MEASURING ENERGY POVERTY: FOCUSING ON ACCESS AND AFFORDABILITY

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Overview

This study constructs a multidimensional index to evaluate energy poverty in South Africa by incorporating household basic needs into the measurement. The multidimensional measure focuses on access and affordability of modern energy services. Energy accessibility considers binary indicators of households mainly using clean energy sources for cooking, lighting, water heating and space heating, while affordability is determined by the ratio of household required energy expenditure to income. We adopt an equivalence scale approach proposed by Ye, Koch and Zhang (2022) to estimate household energy requirements with publicly available household expenditure survey data. We use data from the South African Living Conditions Survey 2014/2015 for the empirical analysis.

Methods

Firstly, we follow the methodology proposed by Alkire and Foster (2011) (AF) to construct the multidimensional energy poverty index (MEPI). The AF approach provides two cut-offs through which a set of energy deprivations that may affect household can be incorporated into a multidimensional measure and the energy poor households can be identified. Further, the adjusted headcount ratio is decomposable which allows to investigate poverty in various subgroups. In this study, our MEPI is composed of two dimensions, i.e. accessibility and affordability, with five binary indicators. A household is identified as multidimensional energy poor if the combination of the deprivations for the household exceeds a pre-defined threshold. In our study, a household identified as multidimensional energy poor is deprived in at least one third of the weighted indicators. Finally, the MEPI is the product of a headcount ratio (share of households identified as energy poor) and the average intensity of deprivation of the energy poor.

Secondly, we estimate household required energy expenditure and calculate a ratio of energy requirement to household income in order to determine energy affordability. Energy affordability is defined by Equation (1) and we choose a 10% threshold as suggested in the literature.

$$\frac{Required\ energy\ expenditure\ (i.e. required\ energy\ usage\ \times\ price)}{Income} > 0.1 \qquad (1)$$

Then, we derive household required energy expenditure from a reference household's energy expenditure and rescale it by a household-specific adjustment factor as in Equation (2):

$$RE_i = \bar{E}\ \times \Lambda_i \qquad (2)$$

where RE_i is household i's rquired energy expenditure, $\bar{E}$ is the reference household's energy expenditure and Λ_i represents the energy equivalence adjustment factor for household i. Reference energy ($\bar{E}$) is based on a reasonable living standard in South Africa. For this analysis, we assume that a reasonable standard of living requires access to or use of electricity, living in a formal urban area, clean energy sources for cooking, as well as cold storage for food, the ability to communicate and be entertained. To estimate the energy equivalence scale (Λ_i), we follow the basic idea proposed in Ye, Koch and Zhang (2022) with a semiparametric model, as shown in Equation (3).

$$\omega(x^r, d^r) = \omega\left(\frac{x^i}{\Lambda_{\mathrm{i}}(d^i)}\right) + \varepsilon$$
$$= f\left(\ln(x^i) - \sum_j \lambda_j d_j^i\right) + \varepsilon \qquad (3)$$

where ω refers to household's energy budget share; x, total household expenditure; d, represents categorical characteristics related to household basic needs, superscript r refers to reference household and i refers to a nonreference household; Λ_i is the energy equivalaence scale to be estimated for household i; λ_j is the coefficient for characteristic j in the semiparametric model; and ε, an error term assumed not to be corelated with other household variables in the model. The function f, a convolution of the reference group's budget share function ω with the exponential function, is estimated nonparametrically, via np package (Hayfield and Racine, 2008) for R. To get the equivalence scale (Λ_i), it is necessary to take the exponential of the sum of the estimates for all of the relevant characteristics (that are different from the reference household). That is,

$$\Lambda_i(d^i) = \exp\left(-\sum_j \lambda_j d_j^i\right) \quad (4)$$

Results

Our estimated household required energy expenditure range from ZAR 94.41 to ZAR 524.49 per month. On average, both household actual and required energy expenditure increase with income in urban and rural areas, although higher income households in urban formal and rural formal spend more on energy consumption than those in another groups. In terms of energy requirement, lower income households tend to have similar required energy across the four settlement groups, while the highest income households require more energy consumption in urban formal and rural formal areas than others.

With respect to energy poverty measures, more than 30% of households in urban informal, traditional and rural formal areas experience energy affordability issue. Regarding energy access, electricity is the main source of energy used for cooking, lighting and water heating across all the settlement groups. More than 93% of urban formal households together with about 80% households in urban informal areas use electricity for daily cooking, lighting and water heating. Despite the high electrification rate in traditional (93%) and rural informal areas (81%), only 64-70% households choose electricity as the main source of energy for cooking and water heating; meanwhile, firewood is widely used in these areas partly due to the fact that wood is much cheaper than electricity and they may be able to fetch wood for free. Due to the mild weather in the country, only 57% urban formal households mainly use electricity for space heating purpose while quite a number of households do not heat their home with any energy source in all the settlement groups. Moreover, the percentage of households mainly using electricity for water heating is higher than that for cooking for almost all the groups. This is consistent with the literature that water heating (often by electric geysers), rather than space heating is the largest end-use of electricity in the residential sector in South Africa. In total, 18% households are identified as multidimensional energy poor in South Africa.

Conclusions

Our study contributes to the literature from at least two perspectives. The main contribution is the construction of a multidimensional measure of energy poverty considering both energy access and affordability. Previous studies on energy poverty measurement have been mostly focused on access to modern energy services as accessibility has been the primary concern in developing countries. Incorporation of affordability into a multidimensional energy poverty measure requires definition and estimation of household basic needs while this information is rarely available in most of existing data. In this study, we incorporate energy affordability into a multidimensional energy poverty measure while the affordability is determined by household required energy expenditure which can be estimated using publicly available household budget survey data. This study also contributes to the limited local literature on multidimensional energy poverty measurement, especially in reveal the urban-rural discrepancy in terms of access and affordability of modern energy services.

References

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