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Persistent Energy Poverty and the Limits of Institutional Support: Evidence from the Spanish Bono Social

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Persistent Energy Poverty and the Limits of Institutional Support: Evidence from the Spanish Bono Social[1]

Abstract

While a growing body of research has analysed the determinants of energy poverty, less is known about its dynamic nature and about whether current support schemes adequately reach households experiencing multidimensional vulnerability. Using the 2020–2023 longitudinal data from the Spanish component of the European Union Statistics on Income and Living Conditions (EU-SILC), representative of the Spanish population, we estimate dynamic panel models through the Wooldridge Conditional Maximum Likelihood (WCML) estimator. We also assess the protective role of the Bono Social–Spain's main public support scheme for vulnerable energy consumers–and simulate the potential impact of alternative cash-equivalent energy support. The results show strong inertia effects: households experiencing energy poverty in the previous period are 1.9 to 6.4 percentage points more likely to experience it again. We also document important limitations in the coverage and take-up of the Bono Social, with especially low coverage among the lowest income deciles. Counterfactual simulations indicate that a modest annual energy support transfer of € 500 per household, whether delivered through direct cash transfers or bill discounts, can substantially reduce energy poverty, with reductions ranging from 1.8 to 17.3 percentage points. These findings highlight the need for more differentiated and better-targeted policy interventions, with eligibility criteria that improve the identification and protection of households at risk of energy poverty.

JEL classification

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Keywords

energy poverty, persistence, dynamic panel models, Bono Social, policy counterfactuals

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1. Introduction

Energy poverty affects key aspects of daily life, including health, income generation, and well-being outcomes (Zhang et al., 2021; Pondie et al., 2024; Wang et al., 2025). Approximately 2.9 million people die each year from indoor air pollution caused by the use of solid fuels and kerosene for cooking (World Health Organization, 2024). Limited access to affordable and modern energy also restricts education and work opportunities, reduces household productivity, and slows the transition toward cleaner technologies (Al Kez et al., 2024).

While a large body of research documents the determinants of energy poverty (Parreño-Rodriguez et al., 2023; Romero et al., 2025; del Río González et.al, 2025), much of this work relies on static snapshots, offering a limited understanding of how households move into, through, and out of energy deprivation over time. A reduced number of studies using household-level panel data document significant short-term persistence effects, showing that experiencing energy poverty in one year substantially increases the probability of experiencing it again in the next (Drescher and Janzen, 2021; Halkos and Kostakis, 2023), particularly among income-poor households (Alem and Demeke, 2020; Budría and Betancourt, 2025). Despite these efforts we still know little about how energy poverty unfolds over time for distinct groups of households. Addressing this gap is relevant because the welfare consequences, the appropriate policy instruments, and the metrics used to evaluate success differ sharply between short-lived shocks and chronic energy poverty. Moreover, a key limitation of this emerging literature is that it typically treats persistence as an average process, abstracting from potential differences between recipients and non-recipients of public support schemes. Yet, the probability that a household continues to experience energy poverty and the probability that it exits energy poverty is likely to be intertwined with the reception of social support and participation on targeted programmes. As a result, estimates of persistence can be policy contingent.

This paper attempts to fill this gap by addressing two policy-relevant questions. First, what are the dynamic patterns of energy poverty—entry, persistence, and exit—and how do they differ between recipients and non-recipients of social programmes? Second, to what extent do existing support schemes reach households experiencing energy vulnerability and mitigate energy poverty among current and potential beneficiaries?

We use panel data from the Spanish module of the European Union Statistics on Income and Living Conditions (EU-SILC), representative of the Spanish population for the period 2020–2023. Studying dynamics—rather than static snapshots—is particularly relevant in this context, as it allows us to understand not only which households are experiencing energy poverty at a given moment, but also who enters, who remains, and who exits energy poverty over time. By applying Wooldridge's (2005) estimator, following the alternative specification proposed by Skrondal and Rabe-Hesketh (2014) for dynamic binary response models, our approach jointly addresses state dependence, unobserved heterogeneity, and the initial conditions problem.

To address the second question, we focus on the *Bono Social*, Spain's main public support scheme for vulnerable energy consumers. The programme combines an electricity bill discount (*Bono Social Eléctrico*) with a heating allowance paid as a direct transfer (*Bono Social Térmico*), thereby operating through both the expenditure and income channels that are central to energy poverty. Using this policy framework, we assess the extent to which existing support reaches households most exposed to energy poverty and how closely programme coverage aligns with observed deprivation. We also examine the role of beneficiary status in relation to the persistence of energy poverty, while remaining agnostic about causal interpretation. In addition, we implement descriptive rule-based counterfactual simulations to translate policy amounts into household-level outcomes. Specifically, we assess how alternative annual cash-equivalent transfer scenarios of €500, €1,000, and €1,500 translate into reductions in LIHC energy poverty across the income distribution. These amounts are chosen to span a plausible range of support intensity, informed by the monetary values reconstructed for the Bono Social in the preceding counterfactual exercises. Although these exercises are descriptive rather than causal, they provide policy-relevant benchmarks for assessing support adequacy, targeting performance, and the potential scope for programme redesign.

While Spain provides a particularly relevant context for analysing energy poverty dynamics, the mechanisms underlying these processes are not unique to the Spanish case. Like many advanced economies, Spain experienced substantial volatility in electricity prices following the energy crisis triggered by the war in Ukraine and disruptions in international gas markets. The average wholesale electricity price exceeded €167/MWh in 2022 before falling to around €100/MWh in 2023 (CNMC, 2025). Beyond these external shocks, the country also exhibits structural vulnerabilities that are increasingly common across advanced economies, including income inequality, labour-market insecurity, housing affordability pressures, and an ageing and thermally inefficient housing stock (OECD, 2025; Taltavull et al., 2022). These factors contribute to unstable household conditions and increase households' exposure to recurrent forms of energy deprivation. At the same time, Spain presents substantial climatic heterogeneity, where both winter heating and summer cooling needs can become important drivers of energy hardship (Calama-González et al., 2024). Within this broader context of structural vulnerability, Spain also offers a distinctive policy framework through the *Bono Social* system, which combines income-based and categorical eligibility criteria alongside both tariff discounts (*Bono Eléctrico*) and direct transfers (*Bono Térmico*). This hybrid architecture makes Spain especially relevant for analysing both the persistence of energy poverty and the extent to which institutional support mechanisms effectively reach households experiencing persistent forms of vulnerability.

This study contributes to the literature on energy poverty in three key directions. First, the paper examines the socio-economic gradient of energy poverty in Spain, using a dynamic model that allows for state dependence. We find that energy poverty in Spain is significantly persistent across all indicators, with past poverty raising the probability of current energy poverty by between 1.9 to 6.4 percentage points (pp). Previous dynamic studies have mainly highlighted the role of employment, income, or energy prices (Halkos and Kostakis, 2023; Drescher and Janzen, 2021; Alem and Demeke 2020). Our results complement this view by showing that persistent energy poverty is strongly structured by short-term financial stress or, in other words, households unable to absorb unexpected expenses and already burdened by debt-related payment difficulties face systematically higher risks of deprivation.

Second, earlier studies impose a common (average) socio-economic gradient across households. In this paper, we instead discriminate between recipients and non-recipients of social programmes, showing that recipients of Spain's *Bono Social* exhibit somewhat distinct dynamics. Specifically, energy poverty persistence is relatively higher among beneficiaries. This pattern suggests that the programme reaches households facing more persistent forms of multidimensional deprivation but does not necessarily eliminate the structural conditions underlying recurrent energy poverty. In other words, while in Spain energy poverty persistence it is broadly in line with previous estimates for developed countries, cross-study comparisons may be misleading if they ignore at-risk populations and programme take-up.

Third, in the case of Spain, two studies have analyzed the effects of the Bono Social on alleviating household vulnerability. However, both García Alvarez and Tol (2021) and Bagnoli and Bertoméu-Sánchez (2022) focus exclusively on eligibility criteria rather than examining who receives the subsidy. As we show in this paper, a substantial share of eligible households does not receive the benefit, which introduces important discrepancies between formal eligibility and effective coverage and may bias assessments based solely on statutory criteria. To address this gap, we extend the methodological approach used in Reaños et al. (2025) and implement a set of policy-relevant counterfactual simulations. These show that i) the *Bono Social* plays a meaningful protective role among current recipients, particularly in the lower income deciles, where a non-negligible share of households observed outside energy poverty would fall back into deprivation in the absence of support; ii) there is substantial scope for improvement in programme coverage, as full take-up among eligible non-recipients would lead to large reductions in energy poverty and iii) our cash-equivalent support simulations indicate that relatively modest additional support can materially reduce energy poverty among low-income households. Taken together, these results provide new evidence not only on who is persistently vulnerable, but also on how programme design, coverage, and support adequacy shape the potential for policy to reduce energy poverty. While recent evidence suggests that the *Bono Social* provides only modest reductions in energy poverty and limited health improvements using cross-sectional data (Jové-Llopis et al., 2025), our longitudinal findings indicate that recipient households continue to exhibit comparatively high persistence rates, particularly for multidimensional measures of deprivation.

The remainder of this study is organized as follows. Section 2 reviews the literature on energy poverty, focusing on its persistence, multidimensional measurement, and the design of targeted support schemes. Section 2 presents the empirical framework, detailing the measurement of energy poverty and describing the data from the Spanish module of the EU-SILC along with the definition of variables. Section 3 reports the main results, including estimates of the persistence of energy poverty and the factors influencing transitions in and out of deprivation. Section 4 assesses the performance and coverage of the *Bono Social*, highlighting differences between recipients and non-recipients and presenting counterfactual simulations of compensatory transfers required to lift households out of energy poverty. Section 5 offers concluding remarks and policy recommendations, with an emphasis on improving the design and targeting of energy support schemes.

2. Material and methods

2.1. Data and definition of variables.

The data used in this study come from the *Encuesta de Condiciones de Vida* (ECV), the Spanish implementation of the European Union Statistics on Income and Living Conditions (EU-SILC). The survey is carried out by the *Instituto Nacional de Estadística* (INE) as part of the harmonized statistical framework coordinated by Eurostat and is governed by Regulation (EC) No 1177/2003 of the European Parliament and of the Council. This legal framework ensures methodological consistency and comparability across EU member states.

The ECV provides nationally representative data, with additional coverage at the level of Autonomous Communities. In some cases, data also support urban–rural disaggregation by municipality size. The survey combines cross-sectional and longitudinal components: each panel tracks the same households over four consecutive years, enabling the analysis of income trajectories and material deprivation dynamics. The ECV employs a two-stage stratified sampling design. In the first stage, census sections are selected within each stratum using probability proportional to size (PPS), based on the number of main dwellings. In the second stage, main residences are selected using systematic sampling with a random start. This design produces self-weighted samples within each stratum. Although the household is the primary sampling unit, data are collected at both the household and individual levels. Standardized interviews are conducted with all individuals aged 16 and over. These features make the ECV a robust and reliable data source for analyzing energy poverty and related socio-economic inequalities in Spain.

This study uses longitudinal ECV waves covering the 2020–2023 period. To construct the analytical sample, the household-level panel file was merged with the individual-level file using a unique household identifier. The reference person of each household is explicitly identified in both files, allowing direct linkage between household characteristics and the socio-demographic profile of the household head.

We used a set of covariates to account for household economic conditions, housing characteristics, geographical context, and the socio-demographic profile of the household head. These controls capture multiple structural and contextual factors, such as income, material deprivation, tenure status, dwelling type, regional labor market conditions, and individual-level attributes (age, gender, education, and marital status), that influence both energy needs and a household's ability to afford adequate energy services. The household remains the primary unit of analysis, and all indicators, including those related to energy poverty, are measured accordingly.

Since the public-use version of the ECV only reports aggregated household energy expenditures, a formal request for access to disaggregated expenditure data by energy source (including electricity, gas, and heating fuels) was submitted to the Spanish National Statistics Institute (INE). Access was granted under INE's standard research protocols. The resulting household-level expenditure files retained the original household identifiers, which allowed them to be merged with the longitudinal ECV dataset using household codes and survey wave identifiers.

The unfiltered panel comprises 56,804 household-year observations, corresponding to 22,615 unique households (2020–2023). After excluding records with missing values in key variables, the analytical sample consists of 52,426 observations (a 7.7% reduction), covering 21,882 households (a 3.2% reduction). All regression models are estimated using the longitudinal household weights provided in the ECV, which correct for both sample design and attrition over survey waves.

2.2 Energy poverty

Approaches to measuring energy poverty usually fall into two broad families: those based on observed expenditure patterns and those based on households' own assessments of hardship. In this paper we use both approaches. Expenditure-based measures start from the idea that energy affordability problems become visible when domestic energy costs absorb an unusually large share of household resources, a concern that is especially salient among lower-income households (Boardman, 1991). Their main advantage is transparency, but they can miss forms of deprivation that arise precisely because constrained households suppress consumption in order to cope financially. In such cases, low recorded expenditure does not necessarily indicate adequate access to energy services but may instead reflect hidden deprivation. To address this limitation, part of the applied literature has relied on subjective indicators, such as reported thermal discomfort or difficulties paying utility bills, to capture household's lived experience of energy hardship. These measures provide information that expenditure-based indicators may miss, but they also present important limitations. Self-reports may be shaped by differences in expectations, social norms, reporting behaviour, and intra-household bargaining, which complicates comparability across groups and settings contexts (Wojewódzka-Wiewiórska et al., 2024). They may also understate deprivation when households adapt to inadequate conditions or are reluctant to disclose hardship.

To address these complementary strengths and limitations, we combine objective and subjective measures. Specifically, we construct four indicators from EU-SILC items, two subjective and two objectives. These respond to the following questions: (1) Can your household afford to keep the home adequately warm during the winter months? (Warm), and (2) Has your household experienced any delays in paying household bills? (Arrears). Although the second item includes telephone and water bills, we treat it as a proxy for a household's ability to meet energy needs and manage related costs. The other two measures are objective indicators based on expenditure energy and income: (3) Whether the proportion of household energy spending relative to income exceeds twice the national median (2M), and (4) Whether the proportion of household energy spending relative to income exceeds the national median fall below 60% of the national median income (LIHC). The latter captures affordability strain among low-income households (Hills, 2012).

To capture the multiple dimensions of energy hardship, we construct a Multidimensional Energy Poverty Index (MEPI) based on the four EU-SILC items described above. The index follows a multidimensional deprivation approach, combining information on affordability, payment difficulties, and thermal adequacy into a single summary measure. In doing so, we adapt the general framework proposed in Budría and Betancourt (2025) to the indicators available in our data. Let H be the set of households and K the set of energy-poverty indicators considered in the study. For each household h, observed in waves $t \in T_h$, and for each indicator $k \in K$, we define a binary deprivation status D_{hkt}, where $D_{hkt} = 1$ indicates that household h is deprived under indicator k in wave t, and $D_{hkt} = 0$ otherwise. The multidimensional energy-poverty score of households h in wave t is defined as

$$MEPI_{ht} = \left(\sum_{k \in K} \omega_{kt} D_{hkt} \right)^{\beta}, \beta > 0 \quad k \in K, t \in T_h \tag{1}$$

where ω_{kt} denotes the weight assigned to indicator k in wave t, with

$$\sum_{k \in K} \omega_{kt} = 1, \qquad k \in K, t \in T_h \tag{2}$$

A household is classified as energy poor in wave t whenever its score exceeds the deprivation cutoff identified by c, that is,

$$MEPI_{ht} > c \tag{3}$$

In our baseline parametrisation, we set $\beta = 1$ and $c = 0$. Rather than assigning equal weights, we adopt a frequency-based weighting scheme (Decancq & Lugo, 2013), under which indicators with lower deprivation rates receive greater weight. Let r_{kt} denote the share of households deprived in indicator k in wave t. We then define

$$\omega_{kt} = \frac{1 - r_{kt}}{\sum_{k \in K} (1 - r_{kt})} \tag{7}$$

Under this weighting rule, deprivations in dimensions that are less common in the population receive greater importance in the aggregate index. In substantive terms, this means that failing to attain goods or services that are widely accessible is interpreted as reflecting a more acute disadvantage. However, uncertainty regarding the appropriate weighting structure suggests that robustness checks using alternative weighting schemes should be considered (Seth and McGillivray, 2018). In line with this view, we performed sensitivity analyses comparing data-driven weights with equal weights.[4]

[4] The minimum weight in our data is 0.241 and the maximum is 0.268, with a standard deviation of only 0.008. Hence, all weights remain very close to the benchmark value of 1/4 = 0.25 implied by an equal-weight scheme. Additional

---Insert Table 1 here ----

2.3 The Bono Social in Spain: programme design, eligibility, and relevance for energy poverty.

The Spanish electricity social tariff (*Bono Social Eléctrico*) is governed by Royal Decree 897/2017, which defines the categories of vulnerable consumers, the conditions for access to the scheme, and the main consumer protection measures associated with it. Access is limited to natural persons who are holders of an electricity supply point in their habitual residence, have contracted power equal to or below 10 kw, and are supplied under the regulated tariff (PVPC) (Gobierno de España, 2017, arts. 2, 3.1). During the period analysed, households could qualify as vulnerable consumers through four main channels: by meeting an income threshold equal to or below 1.5 times the 14-payment IPREM (*Indicador Público de Renta de Efectos Múltiples*), increased by 0.3 for each additional adult and 0.5 for each minor in the cohabiting unit; by holding large-family status; by being composed of pensioners receiving the minimum retirement or permanent disability pension and no other annual income above €500; and, following the 2022 reform, by including a beneficiary of the Minimum Vital Income (Ingreso Mínimo Vital) (Gobierno de España, 2017, art. 3.2; Gobierno de España, 2022a). The applicable income threshold is further relaxed in the presence of "special circumstances," including disability of at least 33%, victim status of gender violence or terrorism, recognised dependency grades II or III, and single-parent households with at least one minor (Gobierno de España, 2017, art. 3.3). A further distinction is made for severely vulnerable consumers, defined as those whose income does not exceed 50% of the applicable threshold, with alternative thresholds applying to pensioners and large families (Gobierno de España, 2017, art. 3.4). Finally, consumers at risk of social exclusion are classified as severely vulnerable consumers whose electricity bill is at least 50% co-financed by regional or local social services (Gobierno de España, 2017, art. 4.1).

For the *Bono Social Eléctrico*, the applicable discount was not constant over the period covered by the analysis. Under Royal Decree-Law 15/2018, the baseline discount was set at 25% for vulnerable consumers and 40% for severely vulnerable consumers (Gobierno de España, 2018). This baseline arrangement remained in force throughout 2020 and most of 2021. With the onset of the energy crisis, discount rates were temporarily reinforced in successive stages. They were first increased to 60% for vulnerable consumers and 70% for severely vulnerable consumers until 31 March 2022 (Gobierno de España, 2021), then extended until 31 December 2022 (Gobierno

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calculations showed that the MEPI based on equal weights has practically identical distributional properties relative to our benchmark MEPI.

de España, 2022a). A subsequent reform raised them further to 65% and 80%, respectively, through 31 December 2023 (Gobierno de España, 2022b). This sequence is particularly relevant for empirical analysis, since the effective annual subsidy in 2021 and 2022 is better captured as a time-weighted average of the discounts in force over the year rather than as a single annual percentage.

In parallel, the *Bono Social Térmico* was introduced by Royal Decree-Law 15/2018 as a complementary programme of direct support for thermal energy needs, including heating, domestic hot water, and cooking (Gobierno de España, 2018, art. 5). Unlike the electricity social tariff, it is not implemented as a price discount, but as a single annual lump-sum transfer financed through the State Budget (Gobierno de España, 2018, arts. 7, 9). Eligibility is granted automatically to households that were beneficiaries of the electricity social tariff on 31 December of the previous year (Gobierno de España, 2018, art. 8). The amount of support depends on both the household's degree of vulnerability and the climatic zone of the habitual dwelling, with severely vulnerable consumers and consumers at risk of social exclusion receiving a transfer 60% higher than that assigned to vulnerable consumers in the same climatic zone (Gobierno de España, 2018, art. 9; Annex I). Administration and payment are the responsibility of the Autonomous Communities and the Cities with Statute of Autonomy (Gobierno de España, 2018, art. 10).

The minimum value of the *Bono Social Térmico* also changed during the energy crisis and should therefore be explicitly incorporated into both the institutional discussion and the empirical reconstruction. In the original scheme, the minimum annual transfer was €25 per beneficiary (Gobierno de España, 2018, Annex I). This threshold was later increased to €35 for the 2021 exercise, i.e. for households receiving the electricity social tariff on 31 December 2020 (Gobierno de España, 2021, art. 2), and subsequently raised to €40 (Gobierno de España, 2022b). Accordingly, empirical approximations of the *Bono Social Térmico* over 2020–2023 should not rely on a single nominal amount, but on the legally applicable transfer in each year, considering both vulnerability status and climatic zone.

3.Empirical framework

We estimate a dynamic random-effects probit model that allows current energy poverty to depend on its lagged realization while also accounting for unobserved household-specific heterogeneity. In doing so, we adopt the conditional approach proposed by Wooldridge (2005). The probability that household i experiences energy poverty in period $t$is given by:

$$EP_{ht} = \mathbf{1}\ \boldsymbol{if}\ (\rho EP_{ht-1} + X'_{ht}\beta + \zeta_h + u_{ht} > 0) \tag{8}$$

$(h = 1, \ldots., H); (t = 2, \ldots, T)$, where EP_{ht} takes value 1 if household h experiences energy poverty in period t, and 0 otherwise; $X_{ht}$is the vector of observed covariates; ζ_h denotes household-specific unobserved heterogeneity; and $u_{ht}$is an idiosyncratic error term assumed to be normally distributed, $u_{ht} \sim N(0, \sigma_u^2)$.

The dynamic specification is designed to capture persistence in cumulative deprivation by allowing past deprivation status to affect current outcomes. A central issue, however, is whether this persistence reflects genuine state dependence or simply the influence of time-invariant unobserved factors. The distinction is important both substantively and from a policy perspective. Genuine state dependence arises when experiencing deprivation in one period increases the likelihood of experiencing it again in the next, even after conditioning on observed characteristics. By contrast, apparent persistence may instead be driven by stable unobserved traits or omitted factors that make some households systematically more exposed to deprivation over time, thereby generating serial correlation in observed outcomes without a direct causal effect of past deprivation itself.

To deal with the initial conditions problem, we follow Skrondal and Rabe-Hesketh (2014) and model the unobserved household-specific effect through an auxiliary distribution conditional on the initial energy-poverty status, EP_{h0}, the initial values of the time-varying covariates, X_{h0}, the household-specific means of those time-varying covariates, $\bar{X}_h$, and the time-invariant covariates, Z_h.

$$c_h | EP_{h0}, Z_h\ , X_{ht} \sim N\left(\theta_0 + \theta_1 EP_{h0} + X'_{h1}\theta_2 + Z'_h\theta_3 + \bar{X}'_h\theta_4 + \xi_h, \sigma_\xi^2\right) \qquad (9)$$

$$c_h = \theta_0 + \theta_1 EP_{h0} + X'_{h0}\theta_2 + Z'_h\theta_3 + \bar{X}'_h\theta_4 + \xi_h\ , \quad \xi_i \sim N\left(0, \sigma_\xi^2\right) \qquad (10)$$

In this setting, the auxiliary specification for the household-specific unobserved effect addresses two related sources of endogeneity. First, it allows the unobserved effect to be correlated with the observed covariates, that is, $E(X'_{ht}c_h) \neq 0$. Second, it allows the unobserved effect to be correlated with the initial energy-poverty status, so that $E(EP_{h1}c_h) \neq 0$.

3. Results

3.1 Summary Data

Figure 1 shows the regional distribution of households experiencing energy poverty in Spain during 2020–2023, based on the Multidimensional Energy Poverty Index (MEPI). The maps reveal a consistent spatial pattern: southern regions, especially Andalusia, Castilla-La Mancha, and Extremadura, report the highest percentages of population affected each year. In contrast, northern regions like Navarre, La Rioja, and, to a lesser extent, Cataluña, consistently register the lowest rates. While the spatial analysis reveals persistent territorial patterns, this territorial vulnerability intersects strongly with income-based disparities.

------Insert Figure 1---------

The left panel of Figure 2 presents the distribution of five energy-poverty indicators—Inability to keep warm, Arrears, 2M, LIHC, and MEPI—across income deciles in Spain (2020–2023). The figure shows that households experiencing energy poverty are concentrated in the lower income deciles, with the highest incidence—up to ~80% in some cases—in decile 1. As income rises, the share of households experiencing energy poverty declines across all indicators. Inability to keep warm and Arrears also decrease with income but remain non-trivial through the lower-middle deciles. This variation across indicators points to distinct vulnerability profiles: while LIHC and 2M capture structural/expenditure-based deprivation concentrated among the poorest households, Inability to keep warm and Arrears reflect more widespread yet persistent difficulties across lower- and middle-income groups.

The right panel of Figure 2 shows the evolution of the MEPI by income decile from 2020 to 2023. Energy poverty increased across the income distribution relative to 2020, with a clear upward shift in 2022 and persistently higher levels in 2023. The rise is most pronounced in the lower and middle deciles (roughly deciles 1–5), where prevalence increases by roughly 20 percentage points at the peak of the shock. In the upper deciles, MEPI levels remain comparatively low but exceed their 2020 values, indicating a modest broadening of energy-poverty exposure toward higher-income groups.

------Insert Figure 2---------

Table 1 summarizes the temporal distribution of energy poverty across indicators between 2020 and 2023. While most households never experienced energy poverty, ranging from 53% under MEPI to nearly 87% under Arrears, a non-negligible share appears in multiple waves. Recurrence is most pronounced for MEPI: 14.9% of households experience energy poverty in two waves, and 2% remain poor in all four waves. These patterns indicate that, beyond one-time shocks, a subset of households recurrently experiences energy poverty.

------Insert Table 1---------

In Table 2 we categorize households into three income groups according to their position relative to the mean income level. Approximately 9% of households fall below one standard deviation from the mean (i.e., with a subgroup mean income of € 6,684), while 7.8% are classified as high-income households, earning more than one standard deviation above the mean (i.e., with a subgroup mean income of €79,940). The ratio between the upper- and lower-income thresholds (11.96:1) highlights the pronounced inequality within the income distribution and its potential implications for energy vulnerability. Among low-income households, 34.2% report being unable to keep their home adequately warm, and 5.0% have experienced arrears in utility payments. In contrast, these rates drop to 4.4% and 2.1%, respectively, among high-income households. Objective expenditure-based measures reveal even larger differences: 68.3% of low-income households exceed the 2M threshold, and 61.3% are classified as energy poor under the LIHC indicator. Conversely, these values are nearly negligible among high-income households (0.2% and 0.0%, respectively). The MEPI, as a composite measure, identifies 81.2% of low-income households as energy poor, compared to just 5.8% in the high-income group.

Uptake of energy-cost support schemes (*Bono Social Eléctrico* and *Bono Social Térmico*) remains limited at the population level. Only 8.2% of households receive any support. However, this share varies significantly by income group: 20.9% among low-income households versus 5.1% among high-income households. This pattern suggests progressivity in access. However, it also points to targeting and take-up gaps, with leakage at the top and potential under-coverage at the bottom. For instance, current eligibility criteria—partly categorical under BOE rules—allow access to the subsidy at income levels well above €79,940, even though a large fraction of them does not benefit from the *Bono Social*.

Socio-demographic characteristics further reflect these structural disadvantages. Among high-income households, more than 80% do not face difficulties in making ends meet and covering unexpected expenses. In contrast, practically one third of low-income households report issues on these fronts. Housing tenure reinforces these inequalities: 37.9% of high-income households own their home with a mortgage, versus only 13.4% of low-income households. Renting and granted-use arrangements are more frequent among the latter (24.5% and 10.6%, respectively), suggesting reduced housing security and limited capacity to implement energy efficiency improvements.

Employment status is also highly polarized: almost 70% of high-income household heads are employed, compared to only 30% in the low-income group. Nearly a quarter (24.8%) of low-income household heads are unemployed. Similar differences emerge in terms of education, marital status and regions.

------Insert Table 2---------

3.2 Energy poverty state dependence

Understanding whether households' experience energy poverty is transitory or persistent is crucial for effective policy design. Table 3 reports the marginal probability effects obtained from the WCML estimates under two specifications: columns 1, 3, 5, 7, and 9 treat prior energy poverty (EP_{t-1}) as exogenous, while columns 2, 4, 6, 8, and 10 treat it as endogenous to capture true state dependence.

Under the exogenous specification, lagged effects are large and significant across all five indicators, with marginal effects from 10.5 percentage points (pp) to 25.3 pp in the case of the MEPI. This suggests high persistence, though these estimates may partly reflect unobserved heterogeneity. When the initial condition is treated as endogenous, effects fall but remain significant: prior exposure to energy poverty raises the probability of current poverty by 1.9–6.4 pp, with the highest persistence for MEPI and the lowest for Arrears. Hence, between 71.5% and 89.0% of the persistence initially captured by the model is explained by unobserved heterogeneity, yet genuine state dependence remains[5]. Moreover, in all cases, an initial energy poverty status (EP_0) significantly predicts current poverty.

---Insert Table 3 here ----

The degree of energy poverty inertia in Spain is sensitively below recent estimates reported in the literature. Using Australian data, Budría and Betancourt (2025) focus on the energy poverty experiences of particularly vulnerable households. They reported state dependence effects ranging from 11 to 13 pp, although they use a more stringent criterion of energy poverty specially tailored for vulnerable households. Utilizing data from the German Socio-Economic Panel, Drescher and Janzen (2021) reported state dependence effects ranging from 3.8 to 7.5 pp. They

[5] Proportions of state dependence attributable to unobserved heterogeneity were computed as $(1 - \frac{\beta_{end}}{\beta_{exo}})$ where β_{end} y β_{exo} refer to the estimated coefficients on the lagged dependent variable in the exogenous and endogenous initial condition models, respectively.

employed three objective indicators of energy poverty (2M, TPR, and LIHC) and a subjective indicator (the ability to keep the house warm), which broadly represent similar conditions to those imposed in our definition of energy poverty. Alem and Demeke (2020), using data from the Ethiopian Urban Socio-Economic Survey, estimate lagged poverty effects between 9.8 and 16.4 pp, while in Halkos and Kostakis (2023) the estimates are around 10 pp for Greece. Hence, the low state dependence observed in our data aligns more closely with estimates from high-income contexts. Notwithstanding, these results confirm suggest that energy poverty in Spain is not purely a temporary shock but, for many households, a condition reinforced over time.

3.3 Socio-economic spectrum of energy poverty

Table 3 provides insights into the socio-economic gradient of energy poverty. The discussion below focuses on the marginal effects derived from the specification with endogenous initial conditions, which offers a more accurate representation of structural state dependence.

Income of the household head exhibits a significant protective effect on the persistence of energy poverty, particularly for expenditure-based indicators[6]. A 10% increase in income for a household head earning the sample mean (€19,870.32) would lower the probability of energy poverty by approximately 0.21 pp using MEPI as a reference.[7] No significant associations are observed with subjective indicators such as inability to keep the home adequately warm or arrears. These results suggest that income gains exert a modest but measurable effect in reducing structural forms of energy poverty. Financial resilience stands out even more: the ability to make ends meet is negatively associated with energy poverty, with an estimated effect of 7.3 pp for MEPI. Similarly, the ability to cover unexpected expenses is negative associated with the probability of energy poverty (-11 pp). In contrast, financial stressors —such as arrears on hire purchases— can raise the probability of persistence by more than 10 pp.

Tertiary education is negatively related to energy poverty, by up to 5.3 pp, while housing and labour conditions are also significant under some indicators. Unemployment among household heads also heightens risks, especially for expenditure-based indicators. Personal characteristics

[6] We use the household head's income to proxy earning capacity while avoiding conditioning on household income, which enters the construction of several energy-poverty indicators (e.g., LIHC, 2M). This mitigates potential endogeneity concerns.

[7] Marginal effects are calculated per unit increase in ln(income). For interpretability, results are expressed in terms of a 10% increase in income, corresponding to $\ln(1.10) \approx 0.0953$. The marginal effects were scaled accordingly.

display weak and statistically inconsistent associations: being married is linked to modest reductions in persistence for some indicators, whereas gender and age effects are negligible.

3.4 Dynamics by socio-economic groups

We use the estimated transition probabilities to characterise the long-run dynamics of energy poverty. Following Grotti and Cutuli (2018), we focus on four summary measures: the probability of entering and leaving energy poverty, the expected duration of poverty spells, and the steady-state probability (SSP), which captures the long-run likelihood of experiencing energy poverty. The entry probability refers to the likelihood that a household enters energy poverty between two consecutive periods conditional on not being energy poor in the previous wave, while the exit probability captures the probability of leaving energy poverty conditional on previous deprivation. The individual steady-state probability of energy poverty is defined as:

$$SSP_i = \frac{p_{01,i}}{p_{01,i}+p_{10,i}} \tag{11}$$

and the expected (average) duration of an energy poverty spell is

$$ADP_i = \frac{1}{p_{10,i}} \tag{12}$$

In Table 4, we report transition indicators by housing tenure, income, gender, age, educational attainment and employment status. This breakdown shows how energy-poverty dynamics differ across socio-economic groups. Differences in the unconditional distribution of these characteristics were already documented in Table 2. From this evidence, three main patterns emerge.

Income remains the strongest stratifying factor. Households below the mean income show markedly higher entry probabilities across all dimensions. For instance, the entry probability for the "inability to keep warm" indicator is 15.1 pp higher (25.9% vs. 10.8%), and for the 2M indicator 31.7 pp higher (35.7% vs. 4.0%), compared to higher-income households. Exit probabilities are also substantially lower among low-income groups, particularly for MEPI (18.9% vs. 66.4 %, a difference of 47.5 pp) and LIHC (70.4% vs. 41.6%, a difference of 37.6 pp). As a result, steady-state probabilities of persistent energy poverty are much higher among low-income households, 63.4% vs. 18.5% for MEPI (43.9 pp), with longer average durations (2.40 vs. 1.20 waves for MEPI, 1.2 waves).

Employment status also shows clear gradients. Unemployed household heads have slightly higher entry probabilities (e.g., MEPI +6.6 pp; "inability to keep warm" +0.4 pp) and lower exit probabilities (MEPI –6.9 pp), leading to marginally longer durations (1.88 vs. 1.59 waves in MEPI). While smaller than income effects, unemployment remains a relevant risk factor, especially in expenditure-based indicators.

Age effects are clearer in entry rates: household heads above the mean age face higher risks (+7.5 pp for 2M, +3.2 for Arrears, and +5.7 pp for warm home) and slightly longer durations, suggesting vulnerabilities linked to fixed incomes or specific housing conditions. Educational attainment is protective. University-educated household heads show lower entry probabilities and shorter durations; in MEPI, their steady-state probability is 28.0% vs. 30.6% (–2.6 pp), with durations 0.58 waves shorter (1.48 vs. 1.54).

---Insert Table 4 here ----

4. Assessing the Performance and Coverage of the *Bono Social*

In this research, we initially considered two empirical strategies to identify the causal effect of receiving cash-equivalent energy-cost support (*Bono Social*)—whether via a direct transfer (*Bono Térmico*) or an electricity bill discount (*Bono Eléctrico*)—on the probability that households experience energy poverty. The first strategy was a difference-in-differences (DiD) design, where the treatment group would consist of individuals who begin benefiting from the *Bono Social Eléctrico* during the observation window, and the control group would be composed of similar individuals who do not receive it. The second strategy was a regression discontinuity design (RDD), exploiting the eligibility criteria established by law—mainly income thresholds, family size, and employment status—to compare households just above and below the cut-off points.

However, empirical limitations precluded the successful implementation of either identification strategy. In the case of the DiD design, a fundamental issue arose from the panel structure of the data: a substantial share household (24.9%) who report receiving the *Bono Social* already held it in the first wave of the panel. The number of yearly "switchers"—households that transition from non-receipt to receipt—is extremely small (1.65%), rendering the identification of treatment effects infeasible due to lack of within-unit variation over time. Moreover, the rotating structure of the panel—25 % of households are replaced in each wave—limits our ability to track households over time. This attrition further reduces the number of valid treatment transitions observable within the panel and weakens the longitudinal consistency required for a robust difference-in-differences identification strategy.

The RDD strategy was also empirically infeasible. Although eligibility for the *Bono Social* is formally determined by clear thresholds in income and household characteristics, it additionally requires that the household be subscribed to the regulated electricity market. Unfortunately, this key eligibility criterion is not observed in the survey data, making it impossible to accurately identify which households truly meet the full set of legal conditions[8]. As a result, the observable eligibility variables exhibit limited predictive power in explaining actual receipt of the benefit. Moreover, a substantial proportion of households that meet the observed income and demographic criteria do not receive the *Bono Térmico* transfer, partly due to administrative arrangements whereby eligibility is set by the central government, but disbursement is handled by regional authorities. This weak first-stage relationship undermines the credibility of the RDD design and suggests the presence of significant implementation or take-up barriers, possibly due to bureaucratic complexity or informational frictions.

Given these empirical limitations, we do not pursue a causal identification of the treatment effect. Instead, we adopt a complementary approach focused on the three relevant policy dimensions described below.

4.1 Energy poverty dynamics by *Bono Social* status

First, we document dynamic patterns of households experiencing energy poverty with and without access to the *Bono Social*. Table 5 reports transition rates and persistence measures by subsidy status. Taking the MEPI variable as a reference, we observe that persistence tends to be higher among recipients than among non-recipients. This pattern, which is also observed for the LICH indicator and the ability to keep home warm, is consistent with the concentration of the programme among households experiencing more persistent forms of deprivation, while also suggesting that existing support may be insufficient to fully break recurrent poverty dynamics. Another distinct pattern is that the coefficient associated with initial energy poverty (EP_0) tends to be lower among non-recipients, suggesting that, within this group, participation in the Bono Social itself may operate as an additional marker of latent vulnerability and future exposure to energy poverty. In other words, conditional on observed characteristics, households receiving the subsidy appear to face deeper or more persistent structural disadvantages than non-recipients.

[8] *Published in the Official State Gazette (BOE), No. 242, 7 October 2017. Available at:* https://www.boe.es/eli/es/rd/2017/10/06/897

---Insert Table 5 here ----

4.2 Targeting Effectiveness of the *Bono Social*

Next, we examine the alignment between the Bono Social and energy poverty, following the methodological approach of Reaños et al. (2025). Specifically, we compute—by income decile—(i) the coverage rate, defined as the share of households experiencing energy poverty that receive support; and (ii) the corresponding share of such households that do not receive the subsidy. We also report the same proportions among households not experiencing energy poverty. We use the MEPI as baseline indicator. The results, in Table 6, indicate only partial alignment between the *Bono Social* and energy poverty. A non-negligible share of households experiencing energy poverty remains uncovered, while some beneficiaries are observed among households not experiencing energy poverty. Coverage among households experiencing energy poverty is particularly low in the bottom income deciles. In the first decile, only 15% of households experiencing energy poverty are recipients of the *Bono Social*, while the remaining 85.0% do not. Given that this decile largely overlaps with the population targeted by the program's legal definition of vulnerability, this pattern raises concerns in terms of coverage and effectiveness of the program. Coverage rises to 19.2% in decile 2 but declines from decile 3 onward. By the ninth and tenth deciles, coverage is virtually negligible.

Turning to households not experiencing energy poverty, we find that a non-negligible share still receives the subsidy, 20.74 % in decile 1, around 4% in the middle deciles, and 1.2% in decile 10. Two non-mutually exclusive explanations may account for this pattern. First, the *Bono Social* may operate as a mitigating mechanism: households that satisfy the program's income and categorical eligibility criteria may receive the subsidy and, as a result, may not be identified as experiencing energy poverty according to the MEPI. Second, eligibility rules, largely based on income thresholds and categorical conditions, may not perfectly correspond to multidimensional measures of energy vulnerability.

These results suggest incomplete alignment in targeting: a non-negligible share of households experiencing energy poverty remains uncovered, while some higher-income households and some households not identified as experiencing energy poverty. All in all, this pattern may reflect informational frictions, administrative barriers, or differences between legal eligibility rules and multidimensional poverty classifications. In particular, certain regulatory criteria, such as large-family status, constitute sufficient conditions for access under the current framework, irrespective of household income levels, which may contribute to the presence of beneficiaries not identified as experiencing energy poverty according to the MEPI. Conversely, the presence of *Bono Social* recipients in higher income deciles is extremely low, which suggests that inclusion errors, households receiving the transfer despite not being economically vulnerable, are relatively minor in this sample of energy-poor individuals.

---Insert Table 6 here ----

4.3 Policy counterfactuals for the Bono Social

To assess the role of the *Bono Social* in reducing energy poverty, we implement two rule-based policy counterfactuals based on the programme's official eligibility criteria and legally established support amounts. We use the LIHC indicator for the purposes of this simulation exercise. This choice is particularly well suited because it identifies energy poverty jointly through two transparent conditions: insufficient residual income and comparatively high energy costs (Hills, 2012). As a result, households may move out of energy poverty through an increase in disposable income, a reduction in energy expenditure, or a combination of both. These are precisely the channels through which the *Bono Social* operates: the *Bono Social Térmico* increases effective disposable income through a lump-sum transfer, while the *Bono Social Eléctrico* lowers electricity expenditure through a regulated tariff discount.

Eligibility is determined using the official thresholds established in Spanish legislation and expressed in terms of equivalized disposable income. Specifically, we compute a household-specific threshold as the product of the Spanish Public Income Indicator (IPREM) and the legal multiplier that varies according to household size and composition. Households are then classified as vulnerable or severely vulnerable depending on whether their income falls below the relevant threshold or below one half of that threshold, respectively. In line with the regulatory provisions, households receiving social services support and meeting the corresponding poverty criteria are also classified as severely vulnerable (Real Decreto 897/2017).

The monetary value of the programme is reconstructed in two steps. First, for the *Bono Social Eléctrico*, we compute an effective annual discount rate by vulnerability status and calendar year that accounts for within-year regulatory changes. Let d_{srt} denote the legally established discount for vulnerability group s under regulatory regime r in year t, and n_{rt} the number of days during which that regime was in force. The annualized discount rate is defined as

$$\bar{d}_{st} = \sum_{r} \left(\frac{n_{rt}}{D_t}\right) d_{srt}, \tag{13}$$

where D_t is the total number of days in year t. This time-weighted formulation captures the substantial variation in the level of support provided by the programme during the energy crisis.

The resulting annualized rates increase from 25% for vulnerable households and 40% for severely vulnerable households in 2020 to 65.0% and 80.0% in 2023. We then use $\bar{d}_{st}$ to recover counterfactual electricity expenditure. If E_{it}^{obs}denotes observed electricity expenditure, then expenditure in the absence of support for current recipients is given by $E_{it}^{noBS} = E_{it}^{obs}/(1 - \bar{d}_{st})$, while expenditure under a full-take-up scenario for eligible non-recipients is given by $E_{it}^{withB} = E_{it}^{obs}(1 - \bar{d}_{st})$. Total household energy expenditure is finally obtained by combining electricity expenditure under each scenario with spending on gas and other household fuels.

Second, for the *Bono Social Térmico*, we impute the legally established minimum transfer by year and vulnerability status (Real Decreto-ley 15/2018). The amount of this transfer also depends on climatic severity, which is assigned in the regulation at the municipal level (Gobierno de España. 2013, Appendix B). Because municipality-level climate-zone identifiers are not available in our data, we approximate the thermal component at the level of the Autonomous Community. Specifically, for each community r, year t, and vulnerability category s, we define the imputed transfer as the simple average of the legally established minimum amounts across the set of climate zones associated with an Autonomous Community:

$$\widehat{BST}_{rt}^{s} = \sum_{z \in Z_r} w_{rzt} B_{zst}, \qquad r \in R, \qquad t \in T \tag{14}$$

where Z_r denotes the set of climate zones represented in Autonomous Community r, B_{zst} is the legally established minimum transfer for climate zone z, vulnerability status s, and year t, and ω_{rz} is the population share of climate zone z within Autonomous Community r and year t, defined as

$$\omega_{rzt} = \frac{Pop_{rz}}{\sum_{z \in Z_r} Pop_{rz}} \qquad r \in R, \qquad z \in Z_r\,, \quad t \in T \tag{15}$$

with Pop_{rz} denoting the total population of the provinces in community r assigned to climate zone z. Each household is then assigned the corresponding community-level imputed amount according to its year and vulnerability status. This should be interpreted as a descriptive approximation rather than an exact administrative allocation, since a fully precise implementation would require municipality-level climate-zone identifiers and, ideally, information on the territorial distribution of actual beneficiaries rather than population alone.

Using these two components, we construct two policy scenarios (see Tables 7 and 8). For current recipients, we simulate the absence of support by subtracting the imputed *Bono Social Térmico* from disposable income and reversing the electricity discount. For eligible non-recipients, we simulate full take-up by adding the imputed thermal transfer to disposable income and applying the corresponding electricity discount to observed electricity expenditure.

In each scenario, LIHC status is recomputed year by year. On the income side, we calculate residual equivalized income after deducting annualized energy expenditure and compare it with 60% of the corresponding year-specific national benchmark. On the expenditure side, we compare annualized household energy costs with the year-specific national median of energy expenditure. A household is classified as LIHC energy poor only when both conditions are simultaneously met.

Table 7 reports the recipient-side simulation. The results show that the *Bono Social* plays a substantial protective role in the lower part of the income distribution. In the observed data, 45.35% of recipients in decile 1 and 38.82% in decile 2 are not classified as LIHC energy poor. Once the support is removed counterfactually, these shares fall sharply to 14.48% and 12.14%, respectively. This corresponds to relative reductions of 68.08% in decile 1 and 68.95% in decile 2 in the share of recipient households remaining outside energy poverty. Even in decile 3, where conditions are comparatively less constrained, the share of non-energy-poor recipients declines from 71.54% to 28.43%, equivalent to a 60.48% reduction.

These results suggest that a substantial fraction of recipient households observed outside LIHC energy poverty remain outside it only because of the support provided by the programme. Put differently, the observed incidence of non-poverty among beneficiaries cannot be interpreted simply as evidence of underlying economic resilience; it partly reflects the buffering role of the *Bono Social* itself. This pattern is particularly evident, where the counterfactual exercise reveals a high degree of latent vulnerability among households that would otherwise move into LIHC energy poverty.

The monetary amounts reported in Table 7 are consistent with this interpretation. The total annual value of support received by current beneficiaries is economically meaningful in all three deciles shown, averaging € 859.11 in decile 1, € 868.11 in decile 2, and € 1,040.42 in decile 3. The composition of support also varies across the distribution. The thermal component is especially important in decile 1, where it reaches € 310.91 on average, while the electricity discount becomes relatively more prominent in decile 3, where the average value of the *Bono Social Eléctrico* rises to € 791.09. Overall, the table indicates that the programme is associated with lower LIHC energy poverty among recipients through support levels that are not only statistically relevant but also economically sizeable.

----Insert table 7 here ----

Table 8 offers the complementary perspective by focusing on eligible households that do not currently receive the *Bono Social*. The observed incidence of LIHC energy poverty in this group is extremely high at the bottom of the income distribution: 74.83% in decile 1 and 75.46% in decile 2, while in decile 3 it falls to 26.59%. Under the full-take-up scenario, these rates fall to 5.21%, 5.61%, and 1.54%, respectively. The implied relative reductions suggest that the *Bono Social* would play a major role in reducing energy poverty or, in other words, that the lack of accurate targeting seriously limits the effectiveness of the policy.

Two implications follow from these results. First, the eligible non-recipient population appears to be concentrated precisely where energy poverty is most severe, suggesting that incomplete take-up or coverage gaps may have important distributional consequences. Second, the potential anti-poverty gains from extending support are very large in the lower deciles. In this sense, the simulation for eligible non-recipients complements the evidence for current beneficiaries: the first shows that many recipient households depend heavily on the programme to remain outside energy poverty, while the second indicates that a sizeable share of eligible households currently excluded from the scheme would also benefit materially if coverage were more complete.

The monetary values imputed in Table 8 reinforce this interpretation. The average annual support needed to scape energy poverty among eligible non-recipients ranges from €1,750.85 to €1,913.71 across the three reported deciles, with the electricity component accounting for the largest share. These values are notably higher than those observed among current recipients, which is consistent with the possibility that some eligible households currently outside the programme face severe affordability constraints and have substantial potential entitlements under the existing rules. At the same time, these estimates should be interpreted as policy simulations under full eligibility-based take-up rather than as realized causal effects. The exercise is intended to characterize the potential scope of the programme under improved coverage, not the behavioural response that would necessarily arise in practice.

----Insert table 8 here ----

4.3 Cash-equivalent support required to exit energy poverty, by income decile and bono social status

In this section, we estimate the cash-equivalent transfer required to close the energy poverty gap through a static accounting exercise. We report results separately for recipients and non-recipients of the *Bono Social*. The LIHC indicator is used as reference benchmark. For each household, we compute the reduction in energy out-of-pocket expenditure that would be necessary for the household to fall below the respective poverty threshold, holding income constant. Table 9 reports the average required transfer by equivalized income decile.

Several patterns emerge. First, households not receiving the *Bono Social* require, on average, higher cash-equivalent transfers to exit energy poverty compared to recipients. For instance, in the first income decile, recipients would require approximately €96 to no longer satisfy the LIHC condition, whereas non-recipients would require around €185. This difference is statistically significant (p-value = 0.000), suggesting that the *Bono Social* acts as a buffer against energy poverty. However, in the second and third income deciles, the differences in the required monetary compensation between recipients and non-recipients are not statistically significant.

Second, required compensation generally increases with income decile among households experiencing energy poverty under the LIHC indicator. Conditional on remaining classified under LIHC, households in higher deciles exhibit larger excess energy costs relative to the benchmark. Within a static accounting framework, these findings suggest that energy poverty in the lower part of the income distribution is heterogeneous in intensity, with deeper monetary gaps observed among those closer to the income cutoff.

Third, the distribution of households experiencing energy poverty under the LIHC indicator reflects the structural income restriction embedded in its definition. Because LIHC requires household income to fall below 60% of the national median, energy-poor households are observed only within the first three income deciles. This concentration therefore stems from the definitional structure of the indicator rather than from an empirical distributional pattern alone.

---Insert Table 9 here ----

Next, we perform a complementary exercise. Average amounts may conceal heterogeneity in the resources required for households experiencing energy poverty to exit that condition. To account for this, we examine the distribution of compensation needs decile by decile and calculate the fraction of households that would escape energy poverty for a given income transfer. For this simulation, we adopt the most stringent benchmark—being non-poor according to the LIHC indicator—and assess the effects of three potential annual lump cash equivalent amounts: €500, €1,000, and €1,500, irrespective of the delivery mechanism (direct transfer or bill discount).

Table 10 summarises the results. The first row reports pre-transfer prevalence of energy poverty by income decile, while the following rows show the reduction achieved under each simulated transfer. The results confirm that even modest income supports can lead to substantial reductions, particularly among the income-poor: a €500 transfer would reduce poverty by 17.4 percentage points in the bottom decile, while a €1,500 transfer would achieve a 24.8 percentage point reduction. These findings suggest that modest, well-targeted transfers can materially reduce energy poverty among low-income households—a pattern also observed in the case of France's *chèque énergie*, a targeted energy voucher (Martin et al., 2025).

---Insert Table 10 here ----

5. Conclusions

This paper examined the socio-economic gradient of energy poverty in Spain, using a dynamic model that allows for state dependence. The results indicate that energy poverty in Spain is significantly persistent, with short-term financial stress being a key risk factor. The paper also examined differences in energy poverty dynamics between recipients and non-recipients of Spain's *Bono Social*. The estimates suggest that recipients of the programme tend to be more entrenched in energy poverty and face more structural vulnerabilities than non-recipients.

The paper also implements a set of policy-relevant counterfactual simulations. The results indicate that the program plays a meaningful protective role among current recipients, particularly in the lower part of the income distribution, where a non-negligible share of households observed outside energy poverty would fall back into deprivation in the absence of support. At the same time, the results reveal substantial coverage gaps: many eligible households not currently receiving the programme remain heavily exposed to energy poverty, and counterfactual full take-up would imply large reductions in deprivation. Taken together, these findings suggest that the problem is not simply whether support exists, but whether it reaches the households for whom it matters most. More broadly, the paper points to the importance of support adequacy. The simulations of cash-equivalent support indicate that the resources required to exit energy poverty vary across households and income deciles, and that relatively modest amounts of well-targeted support may generate sizeable reductions in poverty among the lowest-income groups. This reinforces the case for moving beyond binary recipient/non-recipient distinctions and paying greater attention to the depth of deprivation and the magnitude of the gap that policy must close.

Significant territorial differences suggest that, although current support schemes already account for territorial variation to some extent, particularly through the climate-based component of the *Bono Social Térmico*, this differentiation may not be sufficient to match the uneven territorial distribution of energy poverty. A more territorially adaptive design could therefore improve policy effectiveness, especially in regions where low incomes, inefficient housing, and climatic severity combine more intensely.

Finally, monitoring frameworks should move beyond unidimensional indicators and incorporate multidimensional and dynamic measures capable of identifying persistent, severe, and recurrent forms of deprivation. Doing so would improve both diagnosis and policy calibration, allowing interventions to distinguish more clearly between chronic vulnerability, temporary shocks, and heterogeneous support needs.

We close by noting several limitations and avenues for future research. Our analysis does not identify the causal effect of the *Bono Social*—allocation and take-up are non-random—and results may be sensitive to measurement choices in indicators and thresholds, as well as to possible regulatory changes in tariffs and taxation. Moreover, the lack of granular billing and contract data (e.g., tariff type, contracted power) limits our ability to unpack mechanisms. A natural next step is to incorporate additional depth/intensity measures—beyond the MEPI used here—such as gap metrics in € or kWh to assess not only who is poor and for how long, but also how far households lie from energy adequacy; this would sharpen the evaluation of policy designs and transfer magnitudes. Future work could also combine these depth indicators with richer administrative/billing data and quasi-experimental opportunities arising from eligibility or rule changes, providing more precise guidance for targeting and program calibration.

References

1. Alvarez, G. G., & Tol, R. S. (2021). The impact of the Bono Social de Electricidad on energy poverty in Spain. *Energy economics*, *103*, 105554.
2. Awan, A., Bilgili, F., & Rahut, D. B. (2022). Energy poverty trends and determinants in Pakistan: Empirical evidence from eight waves of HIES 1998–2019. Renewable and Sustainable Energy Reviews, 158, 112157. https://doi.org/10.1016/j.rser.2022.112157

3. Bagnoli, L., & Bertoméu-Sánchez, S. (2022). How effective has the electricity social rate been in reducing energy poverty in Spain?. *Energy Economics*, *106*, 105792.
4. Boardman, B. (1991). Fuel poverty is different. Policy Studies. https://doi.org/10.1080/01442879108423600
5. Budría, S., & Betancourt, A. (2025). Locked out of power: The overlooked role of housing insecurity in energy poverty. *Energy Research & Social Science*, *129*, 104394.
6. Calama-González, C. M., Escandón, R., Suárez, R., Alonso, A., & León-Rodríguez, Á. L. (2024). Household energy vulnerability evaluation in southern Spain through parametric energy simulation models and socio-economic data. *Sustainable Cities and Society*, *103*, 105276.
7. Carter, M. R. (2019). *The economics of poverty traps*. C. B. Barrett, M. R. Carter, & J. P. Chavas (Eds.). Chicago: University of Chicago Press.
8. Crentsil, A. O., Asuman, D., & Fenny, A. P. (2019). Assessing the determinants and drivers of multidimensional energy poverty in Ghana. Energy Policy, 133, 110884. https://doi.org/10.1016/j.enpol.2019.110884
9. del Río, P., Burguillo, M., & Kiefer, C. P. (2025). Which are the main determinants of energy poverty? A systematic review of the literature. *Energy Efficiency*, *18*(6), 58.
10. Decancq, K., & Lugo, M. A. (2013). Weights in Multidimensional Indices of Wellbeing: An Overview. Econometric Reviews, 32(1), 7-34. https://doi.org/10.1080/07474938.2012.690641
11. Dhongde, S., Pattanaik, P. K., & Xu, Y. (2019). Well-Being, Deprivation, and the Great Recession in the U.S.: A Study in A Multidimensional Framework. Review of Income and Wealth, 65(S1), S281-S306. https://doi.org/10.1111/roiw.12411
12. Drescher, K., & Janzen, B. (2021). Determinants, persistence, and dynamics of energy poverty: An empirical assessment using German household survey data. Energy Economics, 102, 105433. https://doi.org/10.1016/j.eneco.2021.105433.
13. Gobierno de España. (2013). Orden FOM/1635/2013, de 10 de septiembre (BOE-A-2013-9511). Boletín Oficial del Estado.
14. Gobierno de España. (2017). Real Decreto 897/2017, de 6 de octubre (BOE-A-2017-11505). Boletín Oficial del Estado.
15. Gobierno de España. (2018). Real Decreto-ley 15/2018, de 5 de octubre (BOE-A-2018-13593). Boletín Oficial del Estado.
16. Gobierno de España. (2021). Real Decreto-ley 23/2021, de 26 de octubre (BOE-A-2021-17458). Boletín Oficial del Estado.
17. Gobierno de España. (2022a). Real Decreto-ley 11/2022, de 25 de junio (BOE-A-2022-10557). Boletín Oficial del Estado.

18. Gobierno de España. (2022b). Real Decreto-ley 18/2022, de 18 de octubre (BOE-A-2022-17040). Boletín Oficial del Estado.
19. Grotti, R., & Cutuli, G. (2018). Xtpdyn: A Community-Contributed Command for Fitting Dynamic Random-Effects Probit Models with Unobserved Heterogeneity—Raffaele Grotti, Giorgio Cutuli, 2018. https://journals.sagepub.com/doi/abs/10.1177/1536867X1801800406.
20. Halkos, G., & Kostakis, I. (2023). Exploring the persistence and transience of energy poverty: Evidence from a Greek household survey. *Energy Efficiency*, *16*(6), 50.
21. Jové-Llopis, E., Trapero-Bertran, M., & Trujillo-Baute, E. (2025). Energy poverty and health: does the social energy tariff help?. *Energy Policy*, *206*, 114762.
22. Lv, Z., Hussain, S., & Ai, F. (2025). Hydrogen energy and the dynamics of energy poverty: Determinants, persistence, and policy implications for sustainability. *International Journal of Hydrogen Energy*, *129*, 315-328.
23. Martin, É., Neirac, L., Pinton, C., & Ryo Le Roux, L. (2025). *La précarité énergétique en 2023: un impact majeur du bouclier tarifaire et des chèques énergie* (Théma Essentiel). Commissariat général au développement durable (CGDD), Service de l'économie verte et solidaire (SEVS).
24. OECD (2025), OECD Economic Surveys: Spain 2025, OECD Publishing, Paris, https://doi.org/10.1787/abc5c435-en.
25. Ozdemir, E., & Koukoufikis, G. (2024). The persistence of energy poverty in the EU. *Luxembourg: Publications Office of the European Union*.
26. Parreño-Rodriguez, A., Ramallo-González, A. P., Chinchilla-Sánchez, M., & Molina-García, A. (2023). Community energy solutions for addressing energy poverty: A local case study in Spain. *Energy and Buildings*, *296*, 113418.
27. Pedersen, L. M., Jakobsen, A. L., Buttenschøn, H. N., & Haagerup, A. (2023). Positive association between social capital and the quality of health care service: A cross-sectional study. International Journal of Nursing Studies, 137, 104380. https://doi.org/10.1016/j.ijnurstu.2022.104380.
28. Pham, A. T. Q., & Mukhopadhaya, P. (2022). Multidimensionl Poverty and The Role of Social Capital in Poverty Alleviation Among Ethnic Groups in Rural Vietnam: A Multilevel Analysis. Social Indicators Research, 159(1), 281-317. https://doi.org/10.1007/s11205-021-02747-y
29. Price, W.-C., Brazier, K., & Wang, W. (2012). Objective and subjective measures of fuel poverty. Energy Policy, 49, 33-39. https://doi.org/10.1016/j.enpol.2011.11.095
30. Romero, J. C., Linares, P., & López, X. (2018). The policy implications of energy poverty indicators. *Energy policy*, *115*, 98-108.

31. Romero, J. C., Linares, P., Rodriguez-Matas, A. F., & Perez-Bravo, M. (2025). Illustrating the conflicts between energy poverty and decarbonization in the energy transition. A case example in Spain. Energy, 314, 134204.
32. Seth, S., & McGillivray, M. (2018). Composite indices, alternative weights, and comparison robustness. *Social Choice and Welfare*, 51(4), 657-679.
33. Skrondal, A., & Rabe-Hesketh, S. (2014). Handling initial conditions and endogenous covariates in dynamic/transition models for binary data with unobserved heterogeneity. Journal of the Royal Statistical Society Series C: Applied Statistics, 63(2), 211-237.
34. Taltavull de La Paz, P., Juarez Tarrega, F., Su, Z., & Monllor, P. (2022). Sources of energy poverty: a factor analysis approach for Spain. Frontiers in Energy Research, 10, 847845.
35. Wojewódzka-Wiewiórska, A., Dudek, H., & Ostasiewicz, K. (2024). Household Energy Poverty in European Union Countries: A Comparative Analysis Based on Objective and Subjective Indicators. *Energies*, *17*(19), 4889. https://doi.org/10.3390/en17194889
36. Wooldridge, J. M. (2005). Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. Journal of Applied Econometrics, 20(1), 39-54. https://doi.org/10.1002/jae.770
37. Zhang, Y., Zhou, X., & Lei, W. (2017). Social Capital and Its Contingent Value in Poverty Reduction: Evidence from Western China. World Development, 93, 350-361. https://doi.org/10.1016/j.worlddev.2016.12.034

Figures

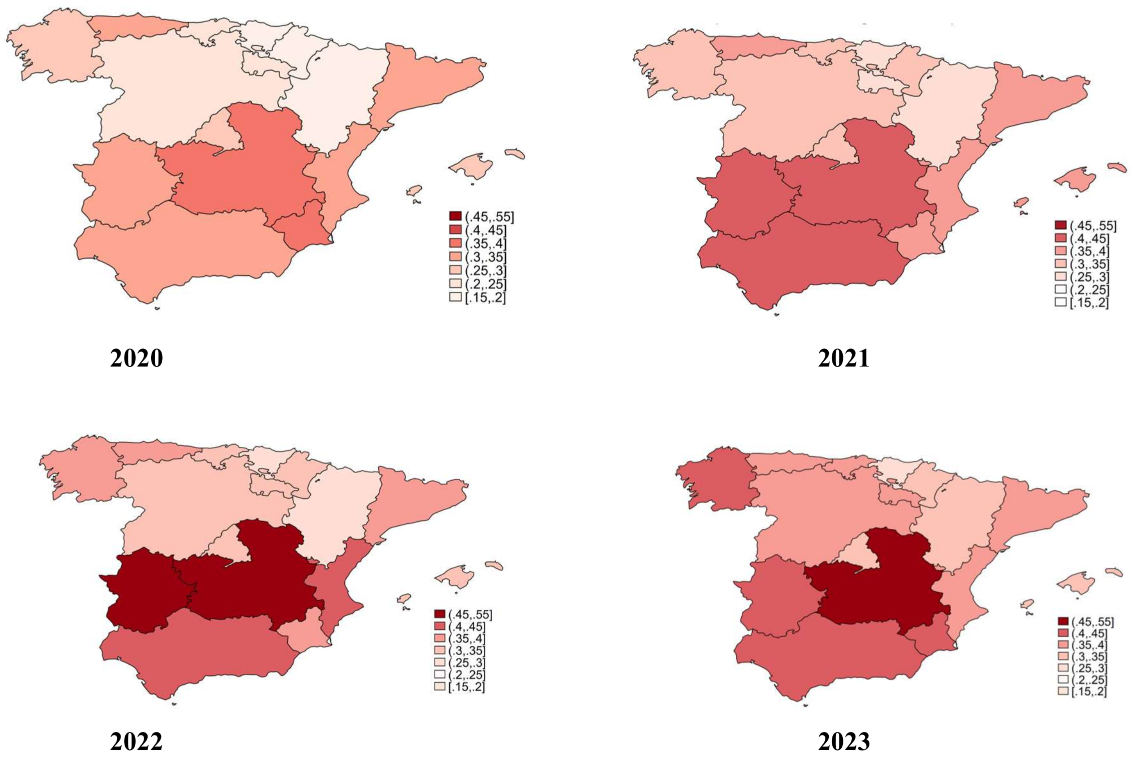

Figure 1. Regional Distribution of Energy Poverty in Spain According to the Multidimensional Energy Poverty Index (MEPI), from 2020 to 2023.

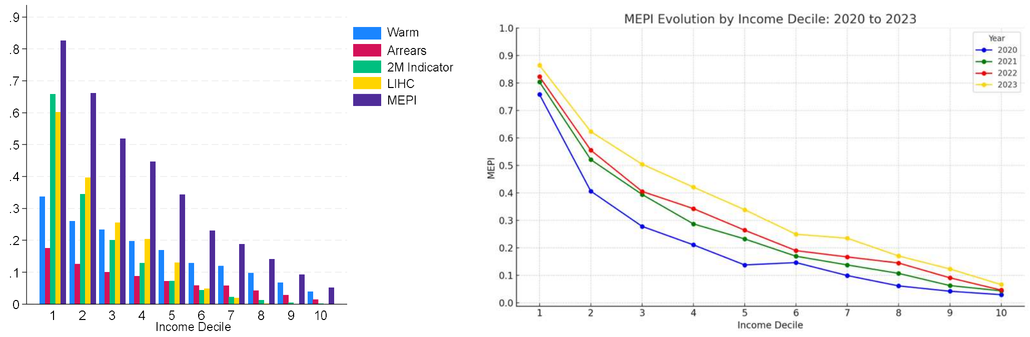

Figure 2. Distribution and Evolution of Energy Poverty by Income Decile in Spain (2020–2023). The left panel shows the prevalence of five energy poverty indicators across income deciles, pooled over the period 2020–2023. The right panel depicts the yearly evolution (2020–2023) of the Multidimensional Energy Poverty Index (MEPI) by income decile.

Tables

Table 1. Percentage of households by duration of energy poverty exposure (2020–2023).

	Never	1 wave	2 waves	3 waves	4 waves	Average duration
Inability to keep warm home	72.85	15.35	7.48	3.65	0.7	1.62
Arrears	87.28	7.59	3.28	1.49	0.4	1.58
2M indicator	74.79	14.67	7.21	2.86	0.5	1.57
LIHC indicator	85.71	7.56	4.10	2.16	0.45	1.69
MEPI	53.40	21.19	14.94	8.43	2.04	1.81

Notes to Table: i) Source: ECV, 4 waves. A household is considered energy poor under the MEPI when the index value is greater than zero (MEPI > 0). Percentages refer to the share of households falling under each indicator for 0 to 4 waves. Average duration is computed among affected households only.

Table 2- Summary statistics by housing status.

	All	Low Household income (H.Inc < Mean (H.Inc) - std (H.Inc))	High Household income (H.Inc > Mean (H.Inc) + std (H.Inc))
No. of observations	52426	4695	6707
Share	100.0	8.94	7.82
Energy Poverty (Relative Freq)			
Inability to keep warm home	0.165	0.342	0.044
	(0.372)	(0.474)	(0.204)
Arrears on utility bills	0.040	0.050	0.021
	(0.197)	(0.219)	(0.142)
2M indicator	0.149	0.683	0.002
	(0.356)	(0.465)	(0.042)
LIHC indicator	0.166	0.613	0.000
	(0.372)	(0.487)	(0.000)
MEPI	0.304	0.812	0.058
	(0.460)	(0.390)	(0.234)
Household income (anual)	33846.39	6684.48	79940.98
	(23714.965)	(2786.997)	(26609.078)
Household energy expenditure (anual)	1307.28	987.65	1627.78
	(813.500)	(639.478)	(980.889)
Bono social	0.082	0.209	0.051
	(0.275)	(0.407)	(0.219)
Monthly financial hardship (Relative Freq)			
Ability to Make Ends Meet	0.568	0.293	0.850
	(0.495)	(0.455)	(0.358)
Ability to Cover Unexpected Expenses	0.673	0.375	0.931
	(0.469)	(0.484)	(0.254)
Arrears on Hire Purchases or Loans	0.040	0.050	0.021
	(0.197)	(0.219)	(0.142)
Major urban area (Relative Freq)	0.832	0.792	0.894
	(0.374)	(0.406)	(0.308)
Rural area (Relative Freq)	0.168	0.208	0.106
	(0.374)	(0.406)	(0.308)
Housing tenure status (Relative Freq)			
Owned	0.511	0.514	0.523
	(0.500)	(0.500)	(0.499)
Mortgaged	0.286	0.134	0.379
	(0.452)	(0.341)	(0.485)
Rented	0.149	0.245	0.073
	(0.356)	(0.430)	(0.260)
Granted use	0.054	0.106	0.025
	(0.225)	(0.309)	(0.155)
Dwelling(Relative Freq)			
Detached house	0.329	0.361	0.337
	(0.470)	(0.480)	(0.473)
Apartment building (≤10 units)	0.185	0.224	5.143
	(0.388)	(0.417)	(0.340)
Apartment building (≥10 units)	0.486	0.414	0.530
	(0.500)	(0.493)	(0.340)
Number of rooms	4.735	4.412	5.143
	(1.099)	(1.165)	(0.962)
Employment status (Relative Freq)			
Employed	0.534	0.300	0.677
	(0.498)	(0.458)	(0.468)
Unemployed	0.080	0.248	0.036
	(0.272)	(0.432)	(0.187)
Retired	0.271	0.221	0.235
	(0.444)	(0.415)	(0.424)
Inactive	0.112	0.230	0.051
	(0.316)	(0.421)	(0.222)
Men (Relative Freq)	0.577	0.418	0.675
	(0.494)	(0.493)	(0.469)
Woman (Relative Freq)	0.423	0.582	0.322
	(0.494)	(0.493)	(0.469)
Age	57.728	59.120	56.549
	(14.678)	(15.904)	(11.578)

	All	Low Household income (H.Inc < Mean (H.Inc) - std (H.Inc))	High Household income (H.Inc > Mean (H.Inc) + std (H.Inc))
Education level (Relative Freq)			
Tertiary education	0.358	0.171	0.693
	(0.479)	(0.376)	(0.461)
Upper secondary	0.217	0.025	0.002
	(0.412)	(0.157)	(0.047)
Lower secondary or less	0.424	0.620	0.142
	(0.494)	(0.485)	(0.349)
Marital status (Relative Freq)			
Married	0.553	0.212	0.811
	(0.497)	(0.409)	(0.391)
Single	0.206	0.334	0.099
	(0.404)	(0.472)	(0.298)
Divorced or separated	0.119	0.245	0.048
	(0.323)	(0.430)	(0.214)
Widowed	0.122	0.209	0.042
	(0.327)	(0.406)	(0.200)
Average annual GDP growth rate	1.7	-	-
	(7.430)		
Regional unemployment	13.8	-	-
	(4.259)		
Spain region(Relative Freq)			
Andalucía	0.109	0.146	0.070
	(0.311)	(0.353)	(0.256)
Aragón	0.042	0.026	0.046
	(0.202)	(0.160)	(0.210)
Asturias	0.031	0.031	0.025
	(0.174)	(0.172)	(0.157)
Baleares	0.027	0.023	0.025
	(0.311)	(0.150)	(0.155)
Canarias	0.003	0.045	0.020
	(0.171)	(0.208)	(0.141)
Cantabria	0.031	0.031	0.025
	(0.172)	(0.174)	(0.158)
Castilla-La Mancha	0.043	0.054	0.029
	(0.203)	(0.226)	(0.167)
Castilla y León	0.064	0.065	0.049
	(0.246)	(0.247)	(0.215)
Cataluña	0.201	0.148	0.257
	(0.400)	(0.355)	(0.437)
Comunidad de Madrid	0.102	0.061	0.178
	(0.302)	(0.240)	(0.383)
Comunidad Valenciana	0.071	0.094	0.054
	(0.257)	(0.292)	(0.226)
Extremadura	0.041	0.072	0.016
	(0.198)	(0.258)	(0.127)
Galicia	0.056	0.067	0.036
	(0.230)	(0.249)	(0.187)
La Rioja	0.028	0.022	0.027
	(0.165)	(0.148)	(0.161)
Murcia	0.036	0.046	0.018
	(0.186)	(0.210)	(0.135)
Comunidad Foral de Navarra	0.025	0.016	0.037
	(0.157)	(0.127)	(0.188)
País Vasco	0.046	0.029	0.066
	(0.209)	(0.167)	(0.249)
Wave			
Wave 1	0.091	0.093	0.078
	(0.288)	(0.291)	(0.269)
Wave 2	0.240	0.293	0.209
	(0.427)	(0.455)	(0.407)
Wave 3	0.342	0.358	0.325
	(0.475)	(0.480)	(0.469)
Wave 4	0.327	0.256	0.380
	(0.469)	(0.436)	(0.487)

All individual-level characteristics (e.g., age, gender, marital status, educational attainment, and employment status) refer to the household head.
The total proportion of households receiving the Bono Social refers exclusively to the Bono Eléctrico and the Bono Térmico, excluding other types of social bonuses such as water.

Table 3- The dynamics surrounding energy poverty.

	WCML (Inability to keep warm home)		WCML (Arrears on utility bills)		WCML (2M indicator)		WCML (LIHC)		WCML (MEPI)	
	Exogenous initial condition	Endogenous initial condition	Exogenous initial	Endogenous initial	Exogenous initial	Endogenous initial condition	Exogenous initial condition	Endogenous initial condition	Exogenous initial condition	Endogenous initial condition
EP_0	---	0.228***	---	0.119***	---	0.247***	---	0.331***	---	0.269***
	---	(0.016)	---	(0.012)	---	(0.001)	---	(0.023)	---	(0.016)
EP_{t-1}	0.181***	0.020*	0.105***	0.019*	0.199***	0.027***	0.253***	0.055***	0.224***	0.064***
	(0.006)	(0.009)	(0.006)	(0.007)	(0.006)	(0.009)	(0.006)	(0.013)	(0.006)	(0.013)
Household Level Variables										
Ability to Make Ends Meet	-0.093***	-0.080***	-0.016**	-0.014**	-0.001	-0.007	-0.021***	-0.013***	-0.069***	-0.073***
	(0.007)	(0.002)	(0.001)	(0.005)	(0.007)	(0.007)	(0.003)	(0.004)	(0.008)	(0.010)
Deferred Purchase Burden	0.031***	0.030***	0.009	0.005	-0.014***	0.005	0.009	0.001	0.028*	0.023
	(0.008)	(0.009)	(0.005)	(0.005)	(0.004)	(0.008)	(0.006)	(0.002)	(0.011)	(0.013)
Ability to Cover Unexpected Expenses	-0.098***	-0.090***	-0.047***	-0.038***	-0.026***	-0.020***	-0.017***	-0.013***	-0.110***	-0.109***
	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)	(0.002)	(0.006)	(0.005)
Arrears on Hire Purchases or Loans	0.031**	0.026*	0.053***	0.037***	0.023	0.026*	0.009	0.005	0.102***	0.107***
	(0.008)	(0.012)	(0.006)	(0.006)	(0.012)	(0.011)	(0.009)	(0.006)	(0.016)	(0.018)
Major urban area (Relative Freq)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Rural area (Relative Freq)	-0.013*	-0.012*	-0.009*	-0.009	0.021***	0.020***	-0.014**	0.009***	0.011	0.012
	(0.006)	(0.006)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.002)	(0.007)	(0.008)
Owned	0.007	0.004	-0.011	-0.009	-0.016*	-0.014*	-0.013*	-0.010*	-0.018	-0.018
	(0.009)	(0.009)	(0.005)	(0.005)	(0.008)	(0.007)	(0.005)	(0.004)	(0.010)	(0.011)
Mortgaged	0.030	0.012	-0.027**	-0.022**	-0.007	-0.006	-0.003	-0.002	-0.028	-0.042*
	(0.016)	(0.016)	(0.010)	(0.009)	(0.015)	(0.028)	(0.010)	(0.009)	(0.018)	(0.011)
Rented	0.030	0.003	-0.031	-0.035*	0.002	0.006	-0.020	0.003	-0.042	-0.063
	(0.016)	(0.028)	(0.018)	(0.017)	(0.027)	(0.028)	(0.021)	(0.018)	(0.033)	(0.038)
Granted use	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Detached house	0.002	0.017	-0.002	-0.025	-0.020	-0.021	-0.037	-0.023	-0.046	-0.067
	(0.035)	(0.041)	(0.024)	(0.021)	(0.034)	(0.039)	(0.029)	(0.018)	(0.042)	(0.053)
Apartment building (≥10 units)	0.004	0.004	-0.004	-0.004	-0.024***	-0.021***	-0.002	-0.001	-0.022***	-0.025***
	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.004)	(0.006)	(0.002)	(0.006)	(0.007)
Apartment building (≤10 units)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Number of rooms	-0.008	-0.001	0.001	-0.007	0.008	0.030*	0.001	0.006	-0.001	0.023
	(0.010)	(0.016)	(0.006)	(0.009)	(0.010)	(0.014)	(0.007)	(0.007)	(0.012)	(0.002)
Household head Variables										
Income Head (ln)	-0.010	0.001	0.001	0.001	-0.024***	-0.021***	-0.013***	-0.009***	-0.017***	-0.021***
	(0.006)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.013)
Employed	-0.011	-0.010	-0.004	0.001	0.036**	-0.003	0.032***	0.019**	0.005	-0.019
	(0.012)	(0.013)	(0.008)	(0.007)	(0.013)	(0.013)	(0.012)	(0.006)	(0.008)	(0.021)
Unemployed	0.005	0.005	0.013**	0.012***	0.005	0.007**	0.014***	0.005*	0.007	0.010
	(0.007)	(0.007)	(0.005)	(0.004)	(0.006)	(0.002)	(0.004)	(0.003)	(0.008)	(0.017)
Retired	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Men	-0.008	-0.006	0.003	0.004	0.004	0.002	0.004	0.002	0.003	0.002
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.002)	(0.005)	(0.006)
Woman	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Age	0.004*	0.002	0.001	-0.001	-0.006***	-0.005***	-0.003**	-0.002*	-0.003	-0.004
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Age^2 x 100	-0.01*	-0.010**	0.001	0.001	-0.01***	-0.01***	-0.01*	-0.01*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.010)	(0.010)	(0.001)	(0.001)
Married	-0.021***	-0.015	-0.010	-0.002	0.029***	-0.043*	-0.041***	-0.020*	-0.047*	-0.021
	(0.006)	(0.020)	(0.012)	(0.011)	(0.005)	(0.018)	(0.012)	(0.009)	(0.023)	(0.027)
Single	-0.003	-0.002	-0.010	-0.013	-0.017**	0.016	-0.007	-0.002	-0.004	0.001
	(0.019)	(0.002)	(0.012)	(0.011)	(0.006)	(0.018)	(0.011)	(0.008)	(0.024)	(0.027)
Widowed	-0.024**	-0.026**	0.002	0.001	-0.073***	-0.006	-0.005	-0.003	-0.007	-0.014
	(0.008)	(0.009)	(0.005)	(0.005)	(0.018)	(0.007)	(0.005)	(0.003)	(0.010)	(0.006)
Divorced or separated	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Tertiary education	-0.024***	-0.023***	-0.011***	-0.009***	-0.035***	-0.032***	-0.010***	-0.007**	-0.050***	-0.053***
	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.002)	(0.005)	(0.006)
Upper secondary	-0.016	-0.009	-0.008	-0.009	-0.018	-0.016	-0.007	-0.006	-0.014	-0.020
	(0.016)	(0.017)	(0.010)	(0.008)	(0.016)	(0.015)	(0.012)	(0.007)	(0.019)	(0.023)
Lower secondary or less	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Regional Level Variables										
Average annual GDP growth rate x 10	0.001	-0.001	-0.005	-0.001	0.001	0.002	0.001	0.001	-0.001	-0.01
	(0.001)	(0.001)	(0.010)	(0.01)	(0.008)	(0.009)	(0.001)	(0.001)	(0.001)	(0.01)
Regional unemployment x 10	-0.03	-0.02	-0.01	-0.01	0.008**	0.060*	0.004*	0.004	0.002	0.003
	(0.03)	(0.02)	(0.02)	(0.01)	(0.001)	(0.02)	(0.002)	(0.002)	(0.003)	(0.003)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	29,393	29,393	29,393	29,393	29,393	29,393	29,393	29,393	29,393	29,393
Num groups	17,206	17,206	17,206	17,206	17,206	17,206	17,206	17,206	17,206	17,206

*Notes: i) Source: ECV, 4 waves; ii) Standard errors small number; iii) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Table 4. Energy poverty dynamic by selected groups.

	Entry probability					Exit probability					Steady state probability					Average duration				
	Inability to keep warm home	Arrears on utility	2M indicator	LIHC	MEPI	Inability to keep warm home	Arrears on utility bills	2M indicator	LIHC	MEPI	Inability to keep warm home	Arrears on utility bills	2M indicator	LIHC	MEPI	Inability to keep warm	Arrears on utility bills	2M indicator	LIHC	MEPI
Income >Mean (income)	0.108	0.034	0.040	0.040	0.189	0.907	0.967	0.968	0.962	0.830	0.107	0.034	0.040	0.040	0.185	1.102	1.033	1.032	1.038	1.203
Income ≤ Mean (income)	0.259	0.124	0.357	0.416	0.664	0.765	0.881	0.698	0.623	0.383	0.253	0.123	0.338	0.400	0.634	1.305	1.134	1.431	1.605	2.605
Men	0.126	0.046	0.101	0.113	0.306	0.853	0.935	0.869	0.841	0.625	0.129	0.047	0.104	0.119	0.328	1.171	1.068	1.150	1.188	1.598
Women	0.132	0.043	0.099	0.108	0.300	0.846	0.940	0.872	0.848	0.687	0.135	0.043	0.133	0.113	0.316	1.180	1.063	1.146	1.178	1.456
Age > Mean (age)	0.191	0.030	0.167	0.168	0.360	0.826	0.966	0.821	0.818	0.653	0.188	0.030	0.169	0.171	0.355	1.210	1.034	1.216	1.221	1.530
Age ≤ Mean (age)	0.134	0.062	0.092	0.175	0.363	0.846	0.919	0.902	0.795	0.582	0.136	0.063	0.093	0.180	0.384	1.181	1.087	1.108	1.257	1.717
University education	0.112	0.038	0.076	0.089	0.262	0.869	0.945	0.899	0.872	0.672	0.114	0.039	0.078	0.092	0.280	1.150	1.057	1.112	1.145	1.486
No University education	0.134	0.046	0.107	0.118	0.285	0.844	0.935	0.861	0.834	0.647	0.137	0.047	0.111	0.124	0.306	1.184	1.069	1.161	1.198	1.544
Employed	0.128	0.041	0.099	0.109	0.346	0.851	0.942	0.871	0.847	0.598	0.130	0.041	0.102	0.114	0.366	1.173	1.061	1.147	1.179	1.593
Unemployed	0.132	0.052	0.102	0.116	0.412	0.846	0.927	0.868	0.837	0.529	0.135	0.053	0.105	0.122	0.438	1.181	1.078	1.151	1.193	1.889

Table 5: Dynamics of energy poverty: beneficiaries vs. non-beneficiaries of the *Bono Social*.

	Inability to keep warm home		Arrears on utility bills		2M indicator		LIHC		MEPI	
	Without Bono Social	With Bono Social	Without Bono Social	With Bono Social	Without Bono Social	With Bono Social	Without Bono Social	With Bono Social	Without Bono Social	With Bono Social
EP_0	0.283^{***}	0.066^{***}	0.116^{***}	0.029^{**}	0.110***	0.038***	0.369^{***}	0.085^{***}	0.354^{***}	0.072^{***}
	(0.002)	(0.013)	(0.012)	(0.009)	(0.018)	(0.024)	(0.029)	(0.015)	(0.014)	(0.011)
EP_{t-1}	0.003	0.028^{**}	0.012	0.006	0.006	0.013	0.025^{**}	0.031^{**}	0.022^{***}	0.094^{***}
	(0.010)	(0.011)	(0.008)	(0.004)	(0.007)	(0.010)	(0.011)	(0.014)	(0.023)	(0.018)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	23,584	23,632	25,097	26,869	24,868	24,019	24,592	23,813	23,934	17,957
Num groups	14,131	14,158	16,298	15,897	16,177	14,464	16,025	14,317	15,610	11,048

*Notes: i) Source: ECV, 4 waves; ii) Standard errors small number; iii) * p < 0.05, ** p < 0.01, *** p < 0.001*

Table 6: Energy-poor vs. non-energy-poor households: *Bono Social* coverage and leakage, by income decile (MEPI indicator).

		Decile 1	Decile 2	Decile 3	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
	Average equivalized disposable income	2204.7	4904.74	6521.57	8848.22	9968.98	11884.9	14328	17518.1	26758.39
	Number of *Bono Social* recipients	232	302	292	242	335	235	149	93	48
Energy-poor households	Share of *Bono Social* recipients (%)	15.02%	19.21%	18.68%	15.25%	18.08%	12.98%	8.64%	5.27%	2.29%
	Number of non-recipients of the *Bono Social*	1,313	1,270	1,844	1,345	1,518	1,576	1,575	1,673	244
	Share of non-recipients of the *Bono Social* (%)	84.98%	82.62%	81.32%	84.75%	81.92%	87.02%	91.36%	94.73%	97.71%
	Obs	1,545	1,572	1,563	1,587	1,853	1,811	1,724	1,766	2,100
	Average equivalized disposable income	8,688	12,027	14,121	18,241	20,607	23,471	27,266	32,775	49,547
	Number of *Bono Social* recipients	513	278	176	134	90	86	58	49	41
Non-energy-poor households	Share of *Bono Social* recipients (%)	20.74%	9.96%	5.98%	4.38%	2.87%	2.63%	1.84%	1.41%	1.23%
	Number of non-recipients of the *Bono Social*	1,960	2,513	2,768	2,927	3,051	3,183	3,093	3,420	3,291
	Share of non-recipients of the *Bono Social* (%)	79.26%	90.04%	94.02%	95.62%	97.13%	97.37%	98.16%	98.59%	98.77%
	Obs	2,473	2,791	2,944	3,061	3,141	3,269	3,151	3,469	3,332

Table 7: Observed and counterfactual non–energy poverty under the *Bono Social*, by income decile (LIHC Indicator).

	Decile 1	Decile 2	Decile 3
Average equivalized disposable income	4386.37	8346.30	10730.56
Non energy poor (Observed, with *Bono Social*)	401	248	372
Share among *bono social* recipients (%)	45.35%	38.82%	71.54%
Non energy poor (Observed, Counterfactual without *Bono Social*)	128	77	147
Share of not energy poor (%)	14.48%	12.14%	28.43%
Relative reduction (%)	68.08%	68.95%	60.48%
Average monetary value of *Bono Social Eléctrico* (€)	548.20	580.59	791.09
Average monetary value of *Bono Social Térmico* (€)	310.91	287.52	249.33
Total value of *Bono Social*	859.11	868.11	1040.42

Notes: Shares are computed over the full sample of Bono Social recipients, including both LIHC energy-poor and non-energy-poor households. In the counterfactual scenario, the Bono Térmico transfer is removed from disposable income and the applicable Bono Eléctrico discount is reversed in electricity expenditure.

Table 8: Observed and counterfactual energy poverty under the *Bono Social*, by income decile (LIHC).

	Decile 1	Decile 2	Decile 3
Average equivalized disposable income	4386.37	8346.30	10730.56
Energy poor (Observed eligible households without *Bono Social* support)	2,949	2,173	581
Share among eligible households without *Bono Social* (%)	74.83%	75.46%	26.59%
Energy poor (Observed eligible households, Counterfactual, with *Bono Social*)	205	161	33
Share of energy poor with *Bono Social* (%)	5.21%	5.61%	1.54%
Relative reduction (%)	93.05%	92.59%	94.32%
Average Monetary value of *Bono Social Eléctrico* (€)	1589.95	1500.40	1651.39
Average Monetary value of *Bono Social Térmico* (€)	302.84	245.34	255.67
Total value of *Bono Social*	1892.79	1745.74	1907.06

Notes: Shares are computed over the full sample of eligible households not receiving the Bono Social, including both LIHC energy-poor and non-energy-poor households. In the counterfactual scenario, the Bono Térmico transfer is added to disposable income and the applicable Bono Eléctrico discount is applied to electricity expenditure.

Table 9: Average difference in excess energy expenditure between *Bono Social* recipients and non-recipients, by income decile (LIHC).

	Decile 1	Decile 2	Decile 3
Recipients of the *Bono Social*	96.29	167.82	462.61
	(10.563)	(16.252)	(34.514)
Non-recipients of the *Bono Social*	185.2	187.25	380.9
	(7.285)	(7.242)	(15.642)
p-value	0.000	0.147	0.978

Table 10: Simulated reduction in energy poverty, by income decile and per-household energy support (LIHC).

	Decile 1	Decile 2	Decile 3
Pre-transfer prevalence of poverty (LIHC)	74.50%	39.80%	25.60%
Poverty reduction by transfer amount			
€ 500	-17.36%	-1.91%	-1.76%
€ 1,000	-21.60%	-3.90%	-3.40%
€ 1,500	-24.80%	-6.20%	-4.80%

Notes: "Energy support" denotes cash-equivalent support to household energy costs, delivered either as direct transfers (Bono Térmico) or bill discounts (Bono Eléctrico).