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The nexus between energy poverty, social capital and well-being in Gauteng, South Africa

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Abstract

The paper reports on an investigation into the impact of energy poverty and social capital on well-being, comparing individuals from below- and above-poverty line households. A multidimensional energy poverty index (MEPI) was constructed using a generalised structural equation modelling approach to measure the effect of energy poverty on well-being. We found that that higher levels of energy poverty, measured objectively as an MEPI, or subjectively as energy satisfaction, affected well-being negatively, while higher levels of social capital increased well-being. However, the effects varied by household income: MEPI only had a negative effect on well-being for low-income household respondents, and subjective energy poverty only had a negative effect on low-income and middle-income household respondents. Similarly, social capital's impact varied by household income: for both groups, the strongest source of higher well-being was a sense of belonging, whereas the impact of political trust was stronger for higher-income groups. The findings suggest that policies which decrease energy poverty would improve well-being, but should take into account specific household and community characteristics. Further, fostering neighbourhood social capital is essential, especially for the poorest of the poor.

Keywords: *multidimensional energy poverty index; subjective energy poverty; sense of belonging; community trust; political trust; income level; life satisfaction index*

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1. Introduction

Well-being is valued both as an end in itself and for its virtuous cycle with other socio-economic and personal outcomes. Determinants of well-being include macro- and microeconomic, personal and demographic, and institutional factors (Rodríguez-Pose and von Berlepsch, 2014). Studies have shown that energy is an important element of well-being. At the household and individual levels, it is essential in every facet of modern life. In recognition of its importance, clean and affordable fuel access has been designated as the seventh of the United Nations Sustainable Development Goals (SDG 7).

Energy poverty is likely to have negative consequences for well-being (Churchill et al., 2020). The negative impacts include reducing income (Liu et al., 2022), harming both mental and physical health (Zhang, Shu et al., 2021), and limiting educational attainment (Phoumin and Kimura, 2019). On the other hand, social capital has the potential to increase well-being by facilitating practical support such as the sharing of useful information (Muliadi et al., 2024), as well as being a cushion of emotional support against stress (Kroll, 2011; Kuroki, 2011). In the context of energy poverty, social capital may provide resilience against energy poverty by enhancing access to energy services (Middlemiss et al., 2019).

South Africa is characterised by its low levels of well-being, ranking 83rd in the 2024 World Happiness Report (Helliwell et al., 2024). This has been ascribed to the intersectionality between the legacies of apartheid, economic stagnation, high levels of crime, and breakdown in the provision of public services, including energy provision. As of 2022, 95% of South Africans had access to electricity (International Energy Agency, 2024a); however, per capita electricity consumption had fallen by 17% from 2000 to 2021 (International Energy Agency, 2024b), primarily due to the ongoing electricity crisis of unprecedented daily blackouts, known locally as load-shedding. The electricity crisis, coupled with the rising costs of other heating, cooking, and lighting fuels, are likely to have negative consequences for people's well-being (Marchetti-Mercer, 2023).

This study, therefore, brings together the two strands of research, energy poverty and social capital, using a Beta regression model to empirically examine if the two constructs affect well-being. Energy poverty has been measured using both objective indicators such as threshold approaches and multi-dimensional indices, and subjective indicators such as self-reported feelings of energy affordability (Churchill and Smyth, 2020). The study therefore measured energy poverty with a multidimensional energy poverty index (MEPI) as well as a subjective energy poverty indicator. The MEPI was developed here using a novel generalized structural equation modeling (GSEM) to construct a latent MEPI variable. The MEPI was introduced by Nussaumer et al. (2012). The original MEPI was a composite index, with weighted indicators representing the cooking, lighting, household appliances, entertainment/education, and communication dimensions. However, the MEPI may be criticised, as the weighting of each indicator is subjective, and weights may be assigned arbitrarily. The novel method in this study provides an index with weighting being derived from an empirical estimate of each indicator's contribution to energy poverty. A new measure of social capital was included: sense of belonging, as proposed by Ahn and Davis (2020).

Lower-income groups are likely to be less resilient to threats to their well-being, including through energy poverty, but studies often fail to consider the differences between income groups. This study therefore developed separate models for low-income, middle-income, and high-income household income.

The study makes several contributions. First, it estimates energy poverty by constructing an MEPI, which takes into account the multi-faceted nature of energy poverty. The study uses a novel approach, which ensures objectivity, to construct the MEPI. Second, it integrates social capital into the model, which previous research has not done comprehensively. Third, it differentiates the effects between individuals from low-income and non-low-income households, highlighting the assertion of Woolcock and Narayan (2000) that social capital is the 'capital of the poor'. Fourth, it analyses data from South Africa, addressing the relative lack of research focused on developing countries. South Africa's high level of electricity penetration, at the same time as undergoing a severe electricity supply crisis, makes it a case study for other countries experiencing such a crisis.

The remainder of the paper is organised as follows. Section 2 discusses the relationship between energy poverty, social capital, and well-being. Section 3 gives an explanation of the data, variables and model specification. Section 4 presents the estimation results. Section 5 provides a discussion of the estimation results. Section 6 concludes the study and provides policy recommendations and limitations.

2. Literature review

2.1 Energy poverty, social capital and well-being

A limited body of literature examines the relationship between energy poverty and well-being. Much deals with the detrimental effects of energy

poverty, defined by access to adequate, affordable, reliable, high-quality, safe, and environmentally benign energy sources (Hailemariam et al., 2021), and related concepts like fuel poverty and energy affordability on well-being. Studies measure well-being through objective indicators like income (Liu et al., 2022) and dropping out of education (Liu et al., 2022; Phoumin and Kimura, 2019), and subjective indicators like social status (Lin and Okyere, 2021) and subjective well-being (Churchill et al., 2020; Druică et al., 2019). Existing research primarily investigated developed countries (Biermann, 2016; Druică et al., 2019; Churchill et al., 2020; Welsch and Biermann, 2017) and China (Nie et al., 2021; Qui et al., 2024), leaving a gap in research on developing countries.

Social capital positively impacts well-being by buffering individuals against the effects of stress, and producing a sense of belonging (Kroll, 2011; Kuroki, 2011). This is crucial within the context of energy poverty, where social relations capabilities enhance access to energy services (Middlemiss et al., 2019), while a lack of trust reduces people's adaptive capacity, making them reluctant to ask for help or deal with institutions that could help them address their energy poverty (Grossmann et al., 2021).

Drivers of well-being affect individuals differently depending on their financial resources. Those living below the poverty line may struggle to mitigate threats to well-being, with spending on energy diverting spending from other essentials (Tuttle and Beatty, 2017). Further, social capital has been described as the 'capital of the poor' (Woolcock and Narayan, 2000). We would then expect that it would provide more substantial benefits for low-income households.

The measures used in the study are discussed below and depicted in Table 1. For well-being, previous studies use single-indicator measures (Biermann, 2016; Churchill et al., 2020; Thomson et al., 2017; Zhang, Appau et al., 2021). However, these measures may be sensitive to mood fluctuations and fail to recognise that well-being is in essence multifaceted (Smyth et al., 2008). To address this potential measurement bias, this study adopts a multiple-indicator index of life-satisfaction, to measure well-being (Clair et al., 2021; Kim et al., 2021; Pavot and Diener, 2008).

Energy poverty has been measured with objective measures such as the 10% rule of Boardman (1991), the MEPI (Hong et al., 2022; Nussbaumer et al., 2012; Ren et al., 2023), energy deprivation (Nie et al., 2021), or low-income-high-cost (LIHC) (Lin and Wang, 2020). These measures are unable to account for climatic, social and cultural heterogeneity at the regional, local, and household level, which has prompted support for subjective indicators (Price et al., 2006; Thomson et al., 2017) that account for the 'lived' nature of energy poverty. Ha-Duong and Nguyen (2021) used the subjective response of whether energy usage has been sufficient to meet a household's needs, a similar measure to how satisfied someone is with their energy supply. This study therefore constructs an MEPI as an objective measure of energy poverty, and introduces a novel subjective indicator, energy satisfaction, a global evaluation of individuals' satisfaction with their energy sources. The measure allows individuals to consider and weight access, quality, and affordability according to their importance. Furthermore, it enables the measurement of energy poverty in developing countries with a scarcity of objective energy poverty data, and resolves the quandary of evaluating energy poverty in countries like South Africa with high levels of access to electricity but which suffer from frequent service disruptions.

Table 1: Measures used in the study

Construct	*Variable*	*References*
Well-being	Life-satisfaction index	Clair et al., 2021; Kim et al., 2021; Pavot and Diener, 2008
Energy poverty	Multidimensional energy poverty index	Hong et al., 2022; Nussbaumer et al., 2012; Ren et al., 2023
	Subjective energy poverty (energy satisfaction)	Ha-Duong and Nguyen, 2021
Social capital	Community trust	Churchill and Smyth, 2020; Guo et al., 2022; Kang et al., 2023; Yang and Moorman, 2021
	Political trust	Chang and Kang, 2018; Dong and Kübler, 2021; Newton, 2001; Sibley et al., 2020
	Sense of belonging	Ahn and Davis, 2020; Fujiwara and Kawachi, 2008

While social capital has been formulated in various ways, trust is considered its core element (Portes, 1998). Different forms of trust positively affect well-being (Helliwell et al., 2014; Yip et al., 2007; Zhao et al., 2024). Trust in the neighbours and community members has been used to operationalise social capital in previous research (Churchill and Smyth, 2020; Guo et al., 2022; Kang et al., 2023; Yang and Moorman, 2021). It is relevant for the individual, as neighbours and community members are the people that they most often have day-to-day interactions with, which would likely impact well-being. A second type of trust that has been used in social capital research is political trust, in other words trust in elected leaders, government, or political system (Chang and Kang, 2018; Dong and Kübler, 2021; Newton, 2001; Sibley et al., 2020), which would be based on both the real achievements of the government or leader, as well as their expected future achievements. A novel measure of social capital is sense of belonging, which was proposed by Ahn and Davis (2020). They find that sense of belonging and social capital are theoretically and empirically intertwined, and recommend its use as a measure of social capital. Further, similar terms such as community belonging, or sense of community, have been used to measure social capital (Fujiwara and Kawachi, 2008).

3. Methodology

3.1 Data

The study analyses data from the *South Africa – quality of life survey 2020-2021* (Round 6) (Gauteng City-Region Observatory, 2021), a dataset of 13 617 adult respondents sampled from all 529 wards of the heavily urbanised Gauteng province in South Africa. In each ward, a minimum of 20 adults were interviewed, and in each municipality a minimum of 600. Data was collected through in person interviews, from late October 2020 through to May 2021. The survey collected data on the reported well-being and quality of life of respondents, along with economic and socio-demographic variables.

3.2 Variables

Well-being is a five-item index, with values falling between 0 and 1, developed as sub-index of a revised quality of life index (Naidoo and de Kadt, 2021) as part of the *South Africa – quality of life survey* (Gauteng City-Region Observatory, 2021). The MEPI is constructed from a set of dummy variables: household appliance ownership such as (1) mobile phone; (2) TV; (3) computer; (4) refrigerator; (5) internet connection; (6) household usage of electricity for lighting; and (7) access to modern cooking fuels. Each dummy variable has a value of 1 if the household is deprived of any indicator, and 0 otherwise. MEPI is widely used to evaluate energy poverty, especially in developing countries (Nussbaumer et al., 2012; Ren et al., 2023). Subjective energy poverty (SEP) is measured by the question 'How satisfied are you with the energy sources you currently have access to?', on a five-point Likert scale, rescaled to Dissatisfied (Very dissatisfied, Dissatisfied, and Neither satisfied nor dissatisfied) and Satisfied (Satisfied and Very satisfied), which is similar to the subjective measure of Ha-Duong and Nguyen (2021). Social capital is measured using three questions. The study bases Sense of belonging (SC1) on the question 'I feel I belong in this area where I live', measured on a five-point Likert scale, rescaled to Disagree (Strongly disagree, Disagree and Neither agree nor disagree) and Agree (Agree and Strongly agree). Community trust (SC2) is based on the question 'Generally speaking, do you think that most people in your neighbourhood or community can be trusted or that you need to be very careful when dealing with people in your neighbourhood?' (Guo et al., 2022), measured as a binary response of: 'You need to be very careful' and 'Most people can be trusted'. Political trust (SC3) is based on the question 'How much do you trust the current leaders of our government?' (Sibley et al., 2020), measured on a five-point Likert scale rescaled to Distrust (including Strongly distrust, Distrust and Neither trust nor distrust) and Trust (including Trust and Strongly trust).

The study controls for socio-demographic and individual characteristics that may affect well-being (e.g. Churchill and Smyth, 2020; Ebrahim et al., 2013; Elgar et al., 2011). Included controls are sex (Sex); age groups by generation (Generation); education (Education); Household size (Number); Population group (Population); and Health (Health).

3.3 Research model estimation

The estimation process consisted of two steps. The first step was the construction of an MEPI using a GSEM approach. The second step estimated a well-being function, which included the energy poverty variable (MEPI) with the subjective energy poverty and social capital variables in a Beta regression model.

3.3.1 Multidimensional energy poverty index

For the construction of the MEPI, a 2-parameter logistic (2-PL) item response theory model was applied, fitted using GSEM. GSEM allows for the incorporation of both observed and latent variables, providing a robust framework for modelling complex relationships between multiple indicators (Figure 1).

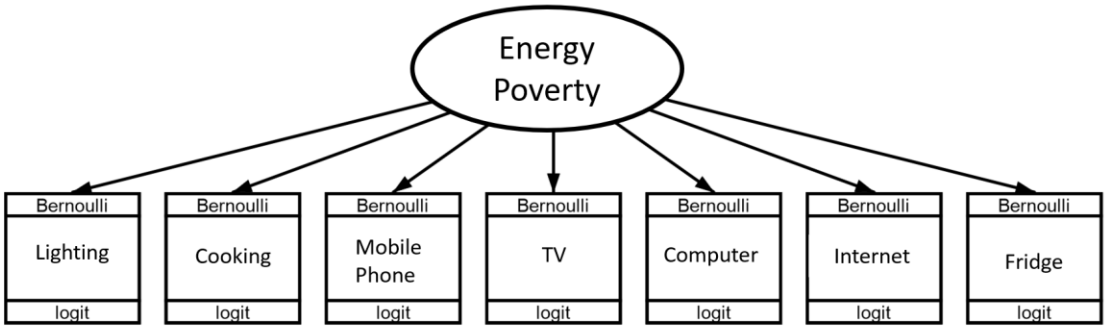

Figure 1: Representation of GSEM for MEPI estimation

Table 2: Dummy variables used for MEPI construction

Variable	*Values*	*Frequency*	*Percentage*	*Number*
Lighting	Electricity (0)	8 240	91.92	8 964
	Other (1)	724	8.08	
Cooking	Modern fuel (0)	8 314	92.75	8 964
	Other (1)	650	7.25	
Mobile phone	Mobile phone (0)	8 758	97.7	8 964
	No mobile phone (1)	206	2.3	
TV	TV (0)	7 695	85.84	8 964
	No TV (1)	1 269	14.16	
Computer	Computer (0)	3 265	36.42	8 964
	No computer (1)	5 699	63.58	
Refrigerator	Refrigerator (0)	7 746	86.41	8 964
	No refrigerator (1)	1 218	13.59	
Internet access	Internet access (0)	2 028	22.62	8 964
	No internet access (1)	6 936	77.38	

The dummy variables used in the construction of the MEPI are shown in Table 2. Above 90% of respondents used electricity for lighting and modern fuel for cooking, reflecting South Africa's high level of access to electricity. Almost all respondents owned a mobile phone; but the ownership rate of household appliances was lower. TV and refrigerator ownership were around 86%, while computer ownership was only around 36%. The low level of computer ownership reflects in the rate of at-home internet access of around 23%.

3.3.2 Beta regression model

To examine the relationship between energy poverty, social capital and well-being, a Beta regression model was estimated by adapting and combining Blanchflower and Oswald's (2004) well-being function and Rodríguez-Pose and von Berlepsch's (2014) social capital function, as in Equation 1.

$$WB_i = f(SEP_i, MEPI_i, SC1_i, SC2_i, SC3_i, X_i) + e_i \quad (1)$$

The Beta regression model (Ferrari and Cribari-Neto, 2004; Smithson and Verkuilen, 2006) accommodates dependent variables that are greater than 0 and less than 1. It estimates the mean of the dependent variable y given covariates x, represented as μ_x. As y (SWB_i) falls within the range of 0 and 1, μ_x should also stay within this range. Therefore, a link function g(·) is utilised to model the conditional mean, as without it, linear combinations of the covariates could exceed the (0, 1) bounds, as in Equation 2.

$$g(\mu_x) = x\beta \text{ or, equivalently } \mu_x = g^{-1}(x\beta) \quad (2)$$

where $g^{-1}(\cdot)$ is the inverse function of $g(\cdot)$. For the logit link that implies Equation 3,

$$\ln\{\mu_x/(1-\mu_x)\} = x\beta \; and$$
$$\mu_x = \exp(x\beta)/\{1+\exp(x\beta)\} \quad (3)$$

the conditional variance of the beta distribution is shown in Equation 4:

$$Var(y|x) = \{\mu_x(1-\mu_x)\}/(1+\psi) \quad (4)$$

The parameter ψ is referred to as the scale factor as it adjusts the conditional variance accordingly. The scale link function is employed to ensure that $\psi > 0$.

As the main analysis method, a series of Beta regression models using STATA 17 was performed. Beta regression does not allow for the magnitude of the effect of coefficients to be determined. Therefore, the post-estimation command 'margins' was applied after the beta regression to obtain interpretable effect sizes for the covariates. After accounting for missing values, a sample size of 8 964 was analysed. First, Model 1 examines if energy poverty and social capital significantly affect well-being for the total sample. Next, the sample was divided into three groups: low-income (up to R19 200 per month), middle-income (from R19 201 to R76 800 per month), and high-income (above R76 800 per month). The three groups were selected following the classification of the University of Cape Town Liberty Institute of Strategic Marketing (2024). In the classification, Poor was defined as household income level qualifying for RDP house/housing subsidy (2012–2022); Working poor as household income level qualifying for child support grant (2012-2022); Working class as household income level qualifying for the Gap Market Housing Subsidy under the Finance Linked Individual Subsidy Programme (2012-2022); Middle class as household income level no longer qualifying for direct government support but still having a household income of less than R75 000 per month; and Upper class consisting of households with the top 2 % of earners and generally having a household income of more than R1 million per year. Further consideration was given to the income scales of the data, as the income bands did not match exactly. Therefore, Poor, Working poor, and Working class became Low-income (i.e. qualifying for government grants), Middle class became Middle income (i.e. not qualifying for direct government support), and Upper class became High-income. Model 2 examines if energy poverty and social capital significantly affect well-being for the low-income households, Model 3 for middle-income households, and Model 4 for high-income households. All models controlled for individual and household characteristics.

4. Results

4.1 Descriptive statistics

The descriptive statistics for the variables are provided in Table 3. A number of interesting results emerged. For well-being, rated between 0 and 1, the mean was around 0.6, meaning that if respondents were to be rated on a 1–10 scale, with 1 being the lowest and 10 the highest well-being, the average respondent would score only 6. Around one third of respondents were dissatisfied with their energy access and quality. Regarding social capital variables, a high proportion of respondents felt they belonged to the area where they lived, while a majority were distrustful of people in their neighbourhood. The distrust of current leaders was even more pronounced. The economic difficulties of respondents were demonstrated by the overwhelming majority falling into the low-income group, although more than half had completed secondary education.

4.2 Beta regression without marginal values

To proceed with the estimation of the main model, the MEPI was estimated. Table 4 shows the estimation results of the GSEM model. The results indicate that all considered indicators have a positive and statistically significant impact on MEPI, showing that if a household is deprived of any indicator, the value of the MEPI increases, implying higher energy poverty. The larger an indicator's coefficient, the higher the relative contribution to a household's energy poverty (compared with other indicators). The results show that a lack of electricity for lighting and modern energy sources for cooking contribute most to energy poverty, while the possession of a mobile phone has the smallest impact.

Table 3: Characteristics of variables

Characteristics of continuous variables					
Variable	*Mean*	*Standard deviation*	*Minimum*	*Maximum*	*Number*
Well-being	0.624	0.155	0.032	0.968	8 964
MEPI	-0.005	0.849	-1.306	2.307	8 964
Size	3.508	2.289	1	24	8 964
Health	0.745	0.244	0	1	8 964

Characteristics of categorical variables				
Variable		*Frequency*	*Percentage*	*Number*
SEP	Satisfied	6 102	68.07	8 964
	Dissatisfied	2 862	31.93	
SC1	Agree	6 675	74.46	8 964
	Disagree	2 289	25.54	
SC2	Trust	3 472	38.73	8 964
	Distrust	5 492	61.27	
SC3	Trust	2 035	22.70	8 964
	Distrust	6 929	77.30	
Sex	Male	4 174	46.56	8 964
	Female	4 790	53.44	
Generation	Generation Z (1997–2012)	1 186	13.23	8 964
	Millennials (1981–1996)	3 522	39.29	
	Generation X (1965–1980)	2 369	26.43	
	Baby boomers (1946–1964)	1 887	21.05	
Education	Less than primary	133	1.26	8 964
	Primary	785	8.76	
	Secondary incomplete	2 959	33.01	
	Matric	2 883	32.16	
	Tertiary: Degree or above	2 224	24.81	
Population	Black African	7 577	84.53	8 964
	White	1 030	11.49	
	Other	357	3.98	
Income	Low-income	7 762	86.59	8 964
	Middle-income	1 028	11.47	
	High-income	174	1.94	

Table 4: Estimation of MEPI using GSEM

Variables	*Lighting*	*Cooking*	*Mobile phone*	*TV*	*Computer*	*Internet*	*Fridge*
MEPI	4.210***	4.663***	0.927***	1.921***	2.305***	2.582***	2.885***
	(0.242)	(0.300)	(0.0817)	(0.0725)	(0.0913)	(0.113)	(0.128)
Constant	-6.302***	-7.187***	-4.149***	-2.748***	0.992***	2.328***	-3.633***
	(0.297)	(0.393)	(0.0998)	(0.0683)	(0.0455)	(0.0812)	(0.121)
Var(MPEI)	1 (constrained)						
Observations	8 964						
Log likelihood	-19429.674						

*** p < 0.001, ** p < 0.010 * p < 0.050

Table 5 shows the estimation results for three models. Model 1 summarises the regression results for well-being over the whole sample. Models 2–4 were estimated to compare the parameter estimates of different variables in the three income groups: low, middle, and high. For the baseline model (Model 1), which included the full sample, Beta estimation results showed that for the energy poverty variables, both MEPI and subjective energy poverty significantly decreased well-being, and all social capital variables significantly decreased well-being. Comparing the Beta estimation results for the low-income group (Model 2), middle-income group (Model 3) and high-income group (Model 4), for the energy poverty variables, MEPI significantly decreased well-being for the low-income group (Model 2), and satisfaction with energy (SEP) significantly increased well-being for the low-income group (Model 2), and middle-income group (Model 3). The results indicated that for the low-income group, respondents with a higher value of the MEPI had decreased well-being, whereas for the low- and middle-income groups, respondents who were satisfied with their energy sources had a higher well-being level compared to those who were dissatisfied with them. All the considered social capital variables had a significant positive impact on well-being for the low-income group (Model 2), and middle-income group (Model 3), whereas for the high-income group, only sense of belonging (SC1) and political trust (SC3) had a significant positive impact on well-being. The results indicate that for the low-income and middle-income group, respondents who felt a sense of belonging to the living area, trusted most people in the neighbourhood or community, and trusted in current government leaders had an increased well-being; however, for the high-income group respondents who felt a sense of belonging to the living area and trusted in current government leaders had increased well-being.

The results for socio-demographic controls are as follows. For the baseline (Model 1), females had a significantly higher well-being than males, respondents from generations M and X had a significantly lower well-being, and those from the baby boomer generation a significantly higher well-being than respondents from generation Z. White respondents had a significantly higher well-being than Black respondents, and household size and health both had a significant positive effect on well-being. Comparing the results for socio-demographic controls for the three income groups, females had a significantly higher well-being than males for the low-income group, respondents from generations M and X had a significantly lower well-being, and those from the baby boomer generation a significantly higher well-being than respondents from generation Z for the low-income group; White respondents had a significantly higher well-being than Black respondents for the low-income and middle-income group; and health had a significant positive effect on well-being for the low-income group. The lower part of Table 5 shows the estimation of the scale variables that might influence the variance of the estimated means.

4.3 Beta regression with marginal values

To obtain the magnitude effects from the estimations in Table 5, the paper implements the command 'margins,' which calculates effect sizes for the covariates on the conditional mean of the dependent variable. Table 6 reports the regression results with marginal effects for the impact of energy poverty and social capital on well-being. Considering that well-being is measured on a scale from zero to one, it is possible to interpret the marginal effects as percentages.

Table 5: Beta regression without marginal effects

WB		*(1)*	*(2)*	*(3)*	*(4)*
Variables		*Baseline (full sample)*	*Low-income*	*Middle-income*	*High-income*
MEPI		-0.071*** (0.009)	-0.074*** (0.010)	-0.022 (0.037)	0.059 (0.098)
SEP	Dissatisfied	-0.130*** (0.015)	-0.134*** (0.016)	-0.135* (0.054)	0.017 (0.109)
SC1	Disagree	-0.212*** (0.016)	-0.213*** (0.017)	-0.192** (0.060)	-0.303* (0.152)
SC2	Distrust	-0.057*** (0.014)	-0.050** (0.026)	-0.065 (0.040)	-0.191 (0.105)
SC3	Distrust	-0.129*** (0.015)	-0.117*** (0.016)	-0.194*** (0.046)	-0.276* (0.137)
Sex	Female	0.061*** (0.014)	0.072*** (0.015)	-0.012 (0.040)	0.037 (0.098)
Gener-ation	M	-0.122*** (0.021)	-0.116*** (0.022)	-0.189* (0.084)	-0.067 (0.177)
	X	-0.099*** (0.023)	-0.093*** (0.024)	-0.150 (0.084)	-0.172 (0.179)
	Baby boomer	0.103*** (0.024)	0.106*** (0.025)	0.045 (0.086)	0.244 (0.193)
Popula-tion	Other	0.038 (0.033)	0.018 (0.061)	0.061 (0.073)	0.336 (0.213)
	White	0.111*** (0.023)	0.061* (0.030)	0.157** (0.046)	0.261 (0.134)
Size		0.006** (0.003)	0.006 (0.003)	0.000 (0.012)	0.022 (0.035)
Health		0.151*** (0.030)	0.142*** (0.031)	0.199 (0.108)	0.394 (0.230)
Constant		0.604*** (0.037)	0.592*** (0.039)	0.749*** (0.032)	0.661* (0.292)
		Scale			
MEPI		-0.076* (0.034)	-0.093* (0.039)	-0.041 (0.135)	-0.546 (0.516)
Size		-0.025* (0.012)	-0.023 (0.013)	-0.047 (0.044)	-0.187 (0.121)
Health		-0.482*** (0.113)	-0.522*** (0.119)	0.046 (0.388)	-1.303 (1.249)
Constant		3.594*** (0.100)	3.624*** (0.105)	3.353*** (0.362)	5.758*** (1.389)
Wald chi2 (Prob>chi2)		1114.94***	868.25***	123.88***	109.51***
Log pseudolikelihood		4702.405	4023.494	583.184	121.104
Observations		8 964	7 762	1 028	174

Model 1 is the baseline model which reports the regression for the whole sample, Model 2 for the low-income sample, Model 3 for the middle-income sample, and Model 4 for the high-income sample.

Reference category for SEP is Satisfied, for SC1 is Agree, for SC2 and SC3 is Trust, for Sex is Male, for Generation is Z, and for Population is Black African.

Coefficients are reported, with robust standard errors in parentheses.

*** p < 0.001, ** p < 0.010 * p < 0.050

Table 6. Beta regression with marginal effects

WB		*(1)*	*(2)*	*(3)*	*(4)*
Variables		*Baseline (whole sample)*	*Low-income*	*Middle-income*	*High-income*
MEPI		-0.017*** (0.002)	-0.017*** (0.002)	-0.005 (0.008)	0.012 (0.020)
SEP	Dissatisfied	-0.030*** (0.004)	-0.032*** (0.004)	-0.030* (0.012)	0.004 (0023)
SC1	Disagree	-0.050*** (0.004)	-0.051*** (0.004)	-0.044** (0.014)	-0.066* (0.034)
SC2	Distrust	-0.013*** (0.003)	-0.012** (0.003)	-0.015 (0.009)	-0.040 (0.023)
SC3	Distrust	-0.030*** (0.004)	-0.027*** (0.004)	-0.042*** (0.009)	-0.056* (0.027)
Sex	Female	0.014*** (0.004)	0.017*** (0.003)	-0.003 (0.009)	0.008 (0.020)
Generation	M	-0.029*** (0.005)	-0.027*** (0.005)	-0.042* (0.018)	-0.014 (0.037)
	X	-0.023*** (0.005)	-0.022*** (0.006)	-0.033 (0.018)	-0.037 (0.037)
	Baby boomer	0.023*** (0.005)	0.024*** (0.006)	0.010 (0.019)	0.048 (0.039)
Population	Other	0.009 (0.008)	0.004 (0.009)	0.014 (0.016)	0.070 (0.043)
	White	0.026*** (0.005)	0.014* (0.007)	0.035** (0.010)	0.055 (0.029)
Size		0.001* (0.001)	0.001 (0.001)	0.000 (0.003)	0.005 (0.007)
Health		0.035*** (0.007)	0.033*** (0.007)	0.044 (0.024)	0.082 (0.047)

Model 1 is the baseline model which reports the regression for the whole sample, Model 2 for the low-income sample, Model 3 for the middle-income sample, and Model 4 for the high-income sample.

Reference category for SEP is Satisfied, for SC1 is Agree, for SC2 and SC3 is Trust, for Sex is Male, for Generation is Z, and for Population is Black African.

Marginal effects are reported, with delta-method standard errors in parentheses.

*** $p < 0.001$, ** $p < 0.010$ * $p < 0.050$

Looking at the baseline (Model 1), which includes the full sample, the results were as follows. Regarding energy poverty, for the MEPI, a one-unit increase in the MEPI score decreased well-being by 1.7%. For the subjective energy poverty (SEP) variable, being satisfied with one's energy supply increased well-being by 3%. Regarding social capital, sense of belonging (SC1) increased well-being by 5%, community trust (SC2) increased well-being by 1.3%, and political trust (SC3) increased well-being by 3%.

Comparing the marginal effects, the three income models revealed several similarities and differences. For energy poverty, a one-unit increase in the MEPI score decreased well-being by 1.7% for the low-income group; however, there was no significant effect for the middle-income and high-income groups. Subjective energy poverty (SEP) increased well-being by 3.2% for the low-income group, and by 3.0% for the middle-income group; however, there was no significant effect for the high-income group. Regarding social capital, sense of belonging (SC1) and political trust (SC3) were the only variables that had a significant positive effect on well-being for all income groups. Sense of belonging (SC1) increased well-being by 5.1% for the low-income group, by 4.4% for the middle-income group, and by 6.6% for the high-income group. Community trust (SC2) increased well-being by 1.2% for the low-income group; however, there was no significant effect for the middle- and high-income groups. Political trust (SC3) increased well-being by 2.7% for the low-income group, by 4.2% for the middle-income group, and by 5.6% for the high-income group.

Among the socio-demographic control variables, females had a 1.7% higher well-being than males for the low-income group; respondents from generation M had a 2.7% lower well-being for the low-income group, and 4.2% for the middle-income group, than respondents from generation Z; respondents from generation X had a 2.2% lower well-being for the low-income group than respondents from generation Z; respondents from the Baby Boomer generation had a 2.4% higher well-being for the low-income group than respondents from generation Z; White respondents had a 1.4% higher well-being for the low-income group, and a 3.5% higher well-being for the middle-income group, than Black respondents; health had a 3.3% positive effect on well-being for the low-income group.

5. Discussion

This discussion explores the impact of energy poverty and social capital on well-being.

A higher MEPI reduced well-being for respondents from low-income households, but not those from middle-income or high-income households. Furthermore, subjective energy poverty reduced well-being for respondents from low-income and middle-income households, but not those from high-income households.

The MEPI was constructed using GSEM as an objective way to measure energy poverty, without introducing bias through subjective weighting choices. The results corresponded well with studies using other methods of measuring energy poverty (e.g. Churchill et al., 2020; Li et al., 2025; Lin and Okyere, 2021; Nie et al., 2021; Qui et al., 2024). While the general negative effect of energy poverty on well-being corresponds with the findings of prior research, the harmful effects of multiple energy poverty are concentrated only on those from low-income households. These households are less able to afford basic necessities such as clean cooking fuels, and essential means of communication. Adding a subjective measure broadened the scope of energy poverty to acknowledge people's subjective experiences, given the 'lived' nature of energy poverty. The effect of subjective energy poverty on well-being encompasses respondents from both low-income and middle-income households. Subjective effects are often linked to expectations. In the field of energy, energy inflation and the ongoing energy crisis in South Africa mean that both groups are unable to meet their expectations regarding their ideal state of energy access. Furthermore, for respondents from high-income households, energy poverty and well-being are not connected. In fact, it is unlikely for them to be experiencing energy poverty measured as MEPI; however, when it comes to subjective energy poverty, high-income households can meet their energy expectations from a variety of sources, even if they are inconvenienced by load-shedding.

In general terms, social capital increased subjective well-being, especially for respondents from low-income households, echoing previous studies (e.g. Guo et al., 2022; Hmimou et al., 2024; Iqbal et al., 2024). The relationship between social capital and well-being has been explained as flowing through affective and instrumental pathways, meaning people can receive emotional and practical benefits from social capital. In the context of energy poverty, the instrumental value of social capital is relevant. Social capital helps vulnerable groups access public services (Hou and Zhang, 2017; Nolan-Isles et al., 2021). Trust of community and a sense of belonging would indicate being embedded in the community and increase a person's tendency to turn to neighbours and others for help to deal with energy poverty (Grossmann, et al., 2021; Middlemiss, et al., 2019). During the current electricity crisis, neighbours would be valuable sources of help in kind. Trust in government leaders would be associated with favourable attitudes toward state institutions. Grossmann et al. (2021) found that distrust in institutions hindered the use of support schemes. Those with less trust would be less likely to make use of these schemes, such as Free Basic Electricity vouchers. For low-income households, all measures of social capital increased well-being. The results contradict the assertion of Ren, et al. (2023) that social capital does not serve as 'capital for the poor', instead reinforcing the findings of Woolcock and Narayan (2000). Strong social connections within the community would be especially important for the lowest income groups to maintain their well-being under conditions of energy poverty. The impact of political trust was stronger for the higher income groups. These groups are likely to be influenced through affective pathways. Trusting in government leaders would engender a more positive outlook for the future of the country, whereas those in the low-income group would be more focused on their own survival.

6. Conclusions and policy recommendations

The study constructed an MEPI using a novel method, to measure the effect of energy poverty on an index measure of well-being. The approach provided an objective measure of energy poverty which was not biased by subjective weighting of indicators, thereby providing reliable results. The findings supplement two disparate areas of literature, the relationship between energy poverty and well-being, and between social capital and well-being. Results show that higher levels of energy poverty (measured objectively as an MEPI or subjectively as energy satisfaction) decreased well-being, whereas higher levels of social capital (sense of belonging, community trust, and government trust) increased well-being. Differences were found between those from low-income, middle-income, and high-income households, whereby MEPI had a negative effect on well-being for low-income households while subjective energy poverty had a negative effect on low-income and middle-income households. Regarding the effect of social capital, for the three income groups, the strongest source of higher well-being was a sense of belonging to their area. Further, the impact of political trust on well-being was stronger for middle- and high-income groups than for the low-income group.

Several implications and policy suggestions can be derived. First, regarding measurement, an MEPI constructed using GSEM provides an objective way to measure energy poverty, without introducing bias through subjective weighting choices. However, adding a subjective measure broadens the scope of energy poverty to encompass people's own subjective experiences. Second, policies which decrease energy poverty would improve well-being. This underlines the urgency of resolving the current electricity crisis in South Africa. Policies should be tailored to the specific characteristics of the locality, community and household. Third, fostering neighbourhood social capital is essential, especially for the poorest of the poor.

The study was limited by several factors. First, the data used was from a single, largely urban province of South Africa. The sample has particular contextual characteristics which may not be present in a rural setting where people's energy choices are limited not by income, but by a lack of energy infrastructure. However, the study provides valuable insights for urbanised areas in the developing world. Second, though the study included social capital in the model, it did not empirically establish how social capital fitted into the relationship between subjective energy poverty and well-being. Future research could address these limitations by looking at a spatially larger dataset, and apply a structural model that delves deeply into the relationships between energy poverty, social capital, and well-being.

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