Determinants, Persistence and Dynamics of Energy Poverty: An Empirical Assessment Using German Household Survey Data

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What is Energy Poverty?

- Experiencing an inadequate level of domestic energy services, but no uniform definition
- Primary indicators to capture different dimension of energy poverty by EU:
  - Arrears on utility bills
  - Low absolute energy expenditures
  - High share of energy expenditure on income
  - Inability to keep the house adequately warm
- Related to energy inefficient homes, high energy costs and low household income
Measuring Energy Poverty

Expenditure-based approach
It is based on monthly household expenditures on domestic energy services relative to household income, with a household considered energy poor if the share of income spent on energy is more than twice the national median.

Consensual approach
It is based on self-reported inability to secure a certain level of domestic energy services.
Motivation

- Just and fair energy transition
- Negative welfare effects
  - Reduction of mental and physical health
  - Reduction of children’s educational attainment
- Requirement of targeted policy measures to tackle energy poverty
Starting with Boardman (1991), there is a well-established literature body on the extent of energy poverty in the UK and Ireland.

Growing number of studies on the prevalence of energy poverty in other European countries.

Empirical findings on determinants of energy poverty are rather limited:
- Healy & Clinch (2004) find that the long-term ill and lone-parent families are among the most energy vulnerable households in Ireland.
- Heindl & Schuessler (2019) find that income, energy expenditure, employment status and housing conditions determine energy poverty in Germany.

Few studies in dynamic context:
- Phimister et al. (2015) find that there is a greater movement out of expenditure-based energy poverty relative to subjective energy poverty and income poverty in Spain.
- Chaton & Lacroix (2018) show that energy poverty in France is mostly a transitory state.
Data

- German Socio-Economic Panel (GSOEP)
- Information on socio-economic, socio-demographic characteristics and housing conditions
- 3 waves (2016-2018)
- Balanced panel
- 9,032 households
Figure 1: (a) PDF of electricity, heating and energy expenditures (b) income profiles and average monthly expenditures on domestic energy services, pooled sample 2016-2018

*Note: Dashed horizontal line represents the mean value of the distribution, while the solid horizontal line represents the median value.*

|                  | D1    | D2    | D3    | D4    | D5    | D6    | D7    | D8    | D9    | D10   |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Average income (€) | 766.28| 1083.18| 1366.20| 1484.92| 1688.54| 1969.93| 2135.88| 2452.79| 2927.97| 4543.67|
| Electricity cost (€) | 46.43 | 48.14  | 48.05  | 47.97  | 48.53  | 49.56  | 50.52  | 50.73  | 52.58  | 59.70  |
| Heating cost (€)   | 55.59 | 61.58  | 64.47  | 65.25  | 67.22  | 68.51  | 69.07  | 68.78  | 73.31  | 57.87  |
| Total energy cost (€) | 113.52| 116.72 | 114.31 | 113.22 | 116.05 | 119.07 | 119.59 | 119.62 | 127.19 | 147.27 |
| Share of income spent on energy (%) | 13.71 | 10.13  | 8.61   | 7.62   | 6.87   | 6.26   | 5.68   | 4.87   | 4.34   | 3.24   |
| Energy Use Intensity (€/eqm)   | 1.44  | 1.31   | 1.20   | 1.15   | 1.15   | 1.13   | 1.04   | 1.01   | 1.02   | 1.03   |
Empirical Strategy

1. **Dynamic random effects probit model** → identifying driving factors of energy poverty dynamic panel data model

2. **Identification function & multinominal logit model** → differing between chronic and transient energy poverty
Dynamic Random Effects Probit

\[ y_{it} = 1[y_{it}^* > 0] \quad (1) \]

\[ y_{it}^* = \gamma y_{it-1} + x_{it}' \beta + u_i + \epsilon_{it}, \quad i = 1, ..., N; \quad t = 1, ..., T \quad (2) \]

- But: initial conditions problem
- Solution: specifying a distribution of heterogeneity conditional on the energy poverty status of a household at the beginning of our panel (Wooldridge, 2005, 2010):

\[ u_i = \alpha_0 + \alpha_1 y_{i0} + \bar{x}_i' \alpha_2 + \nu_i, \quad \nu_i \sim N(0, \sigma^2), \quad (3) \]

\[ y_{it}^* = \gamma y_{it-1} + x_{it}' \beta + \alpha_0 + \alpha_1 y_{i0} + \bar{x}_i' \alpha_2 + \nu_i + \epsilon_{it}, \quad (4) \]
Identification Function

\[
\psi_{\tau}(y_i; z) = \begin{cases} 
2, & \text{if } d_i \geq \tau, \\
1, & \text{if } 0 < d_i < \tau, \\
0, & \text{if } d_i = 0.
\end{cases}
\]

(5)

where \( y_i \) is a energy poverty measure, \( z \) the energy poverty line, \( d_i \) the fraction of periods where \( y_i < z \) and \( \tau \) is an arbitrary duration line.

Multinominal Logit

\[
Pr(y_{ij} = \psi \mid x_i') = \frac{e^{x_i'\beta_{\psi}}}{1 + \sum_{k=1}^{2} e^{x_i'\beta_{\psi}}},
\]

\( \psi = 0, 1, 2, \)

(6)

where never poor (\( \psi = 0 \)) is the reference group.
## Results

### Table 1: Regression Results: Dynamic Random Effects Probit

| Household Type                     | Expenditure-based | Consumer | Consumer 2 |
|------------------------------------|-------------------|----------|------------|
|                                    | (1)   | (2)   | (3)   | (4)   |
| Single parent                      | 0.030**| 0.067**| 0.027**| 0.030**|
| Lower secondary degree             | 0.089| 0.016**| 0.020**| 0.016**|
| Upper secondary degree             | 0.028**| 0.049**| 0.070**| 0.070**|
| University degree                  | 0.026**| 0.026**| 0.026**| 0.026**|
| Other                              | 0.008**| 0.008**| 0.008**| 0.008**|
| Thermal insulation                 | -0.020**| -0.011**| -0.069**| -0.069**|
| Construction Year                  | Ref. | Ref. | Ref. | Ref. |
| Built before 1949                  | 0.009**| 0.007**| 0.041| 0.041|
| Built after 1979                   | -0.017**| -0.017**| -0.017**| -0.017**|
| Heating Type                       | Ref. | Ref. | Ref. | Ref. |
| Detached                           | -0.053**| -0.053**| -0.053**| -0.053**|
| Apartment building                 | -0.049**| -0.049**| -0.049**| -0.049**|
| Heating Type                       | Ref. | Ref. | Ref. | Ref. |
| Oil                                | 0.026**| 0.026**| 0.026**| 0.026**|
| Electricity                        | 0.089| 0.089| 0.089| 0.089|
| District heating                    | 0.006**| 0.006**| 0.006**| 0.006**|
| Other                              | 0.066| 0.066| 0.066| 0.066|
| Environmental Behaviour            | Ref. | Ref. | Ref. | Ref. |
| Renewable energy                   | -0.032**| -0.032**| -0.032**| -0.032**|
| Climate change concern             | -0.005| -0.005| -0.005| -0.005|
| Single parent                      | Yes | Yes | Yes | Yes |
| Labour Force Status                | Yes | Yes | Yes | Yes |
| Household type                     | Yes | Yes | Yes | Yes |
| Income                             | Yes | Yes | Yes | Yes |
| Number of obs                      | 11105 | 11105 | 11105 | 11105 |

Notes: **p < 0.01, *p < 0.05, (1) standard errors in parentheses.
Table 2: Distribution of energy poverty duration states

| Energy poverty duration state | Share of households | Number of households | Share of households | Number of households |
|------------------------------|---------------------|----------------------|---------------------|---------------------|
| Never                        | 0.809               | 7,309                | 0.958               | 8,649               |
| Transient                    | 0.144               | 1,305                | 0.038               | 345                 |
| Chronic                      | 0.046               | 418                  | 0.004               | 38                  |
| Total                        | 1                   | 9032                 | 1                   | 9032                |
Understanding determinants and dynamics of energy poverty is crucial for policy making.

Expenditure-based energy poverty higher than consensual energy poverty.

Facing energy poverty in one period significantly raises the probability of being energy poor in the subsequent period.

Energy poverty is mostly a transitory state.
## Caveats & Next Steps

| Caveats                  |
|-------------------------|
| - Short panel limits sufficient analysis of energy poverty dynamics |
| - No consideration of the depth of energy poverty                  |

| Next Steps              |
|-------------------------|
| - Adding recent wave of GSOEP (year 2019) to data set               |
| - Including population share weights                               |
Thank you for your attention!
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