statistics and other secondary data. However, its accuracy in measuring EP (in the traditional sense) is expected to be limited.

2.3. The Compound Energy Poverty Indicator (CEPI)

In a recently published study on the measurement of EP across the EU, we proposed an improved aggregate indicator that gauges the phenomenon through a uniform approach across EU members as well as some neighbouring states (Maxim et al., 2016). CEPI relies on a mixed subjective-macro approach (using the terminology discussed in Section 2.2). It combines a set of proxy indicators of EP, as exemplified by previous literature, as well as our own investigations into available datasets. Several of the indicators used were also identified in a report by Pye et al. (2015).

The principal added value of CEPI is that it provides a consistent way of assessing and comparing EP across Europe. It builds upon similar attempts in the past and represents a first step in designing a facile and uniform measure of energy poverty that can be used in cross-sectional, as well as time series and panel analyses (depending on data availability). CEPI is calculated as follows:

$$CEPI = (0.3 \times \textit{Not warm} + 0.2 \times \textit{Not cool} + 0.1 \times \textit{Dark} + 0.2 \times \textit{Arrears} + 0.2 \times \textit{Leaks}) \times 100 \quad (1)$$

where,

Not warm – percentage of people unable to keep their homes adequately warm

Not cool – share of population living in a dwelling not comfortably cool during summer time
Dark – share of population considering their dwelling as too dark
Arrears – percentage of people having arrears in utility bills
Leaks – percentage of people living in a home with a leaking roof, or the presence of damp and rot (poor quality dwellings are less efficient, requiring more energy, which contributes to EP)

Each of the five proxy indicators is given a weight based on its impact on EP and on the households' quality of life. A detailed explanation and further arguments regarding the construction of CEPI is provided in Maxim et al. (2016).

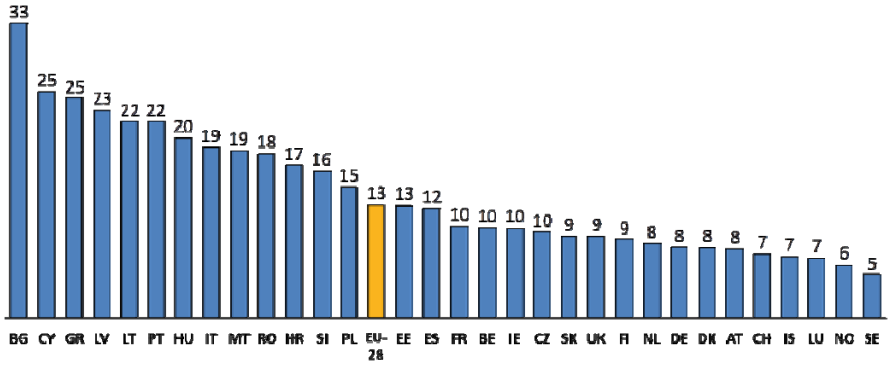

Figure 1: *EP across Europe based on the Compound Energy Poverty Indicator*
Data source: Maxim et al. (2016)

CEPI shows that EP is more prevalent in Eastern and Southern Europe, with Bulgaria being the most affected country and Sweden the least (Figure 1 – data refers to 2012). This result should be observed while taking into consideration the limitations that we have flagged regarding the current version of the aggregate indicator. We proposed that a revised version could be adjusted to take into consideration different weights for *Not warm* and *Not cool* (based on the country or region) as well as the average lifecycle costs of implementing heating, cooling and lighting solutions over a predetermined period.
In addition to measuring EP using CEPI, our study also sought to identify specific variables that are likely to amplify the problem in the future, entitled 'CEPI pressure factors'. The pressure factors were used to create a linear regression model for CEPI. The data for some of the variables was collected directly from existing databases, while others were computed using our own proposed methodologies, as discussed in detail in Maxim et al. (2016). The initially proposed CEPI pressure factors were:

- **Tenure Status** (*Tenant*) – gauges to what extent the population of a country is composed of tenants paying rent at market or reduced prices, owners with a mortgage or outright owners; figures closer to 0 indicate that the population predominantly owns their dwelling, while figures closer to 1 indicate a high incidence of tenants; EP is affected by tenure status as renters are unlikely to want to invest in improving the energy efficiency of their homes, while owners with mortgages may lack the financial means to invest in such improvements.

- **Type of Dwelling** (*Dwelling*) – shows the predominance of detached houses vs. flats within the housing stock; it was hypothesized that collective dwellings composed of flats are more energy efficient as they are less exposed to heat losses compared to independent dwellings.
- **People at Risk of Poverty or Social Exclusion** (*RiskPov*) – indicates the percentage of people living in poverty, material deprivation or low work intensity households; a high risk of poverty or social exclusion is likely to be correlated with a higher risk of energy poverty.
- **Heating System Efficiency** (*RoomHeat*) – shows the proportion of the population using room heating systems, as opposed to centralized or collective systems; the risk of energy poverty increases when less efficient systems are utilized.
- **Residential Consumption of Energy** (*Cons*) – shows the yearly residential consumption of all energy forms per capita at the national level; higher values may indicate an increased risk of energy poverty when confronted with energy market price volatility.
- **Affordability of Energy** (*Afford*) – an additional original contribution of our previous study, this newly proposed indicator calculates how many units of energy (in the form of electricity and/or natural gas, depending on the country) can be purchased by an average equivalized household income in each state; higher values are expected to be associated with a lower EP risk, as the financial inability to purchase sufficient energy is the core definition of energy poverty.

Of the six hypothesized pressure factors, only *RiskPov*, *RoomHeat*, *Cons* and *Afford* were included in the regression model. *Dwelling* was excluded due to a lack of correlation with CEPI, while *Tenant* was not included in the model because it was negatively correlated with CEPI (contrary to the theoretically expected outcome). It is this result that prompted a deeper analysis of our data, which pointed out that the socio-economic context affecting EP is different in SE Europe compared to the rest of the EU. The results are explored and discussed further in Section 3.2.

3. Regional issues when measuring energy poverty

3.1. Particularities in Southern and Eastern Europe

As discussed in the previous sections, while there is a need for a common EU wide approach in studying and alleviating energy poverty, the definition and the implementation of policies regarding this issue may need to have a national or a regional scope – a view that is supported by several experts (Stefan Bouzarovski et al., 2012; Liddell, Morris, McKenzie, & Rae, 2012; Sergio Tirado Herrero & Bouzarovski, 2014). This is due to the specific meteorological, historical, energy and economic context of each country.

A relevant discussion on this issue is provided by Stefan Bouzarovski (2014) who points to the particularities of energy poverty in Mediterranean countries. Aside from the lack of adequate heating systems, a major problem in countries such as Greece, Portugal and Spain seems to be the residential housing stock. Very few dwellings in Greece and fewer in Portugal are equipped with basic energy efficiency features such as cavity wall, floor or roof

insulation. In addition, leaking roofs is another problem affecting a relevant portion of Mediterranean households.

Going beyond the housing problem, the warm climate of Southern Europe brings into focus an issue that was mentioned in Section 2.3: the need to cool homes during periods of high atmospheric temperatures. While the winter season tends to be milder, the peak air temperatures during the summers of 2014 and 2015 have repeatedly surpassed 42°C in Spain (AEMET, 2015; NOAA, 2016) – a situation that generates significantly different energy needs for the population of Southern Europe compared to the UK or Ireland.

It should, however, be noted that the absence of an air conditioning or similar solution (such as special insulation materials) in hot areas of Southern Europe does not automatically indicate that a household is energy poor. When using subjective measures, such as that illustrated by the *Not cool* component of CEPI, people are considered to be affected by EP only if they feel that their home cannot be kept comfortably warm. If a household which lacks air conditioning or other alternatives feels healthy and reasonably comfortable even during the warmer days of summer, they are not catalogued as energy poor. Alternatively, when using objective measures, such as the home temperature standards recommended by the World Health Organization of 18-24 °C (Ormandy & Ezratty, 2012), people are automatically considered to be energy poor if they surpass the threshold – a situation that is fairly common in Southern and South-Eastern Europe.

The regional particularities of energy poverty can also be observed by looking at the case of post-communist countries from Central and Eastern Europe. From the perspective of climate, many of these states can be affected by particularly cold winters, which can create serious problems for households that are unable to afford adequate heating. In addition, periods of high temperatures (over 35-40 °C) during the summer in countries such as Romania, can put additional pressure on energy expenditures as people try to maintain an acceptable level of thermal comfort.

However, a factor that has had an overall significant impact on energy poverty in Eastern Europe is the post-communist path dependence in the areas of energy services, energy markets, the quality of the housing stock and tenure status. With regard to energy services, there is a relatively high incidence of district heating plants that are inefficient and pollutant by current standards. These offer heating services that are able to provide households with sufficient energy, but at a high cost (Sergio Tirado Herrero & Ürge-Vorsatz, 2012).

With regard to energy markets, after the political changes that took place at the end of the 1980s, the heavily subsidized price of energy was gradually liberalized, along with the unbundling and privatization of state owned monopolies in the energy sector. These changes have had a significant negative socio-economic impact by affecting the price and the affordability of energy services (Stefan Bouzarovski et al., 2012; Chester & Morris, 2012; Fiorio & Florio, 2013; Sergio Tirado Herrero & Ürge-Vorsatz, 2012).

The housing stock in many post-communist countries includes numerous multi-storey apartment buildings (many of which are built from prefabricated components or panels) with limited insulation. These buildings are likely to contribute to the spread of energy poverty mostly among urban residents.

Another noteworthy characteristic of post-communist countries in Europe is related to the tenure status. State support in providing housing for large portions of the population,

combined with other cultural factors has resulted in Eastern European countries having the largest proportions of homeowners in Europe (as seen in Figure 2). Romania has the highest percentage of owners in Europe – over 96% of the population.

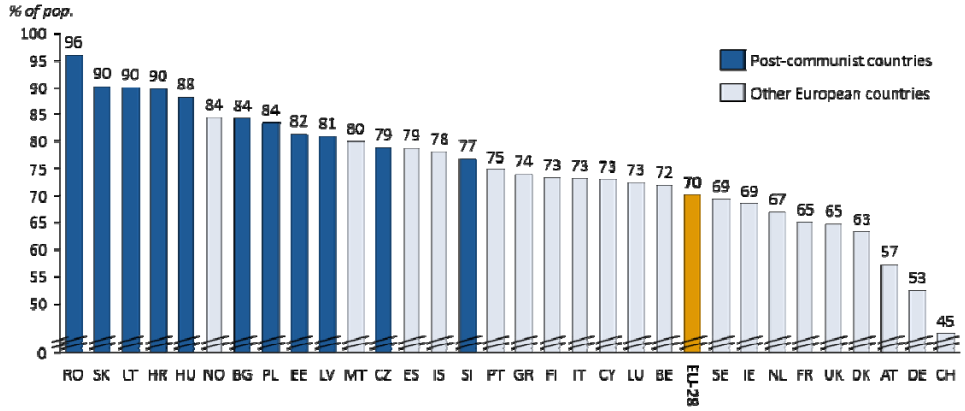

Figure 2: *Proportion of the population that owns their dwelling (status in 2014)*
Data source: Eurostat (2016a)

There are several socio-economic advantages and disadvantages that stem from this distribution of tenure status. However, with regard to energy poverty, our main hypothesis was that it may simplify overall policy design, considering that thermal rehabilitation directly benefits the persons living in the building, while landlords who rent a dwelling would need special incentives to invest in it. The tenure status may also allow for a smoother implementation of policies in the case of individual households (for the same reasons stated above), but may generate complications in the case of multi-apartment buildings, where the consent (as well as the financial contribution) of all owners may be needed in order to begin construction work. A deeper analysis into the CEPI pressure factors suggests that tenure status is a highly relevant (although indirect) predictor for EP.

It is clear that the factors contributing to energy poverty are determined by locally-specific socio-cultural, economic and environmental circumstances (Stefan Bouzarovski, 2014). Consequently, as proposed by the EU legislation, adequate definitions and policies to address energy poverty need to be generated at the national level.

3.2. Peculiar findings in Southern and Eastern Europe

The analyses presented in this subsection are largely based on the variables created for the CEPI dataset. The initial data used to create the variables comes mostly from Eurostat.

The first unexpected result of the pressure factor analysis was the strong negative correlation found between *Cons* and CEPI (Table 1). It suggests that higher levels of consumption per capita are specific to countries which have a lower level of EP. The higher consumption may simply be caused by a higher standard of living specific to a large portion of households in Northern countries, which incidentally have lower CEPI values. However, our research does find that *Cons* can be used to indicate a specific EP risk when CEPI is low – income poor households in countries with a high consumption of energy per capita have a

much higher incidence of arrears on utilities and insufficient heating compared to the general population (Maxim et al., 2016).

Table 1: Correlations of CEPI with Tenure Status and Residential Consumption of Energy

		Tenant	*Cons*
CEPI	Spearman's rho	-0.683*	-0.704*
	N	28	28
*correlations significant at the 0.01 level			

Source: Maxim et al. (2016)

One of the most peculiar findings of the CEPI study was that *Tenant* has a strong, significant and negative correlation with CEPI, meaning that if the population is composed predominantly from owners rather than tenants, energy poverty is more severe. This finding was counterintuitive because we expected that homeowners are highly motivated to invest in improving the energy efficiency of their dwelling, thus reducing energy poverty, while renters are likely to use the home 'as is' (the status quo provided by landlords is generally determined by the aim of reducing investment costs, while meeting legal requirements). In order to bring more clarity to the discussion, the method for calculating the *Tenant* values is provided below:

Tenant = (1 × "*Tenant, rent at market price*" + 0.7 × "*Tenant, rent at reduced price or free*" + 0.2 × "*Owner, with mortgage or loan*" + 0.1 × "*Owner, no outstanding mortgage or housing loan*")/2 (2)

Each component of Equation 2 is valued as a percentage of the population, and the weights have been assigned according to the different perceived EP risk levels for each type of status. The overall result is divided by 2 in order to maintain the indicator value in the 0-100 range for interpretation purposes.

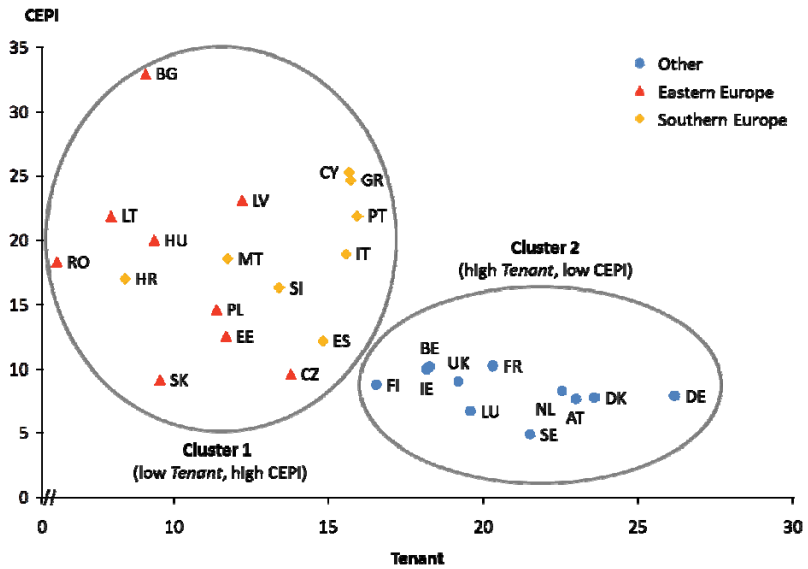

Figure 3: *Geographical clusters in the CEPI-Tenant relationship*
Source: Maxim et al. (2016)

After reviewing the results, a geographical clustering was observed in the relationship of CEPI and *Tenant* (Figure 3). Countries from SE Europe (in this case Eastern Europe includes those EU countries which were part of the USSR or under its sphere of influence) have a higher CEPI score, as well as a lower *Tenant* score. The clustering indicates the existence of a specific socio-economic context in SE Europe that is correlated with the tenure status of the population.

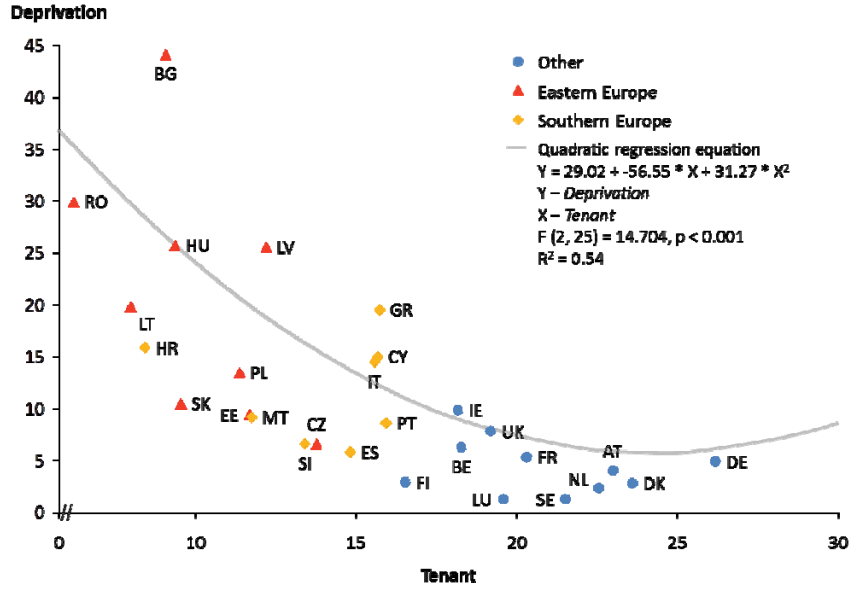

***Figure 4**: The relationship between Deprivation and Tenant*

Further analyses showed a very strong negative correlation between *Tenant* and two indicators of poverty: 'severe material deprivation' (*Deprivation*) and 'risk of poverty and social exclusion' (the former being one of three components of the latter), as seen in Table 2 and Figure 4. In fact, if tenure status could be considered a predictor for severe material deprivation (i.e. a strong motivation to maintain ownership of the dwelling increases the housing costs, which results in a lower disposable income for the household), a quadratic regression model can be calculated, which explains 54% of the variance of *Deprivation*.

Furthermore, the tenure status is also strongly and negatively correlated with the geographical position of the state. In order to confirm this, a dummy variable was created to indicate whether the country is located in Eastern Europe or in another part of the continent. The observed correlation is even stronger when using a dummy for being located in SE Europe.

Table 2: Correlations of *Tenant* with poverty and geolocation variables

		Severe material deprivation	Risk of poverty or social exclusion	East Europe (dummy)	South & East Europe (dummy)
Tenant	Spearman's rho	-0.818*	-0.668*	-0.715*	-0.846*
	N	28	28	28	28

*correlations significant at the 0.01 level

The data presented in Table 2 shows that a higher proportion of homeowners in the population is associated with higher levels of material deprivation and risk of poverty. Although this result can be considered somewhat counterintuitive, it may be caused by various factors not included in the analysis. For example, cultural tradition in some Eastern and Southern European countries favours the stability and predictability of owning a home. This encourages people to make financial efforts to purchase a dwelling and avoid having to become a tenant, explaining the strong negative correlation between *Tenant* and the geolocation dummies. However, home ownership does come at a significant long term cost and economic risk (especially when considering the impact that the real estate and financial crisis had on incomes and mortgages in Southern Europe). In addition, being 'tied' to a specific location reduces the mobility of the population and can severely limit the number of professional opportunities available – with a direct impact on income. Such aspects can lead to a relatively higher risk of poverty and material deprivation, which have a direct impact on energy poverty.

3.3. Implications and possible solutions

Existing studies on the topic of energy poverty in different regions of Europe have argued that the context which sustains and amplifies this problem can vary significantly across the continent. Studies on the particular causalities of EP focused preponderantly on Eastern European countries. Our research suggests that Southern European countries also face specific socio-economic, as well as climatological challenges which impact EP. Moreover, the evidence provided shows that tenure status is a common predictor of material depravation across the South and East or Europe, causing these countries to be more affected by EP.

It is for these reasons that we believe that EP should either be addressed by an overarching, but flexible, set of policy measures based on a pan-European assessment of the phenomenon (using methods such as a revised version of CEPI), or at a much narrower national or sub-regional level (which would allow the problem to be resolved more effectively, but could also contribute to increased regional disparities or to efficiency losses through 'reinventing the wheel').

With regard to detecting EP, we have already mentioned in Section 2.3 some of the improvements that we aim to include in CEPI (adjusting the weights of *Not warm*, *Not Cool* and *Dark* according to objective factors, such as the average recorded temperatures at the national level and the lifecycle costs of heating/cooling/lighting solutions). In addition, we also aim to incorporate microdata from EU-SILC and Eurobarometer (when available) to measure the intensity of EP at the individual household level, similar to the example provided by Nussbaumer, Bazilian, Modi, and Yumkella (2011) for several African countries. This will allow for a much more accurate assessment and cross-country comparison of EP at the EU level.

Conclusions

Energy poverty (or fuel poverty) is a socio-economic phenomenon that has only recently come under the attention of governmental authorities and policy makers across Europe. An increasingly diverse and detailed body of research literature on the topic has

emerged over the last few years. It is becoming clear that, while a universal measure of EP would be useful in creating cross-country comparisons and increasing cohesion, custom abatement policies are necessary in order to effectively address the existing regionally specific causal factors.

The proposed CEPI aggregate indicator represents an efficient tool for measuring EP consistently across Europe. It shows that the problem is more prevalent in some Eastern and Southern European states. However, it has some limitations that do not allow for the specific regional circumstances of energy poverty to be taken into consideration.

Our research indicates some regional factors which are significantly correlated with higher levels of energy poverty. For example, in Southern Europe, specific traits of the housing stock, the warmer climate, as well as the negative repercussions of the economic crisis on mortgages and income, have produced higher levels of EP (as measured through CEPI). In Eastern Europe, EP is affected by factors such as the post-communist path dependence in the area of energy services, the negative impact of privatisation and energy market liberalisation on affordability and the low energy efficiency of the socialist era urban housing stock.

Furthermore, we found that owning homes is negatively correlated with EP within the EU (a surprising result given that homeowners are more motivated to improve the energy efficiency of their dwelling, and thus reduce EP). Our data shows that tenure status is negatively correlated with severe material deprivation (i.e. the higher the proportion of tenants in the population, the lower the level of material deprivation) and positively correlated with the country being located in Eastern or Southern Europe. This suggests that, for various reasons (cultural, historical etc.), people living in these regions prefer to become owners of their homes, even if this results in a lower level of disposable income in the long term. This means that EP abatement policies in SE Europe may need to be focused primarily on helping homeowners (rather than landlords) and the EP threshold should take into consideration the level of income after housing costs.

The results of this study, as well as the proposed revisions to CEPI, would allow us to improve the indicator in order to provide a truly functional, accurate and more efficient tool for cross-sectional and time series assessments of energy poverty at the European level. Further development of such tools is urgently needed in order to allow policy makers to grasp and better address this increasingly common form of poverty across the continent.

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