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Sharing energy poverty: The nexus between social interaction-oriented gift expenditure and energy poverty in rural China

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ABSTRACT

This study examines how social interaction-oriented gift expenditure affects the energy poverty of rural households in China, accounting for energy inaccessibility, unaffordability, and multidimensional energy poverty. A conditional mixed process model was used to estimate the 2016 and 2018 China Family Panel Studies survey data and address the endogeneity of gift expenditure. The results suggest that social interaction-oriented gift expenditure could crowd out rural residents' energy expenditures and drive them to energy poverty. Specifically, every 100 Chinese yuan per capita increase in gift expenditure increases the probability of energy inaccessibility by 2.1 % and energy unaffordability by 1.5 %–1.6 %. This increase also increases the likelihood of rural households being trapped in multidimensional energy poverty by 1.9 %. Furthermore, household deposits mediate the positive associations between gift expenditure and rural energy poverty. Our findings suggest that regulating rural residents' behaviors of giving monetary gifts could help alleviate rural energy poverty.

1. Introduction

The rural energy poverty issue has a long multidisciplinary history, receiving ample and long-lasting attention from policymakers and economists [1–3]. This enduring interest in rural energy poverty could be attributed to the fundamental role of energy sources in human society and the significant threats that energy poverty poses to rural residents' subjective (e.g., happiness and life satisfaction) and objective well-being (e.g., income and expenditures) [1,4,5]. Nevertheless, eliminating rural energy poverty is difficult, especially in developing nations [5–8]. The United Nations Development Program reported that >10 % of the developing world's population still lives with limited electricity access [9]. Furthermore, approximately one-third of the world's population is still excluded from modern and clean energy (e.g., biogas and solar energy) and is burning polluting and unhealthy fuels (e.g., firewood and fossil fuels) for cooking and heating activities. More strikingly, most of this population is from developing nations [9]. Accordingly, the world is still far from achieving the seventh of the sustainable development goals proposed by the United Nations in 2015: empowering people to consume affordable and clean energy by 2030.

Economists have made substantial empirical efforts to investigate energy poverty, and an increasing number of studies have empirically examined the effects of energy poverty, finding that energy poverty diminishes rural residents' well-being. There exist two strands of literature in this field. The first literature strand emphasized that energy poverty reduces people's subjective well-being [5,10–13]. For instance, Nie et al. [5] conducted an empirical study in China and demonstrated that energy poverty significantly lowers people's life satisfaction. Zhang et al. [13] further concluded a negative correlation between energy poverty and children's subjective well-being in China. The second strand focused on objective well-being indicators, indicating that energy poverty reduces human capital [14–16], income [17–19], and household expenditure [20,21]. For instance, Oum [15] and Kose [14] found that energy poverty significantly hinders the accumulation of farmers' human capital, such as educational attainment and health performance in Laos and Turkey, respectively.

Scholars have also closely investigated the factors causing energy poverty and identified coping strategies. They revealed that factors such as energy scarcity due to poor energy resource endowment [22–24], increased energy prices [25,26], extensive utilization of energy [27,28], and income poverty [6,29] have caused severe energy poverty. Specifically, energy scarcity decreases the depth of the energy pool people face by lowering energy accessibility. Increased energy prices and income poverty tighten people's budgets on energy consumption, thus

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decreasing energy affordability; moreover, extensive energy utilization reduces energy use efficiency, simultaneously decreasing people's energy accessibility and affordability.

Existing studies have extensively discussed energy poverty and highlighted the pathways of energy poverty mitigation; however, they do not reveal the entire story. Formal markets are always underdeveloped and even absent for some households in the rural areas of the developing world, such as East Asia, Southeast Asia, and West Africa [2,30]. Thus, the factors (e.g., energy scarcity and income poverty) influencing energy poverty could be distorted by the decentralized nature of decision-making, which is usually manifested as the "*personal prices*" of energy products [31]. The absent formal market tells another story about rural energy poverty.

In rural areas where access to traditional markets is limited, rural residents believe social interaction to be a reasonable coping strategy commonly applied to mitigate unexpected risks and smooth consumption [31–36]. Social interaction facilitates economic cooperation and resource sharing among peer neighbors, friends, and villagers, smoothing the uneven product distribution associated with the heterogeneities of people's abilities and efforts and preventing resource overexploitation [31]. Hence, social interaction may potentially reduce and even prevent rural energy poverty. However, rural residents are also conscious that social interaction brings heavy financial burdens [36,37], potentially leading to energy poverty. Thus, the impact of social interaction on rural energy poverty remains inconclusive. While previous studies largely document the importance of social interaction in reducing lending risks [35,38], determining market participation [39,40], and influencing economic and subjective well-being [36,41], limited information is known about social interaction's impact on energy poverty.

Most existing literature on social interaction tends to define it as a channel for information exchange embodied through word-of-mouth communication and observational learning [34,35,40,41]; however, in many developing countries, social interaction could exist more than information exchange. It is widely manifested as material exchange, such as gift money exchange [36,40]. For instance, rural residents in East Asia consider gift money exchange as their primary strategy in social interactions [36,37]. Compared with communication, exchanging money as gifts indicates people's strong willingness to collaborate [36,37]. Accordingly, social interaction-oriented gift expenditure (SIOGE) could impact energy poverty more than information transmission. Specifically, gift money helps relax people's liquidity constraints and pools the risk of energy pinching, thus reducing energy poverty among rural households. Conversely, an escalating gift expenditure, noted by Hu et al. [36] and Bulte et al. [37], can pose a heavy financial burden to rural households, especially poor ones, and thus squeeze household budgets on non-gift items such as entertainment, education, and energy. In other words, SIOGE could be detrimental to rural household energy consumption. Thus, the impact of SIOGE on energy poverty still remains elusive.

This study investigates the impact of SIOGE on rural energy poverty. Specifically, SIOGE refers to money that a rural household spends as gifts for social interaction events, such as weddings, birthdays, funerals, job promotions, housewarmings, and traditional festivals (e.g., Chinese New Year, Dragon Boat Festival, and Mid-Autumn Festival). A consensus has been reached that escalating SIOGE has a profound impact on rural residents' economic performance in developing areas, such as East Asia, Southeast Asia, and West Africa [36,37], where rural residents struggle to escape from energy poverty [5,21,42–44]. Hence, further elucidating the relationship between SIOGE and rural energy poverty in such areas could be paramount to solving the developing world's rural energy poverty issue. Our study examines China because social interaction in the country is historically based on giving gift money [36,45]. Moreover, energy poverty is also a ubiquitous concern in rural China [5,13].

We make two contributions to the literature on energy poverty and rural energy transition. First, this study attempts to investigate the association between SIOGE and rural energy poverty, utilizing the 2016 and 2018 waves of China Family Panel Studies (CFPS) survey data. Apart from the factors, such as energy scarcity and income poverty, which affect energy poverty [6,22,23], our study provides a new explanation and a practical coping strategy for the incidence of rural energy poverty, the escalating gift money spending, which has been long neglected. Second, we employ a conditional mixed process (CMP) model to address the endogeneity issue of SIOGE. Compared with the panel probit or logit model that only accounts for observed endogeneity, the CMP model robustly addresses observed and unobserved endogeneities. Furthermore, the CMP model relaxes the restrictions on the distributions of the selected variables, which properly suits the matric of binary dependent variables and a continuous key explanatory variable used in our study. Moreover, the CMP model simultaneously regresses the SIOGE and energy poverty equations, improving the estimation efficiency.

The remaining parts of this study proceed as follows. Section 2 outlines the background of social interaction and energy poverty in rural China. Section 3 constructs a simple conceptual framework for disentangling the potential pathways through which SIOGE affects energy poverty. Section 4 introduces the data, key variables, and descriptive statistics; moreover, we discuss the estimation strategy in Section 5, and Section 6 presents and discusses the empirical results. Finally, Section 7 presents conclusions, implications, and limitations.

2. Background

2.1. Social interaction in rural China

Social interaction is a core part of agrarian civilization in China, where society is somewhat *Guanxi* (i.e., relationship) constituted [45]. Chinese villagers rely heavily upon social connections to cope with the disadvantages of the decentralized fashion of agricultural production. Bulte et al. [37] found that rural residents in China spend >10 % of their income on gifts, affording numerous social interaction events such as weddings, birthdays, and funerals. Giving money as a gift among rural residents exerts a significant role in risk hedging, consumption smoothing, and even harmonious rural society building [46]; however, the rapid economic growth and escalating gift expenditure in China have pushed the social interaction's effects on the opposite [36]. That is, gift expenditure exacerbates rural residents' financial burden and crowds out their non-gift expenditures. Hu et al. [36] argued that escalating gift money spending could decrease Chinese rural households' education and entertainment expenditures and reduce their psychological health. Even worse, low-income families in rural China may be forced to conduct dangerous and even illegal behaviors (e.g., selling blood and pilfering) to afford gift-giving spending [47]. As a result, the Chinese government has tried to lessen the importance of gift expenditure in rural areas. For instance, in 2019, Chinese authorities released the "*Guideline on Efforts to Further Eliminate Outmoded Customs and Promote Social Civility in Rural Areas*" to regulate rural gift money giving behaviors; however, objections to this guideline are still voiced in the country. Some scholars believe that gift expenditure is essential for rural society harmony [48,49], and the debate is ongoing concerning the role played by SIOGE in China's rural economic development.

2.2. Energy poverty in rural China

The rural energy poverty issue remains unresolved in China, even though the nation has become the second-largest economy in the world. Despite the full electricity coverage since 2013, over 50 % of rural residents in China still do not have access to modern fuels (e.g., solar energy and natural gas), and they still mainly rely on solid fuels (e.g., firewood and coal) for daily cooking and heating in winter [2]. The amount of coal burned by rural residents accounted for >10 % of their overall energy consumption in 2019 [50]. The extensive use of solid fuels has caused multiple undesirable outcomes in rural China. For instance, residential solid fuel emissions contribute to 85 % of indoor particulate matter ($PM_{2.5}$) and are associated with 94 % of premature deaths in rural areas of China [51]. Furthermore, inaccessibility to modern energies threatens rural residents' psychological health and subjective well-being. Empirical evidence suggests that limited access to clean energy is linked to rural residents in China having higher dissatisfaction with their lives [5,52]. Accordingly, rural energy poverty has become a striking social issue in China.

To alleviate energy poverty, China has taken steps to help rural residents substitute their solid and dirty fuels with modern and clean ones. In 2013, the Chinese central government issued the "coal-to-gas" policy, aiming to promote the shift of rural residents' heating fuel from coal to natural gas. In 2016, the National Development and Reform Commission of China authorized the "*Notice on Benchmarking Feed-in Tariff Policy for Solar Thermal Power Generation*" to encourage rural residents to use solar energy. According to the 2022 Central Document No.1, China has vowed to promote the generation of clean energy, such as photovoltaic and biomass, in rural areas; however, China's rural energy poverty issue has not been fundamentally solved. Fig. 1 illustrates that the installation quantity of solar water heaters in rural areas was only 0.17 m^2/capita in 2020, even though the trend has increased since 2012. Meanwhile, biogas production decreased from 24.72 m^3/capita in 2012 to 20.74 m^3/capita in 2018, representing an average reduction of 2.68 % per year. Furthermore, the coal consumed by China's rural residents reached an astonishing 260 million tons in 2019 [50].

3. Conceptual framework

The theoretical and empirical literature has proven that people in rural areas rely heavily on informal social norms for resource acquisition, subject to limited access to formal markets [31–33,36] Logically, SIOGE could determine rural residents' energy consumption. Drawing literature on social interaction [29,30,32,51] and energy poverty [1,2,5,54], we clarify the relationship between SIOGE and energy poverty by establishing a conceptual framework, as shown in Fig. 2. The various pathways through which SIOGE influences energy poverty can be grouped into the following two categories: promoting pathway and hindering pathway, depending on the giver and recipient roles played by rural residents, respectively.

Regarding the promoting pathway, the underlying logic is that SIOGE erodes gift givers' energy poverty by increasing their financial burdens [36,37]. SIOGE is a typical intertemporal exchange among farmers, which can instantaneously break gift givers' budget balance and increase their financial burdens. As a result, farmers are more likely to be trapped in energy poverty. Specifically, to offer gifts to their friends, relatives, and colleagues; gift givers are forced to allocate a large budget on this with a fixed income. Consequently, they must bear heavy financial burdens and reallocate their household budgets from energy consumption to more urgent needs (e.g., food and medicine bills) [36]. Subsequently, the gift donors involved in the financial burdens sourced from this intertemporal exchange tend to reduce the quantity and quality of fuels consumed. For instance, a rural resident may be forced to collect and burn more firewood to smooth the variation in energy consumption caused by increasing gift expenditure. Conditional to this logic, SIOGE could crowd out rural residents' energy expenditures and drive them to energy poverty. More importantly, cementing a social network cannot be completed quickly, and continuous investment is essential. Meanwhile, partial gift money paid for elevating individuals' social status usually overdrawn rural residents' wallets as it could be motivated by sheer vanity [36,49]. Thus, the positive impact of this intertemporal exchange on energy poverty via financial burden is instantaneous and long-lasting. The endless and competitive SIOGE significantly promotes gift givers' energy poverty.

SIOGE may also hinder the occurrence of energy poverty from the perspective of the gift recipients. First, as an intertemporal exchange, SIOGE can contribute to relaxing rural households' budget constraints on energy purchases. The exchange theory suggests that gift-givers can accumulate a reverse of debts, obligating debtors to need to return the principal and interest in the future [55]; therefore, when the gift-givers transform into recipients, they could significantly improve their financial conditions. Considering Chinese weddings as an example, if "household A" presents 1000 Chinese yuan (CNY) to "household B" for the wedding ceremony, then "household B" needs to present at least 1000 CNY to "household A" for the same event in the future [56,57]. Therefore, as the final gift recipient, "household A" can achieve asset appreciation and thus reduce the probability of energy poverty, such as energy unaffordability; however, this mechanism could be challenged by the theory of the negative-sum game. The intertemporal exchange is between the gift givers and recipients; therefore, gift expenditure could reduce the recipients' energy poverty but simultaneously increase the givers' financial burden and increase their energy poverty.

Second, SIOGE reinforces gift givers' ability to manage unexpected risks [36]. Since time immemorial, social interaction has functioned as the wisdom of risk mitigation when formal insurance is absent [31,33]. In rural areas where decision-making is decentralized, social interaction helps fasten relationships, strengthen group consciousness, and promote collective actions [31]. Accordingly, social interaction could urge people to conduct reciprocal behaviors facing unexpected risks; thus, by exchanging gifts, rural residents are prone to take collective actions, such as mutual aid, to buffer the negative externalities of energy poverty. More directly, gift money, as a kind of "*immediate relief*" for

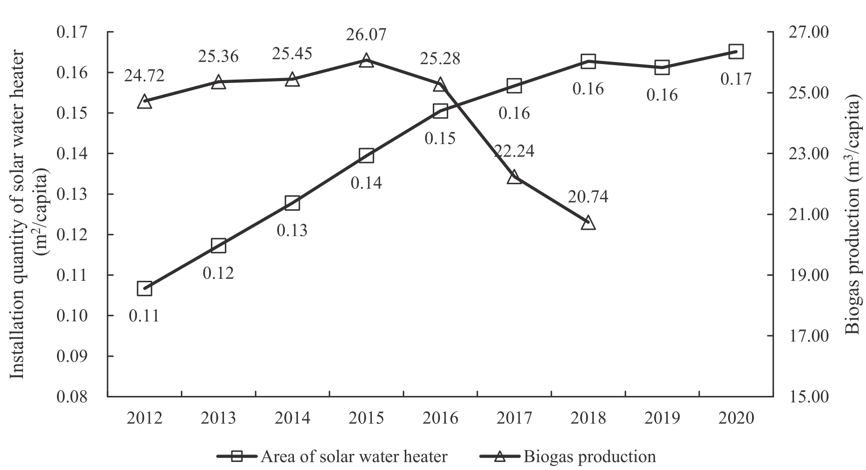

Fig. 1. Renewable energy usage in rural China (2012–2020).
Source: data of the National Bureau of Statistics Ministry of Ecology and Environment (NBSMEE).

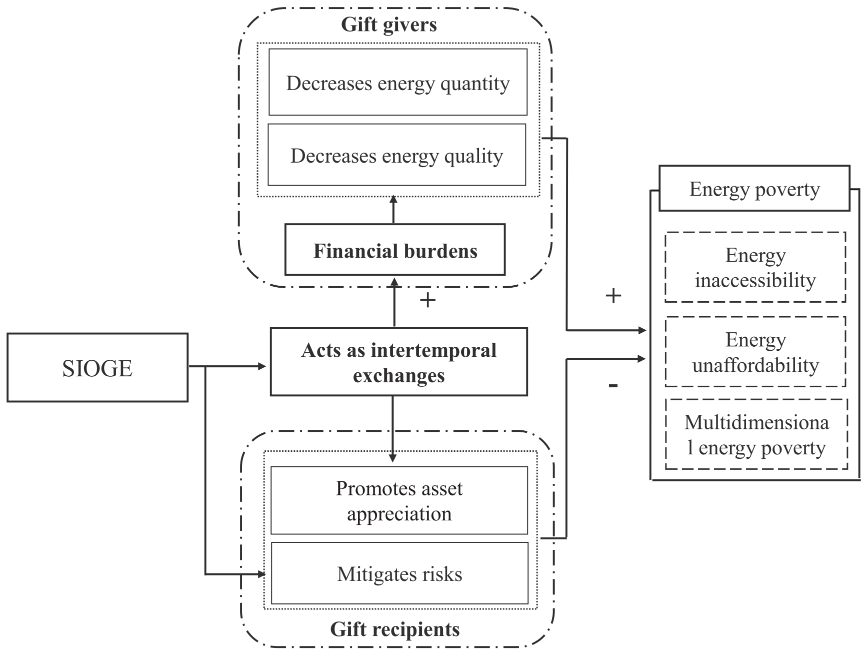

Fig. 2. Potential pathways of the impact of SIOGE on energy poverty.
Note: "+" indicates the "promoting effect", while "-" indicates the "hindering effect".

rural residents, can significantly improve their financial conditions and enhance their resistance to energy shortage.

To summarize, the impact of SIOGE on energy poverty could be mixed as the coexistence of both promoting and hindering pathways. The dataset from the CFPS only provides information on gift money giving; therefore, our study focuses on examining the promoting impact of SIOGE on rural energy poverty from the perspective of gift-givers (i.e., the promoting pathway).

4. Data, variables, and descriptive statistics

4.1. Data

This study used the CFPS data collected by the Institute of Social Science Survey (ISSS) conducted by Peking University, Beijing, China. The CFPS data were collected every two years, beginning in 2010, and the newest household-level publicly available data was collected in 2018. Among them, information on household energy expenditure was not collected in the 2010 wave, and SIOGE information was not collected in the 2012 wave. Furthermore, the definition of SIOGE in the 2014 wave was narrower than in the 2016 and 2018 waves. In more detail, the SIOGE in the 2014 wave only refers to the money spent on the major events (e.g., weddings, birthdays, and housewarming) of relatives and friends, while the expenditure in the 2016 and 2018 waves includes the total spend on the major events of relatives, friends, villagers, colleagues, and strangers. For these reasons, this study used pooled cross-sectional CFPS data collected during the 2016 and 2018 waves.

Utilizing a multistage and random clustered design, the ISSS surveyed 14,763 households from 25 provinces in 2016 and 14,241 households from 31 provinces in 2018. They collected multidimensional information about residents in China, such as demographic characteristics, employment status, household income and expenditure, and financial investments. Given its nationally representative and informative attributes, the CFPS data are widely confirmed as apt and indispensable for studying China's society [58–61]. The 2016 and 2018 CFPS data included abundant information on the patterns of China residents' energy consumption and gift money spending, allowing us to explore the association between SIOGE and energy poverty.

We performed a rigorous clean-up to turn the data from raw to appropriate. First, we retained 14,601 rural observations by dropping the 14,403 urban samples. In China, urban areas have better energy resources than rural areas; there is an urgent need to promote the energy transition and reduce energy poverty in rural China [62,63]. Second, we dropped 1853 observations with outliers and missing values on SIOGE. Third, we removed 1028 samples with abnormal and missing values on the specific energy expenditure (e.g., heating and cooking expenditures). Fourth, to reinforce the accuracy of our empirical results, we also excluded 1652 samples with abnormal and missing values for control variables. The final dataset used in our study comprised 10,068 rural households.

4.2. Key variables

4.2.1. Energy poverty

The measurement of energy poverty does not achieve a consensus in the literature. Extensive research on energy poverty has developed multiple strategies to measure it (see Churchill and Smyth [1] and Farrell and Fry [54] among others). One prominent measure of energy poverty is the multidimensional energy poverty index (MEPI), which is rooted in the pioneering work on the energy poverty definition in the context of African countries by Nussbaumer et al. [64] and then improved by Datt [65] and Alkire et al. [66]. The MEPI captures households' basic energy consumption patterns by considering six dummy indicators: cooking, lighting, heating/cooling, household appliances, entertainment/education, and telecommunication [2,26,67–69]. These dummy indicators are quantified as one if a household does not own a corresponding energy-consuming facility (e.g., computer non-ownership for the entertainment indicator) and zero otherwise; therefore, the MEPI is somewhat of a measure of household wealth.

It bears an emphasis that the 2016 and 2018 CFPS data provide no information to proxy the entertainment indicator, indoor pollution indicator, and telecommunication indicator, limiting our ability to measure the MEPI accurately. Nonetheless, we still refine some alternative indicators for the missing ones from the CFPS dataset and construct a MEPI only for a robustness check. Specifically, we borrow the indicators and the corresponding weights from the famous work of Nussbaumer et al. [64]. For the missing indicators, we utilize internet-connected computer usage, air cleaning facility ownership, and mobile phone usage to proxy the entertainment, indoor pollution, and telecommunication indicators, respectively. Moreover, since China has achieved full coverage of electricity supply since 2013, our study's vector of indicators excludes the lighting dimension. The definitions and weights of the selected indicators are illustrated in Appendix Table A1. Following Li et al. [11] and Nussbaumer et al. [64], we calculate the MEPI using the equation below:

$$MEPI_i = \sum_{i=1}^{n} w_j I_{ij} \tag{1}$$

Here, $MEPI_i$ refers to the MEPI of household *i*. I_{ij} refers to *j* indicators used for calculating MEPI, which covers the dimensions of cooking, indoor pollution, household appliances, education, entertainment, and communication. Moreover, w_j is the weight of a specific indicator that we borrow from the work of Nussbaumer et al. [64].

Based on the calculated MEPI, we categorize a specific rural household as multidimensional energy poverty or not using a dichotomous variable (MEP). Previous studies [13,21,64,70] suggested that MEP takes the value of one if the MEPI exceeds a chosen threshold, such as 0.30, 0.33, 0.50, or 0.70. We followed Zhang et al. [13] and chose the widely used threshold, 0.50. Specifically, MEP equals one if the calculated MEPI is larger than 0.50; in this case, a household is treated as being in multidimensional energy poverty. If the calculated MEPT is <0.50, households are not considered to be in multidimensional energy poverty, and in this case, MEP equals zero.

Apart from the MEPI, Mirza and Szirmai [43] and Yadava and Sinha [44] proposed two indices, the energy inconvenience index (EII) and the energy access index (EAI), respectively, which are widely used to measure energy poverty. EII captures the generalized energy consumption costs, while EAI comprehensively captures energy accessibility. The two indices have been approved apt for reflecting a specific dimension of energy poverty; however, the CFPS data provides no information on the indicators (e.g., frequency of buying or collecting a source of energy, time spent on energy collection per week, household member's involvement in energy acquisition) for calculating the EII and EAI. Therefore, our study is forced to skip these indices. Accessibility and affordability are two relevant and sequential aspects of energy poverty [2]. While developed nations have achieved full energy access and face the discontinuity of energy supply, rural residents in developing countries confront limited energy accessibility and affordability [71]. Thus, a comprehensive measurement of energy poverty for developing nations like China should consider energy accessibility and affordability [2]. Therefore, we measure the multidimensional energy poverty of rural households by including indicators for energy accessibility and affordability.

We use the solid fuel measure (EP1) to capture energy accessibility by borrowing the method from Zhang et al. [2], where individuals are asked if they use solid fuels (e.g., firewood and coal) as the primary fuel. This measure mainly reflects rural residents' inaccessibility to modern and clean energy (e.g., natural gas and solar energy); hence, this index is widely used to measure energy inaccessibility [2]. This study's EP1 variable is defined as a dichotomous variable, which equals one if a rural household uses solid fuel (e.g., firewood and coal) as primary fuel and zero others.

We employ two alternative approaches commonly used in the literature [1,2,5] to capture energy affordability: the "low-income high cost" (LIHC) index (EP2) and the expenditure-based budget share (EP3). The LIHC index measures a household as energy poverty if the residual household income is below the official poverty line, while basic energy expenditure is higher than the sample average [1,5]. Regarding the expenditure-based budget share, an individual or household is considered in energy poverty if the share of their energy expenditure to income is over 15 % [13]. These two indices imply that the expanding share of energy expenditure to household income can erode people's energy consumption, thereby reflecting a household's energy unaffordability [2]. This study captures the EP2 and EP3 using two dichotomous variables. Specifically, the EP2 variable equals one if the residual income of the sampled rural household is below the official poverty line, while the basic energy expenditure is higher than the mean of the sample and zero otherwise. The EP3 variable equals one if the proportion of a rural household's energy expenditure to income is over 15 % and zero otherwise.

Energy inaccessibility or unaffordability only reflects one specific dimension of rural energy poverty, which cannot comprehensively capture the actual condition of farmers' energy consumption. In this case, an index measuring farmers' multidimensional energy poverty is in need, apart from the MEPI above. Therefore, we follow previous studies [5,10] and construct an alternative index (EP4) using the energy deprivation score (EDS) to reflect rural residents' multidimensional energy poverty. Specifically, we construct the index in two steps. First, we calculate the EDS by summarizing equal-weighted EP1, EP2, and EP3. Second, we define the index as one if the EDS is 0.50 or above and zero otherwise. Accordingly, a specific rural household is categorized as multidimensional energy poverty if EP4 equals one and zero otherwise.

4.2.2. Gift expenditure

Our key explanatory variable is SIOGE. Unlike previous studies that focus on total household SIOGE [68,72], we follow Bulte et al. [37] and Li et al. [73] and determine the variable at the per capita level to make the sampled households more comparable. Specifically, SIOGE refers to the sum of total household spending on gifts and the cash directly given to the recipients at the social interaction events (e.g., weddings, birthdays, and funerals) in the survey reference year, measured at 100 CNY per capita.

4.3. Control variables

To capture the effects of individual and households' demographic and socioeconomic characteristics on gift expenditure and energy poverty, we also include a vector of exogenous factors as control variables. Following previous studies [1,2,5,24,54], we use the household head's age, gender (i.e., male or not), educational level, risk attitude, household size, child ratio, and elderly ratio to capture households' demographic characteristics. Previous studies have concluded that farmers' attractiveness in presenting gifts depends on their pursuit of risk elimination [31,32]; therefore, we introduce the variable representing rural residents' risk attitude to determine this correlation. We used household car and land ownership to comprehensively characterize household economic conditions. Although car ownership, a measure of household wealth, can release farmers' financial burden on energy purchases, it may also increase rural households' fossil fuel consumption; thus, we control car ownership and clarify its impact on energy poverty. Previous studies [74,75] have documented that housing conditions may influence energy use efficiency, determining rural households' energy consumption and poverty; hence, we used housing congestion to reflect the effects of housing conditions. Besides, three location dummies (i.e., eastern, central, and western China) and two-year dummies (2016 and 2018) are introduced into our empirical model to capture spatial and temporal-related unobserved disparities, respectively.

4.4. Descriptive statistics

Table 1 presents the descriptive statistics of the selected variables, indicating that the mean values of EP1, EP2, EP3, EP4, and MEP are 0.47, 0.21, 0.10, 0.13, and 0.14, respectively. These values suggest that a considerable proportion of rural residents in China are presently trapped in energy inaccessibility, unaffordability, and multidimensional energy poverty. These findings support the conclusion of Nie et al. [5] and Zhang et al. [2] that rural residents in China are confronting severe

Table 1
Variable definitions and descriptive statistics.

Variables	Definition	Mean	S.D.
Energy inaccessibility			
EP1	1 if rural household uses solid fuel (e.g., firewood and coal) as primary fuel, 0 otherwise	0.47	0.50
Energy unaffordability			
EP2	LIHC index: 1 if rural household's residual household income is below the official poverty line while basic energy expenditure is higher than the average of the sample, 0 otherwise	0.21	0.41
EP3	1 if the ratio of household energy expenditure to total household income is over 15 %, 0 otherwise	0.10	0.30
Multidimensional energy poverty			
EP4	1 if the energy deprivation score is 0.5 or above, 0 otherwise	0.13	0.34
Key explanatory variable			
Gift expenditure	Total annual gift expenditures for social interactions (e.g., weddings, birthdays, and funerals) (100 CNY/capita/year)[a]	10.18	11.22
Mediators			
Deposits	Total household deposits (1000 CNY/capita)	7.82	22.10
Indebtedness	1 if rural household is in debt with formal and/or informal institutions, 0 otherwise	0.23	0.42
Control variables			
Age	Age of household head (HH) (years)	48.32	16.35
Male	1 if HH is male, 0 otherwise	0.50	0.50
Education	Educational level of HH (years)	6.10	4.75
Risk-averse	1 if HH is risk-averse, 0 otherwise	0.40	0.49
Household size	Number of people residing in a rural household	4.09	1.93
Child ratio	Ratio of the number of residents aged 0–14 years to household size	0.03	0.10
Elderly ratio	Ratio of the number of residents aged over 64 years to household size	0.18	0.34
Car ownership	1 if rural household owns a car, 0 otherwise	0.18	0.39
Land ownership	1 if rural household owns farmland, 0 otherwise	0.88	0.33
Housing congestion	1 if the house is congested, 0 otherwise	0.27	0.44
2016	1 if sample is collected in 2016, 0 otherwise	0.48	0.50
2018	1 if sample is collected in 2018, 0 otherwise	0.52	0.50
Eastern region	1 if household is located in eastern China, 0 otherwise	0.34	0.47
Central region	1 if household is located in central China, 0 otherwise	0.29	0.46
Western region	1 if household is located in western China, 0 otherwise	0.37	0.48
Trustworthiness (IV)	1 if HH believes that most of the people around him/her are trustworthy, 0 otherwise	0.72	0.45
Additional variables used in robustness checks			
Average age	Average age of members in the household (years)	34.60	15.74
MEP	1 if MEPI≥0.50, 0 otherwise	0.14	0.35
Sample size		10,068	

Note: S.D. refers to standard deviation. 1 yuan = 0.145 USD.
[a] CNY refers to the Chinese yuan.

energy poverty. We obtained an average SIOGE of 1018 CNY/capita per year in our sample, approximately accounting for the 6.80 % of household income. Conversely, China's rural residents only spent an average of 6.91 % of their disposable income on education and entertainment in 2020 [50]. Accordingly, China's villagers cast social interaction as a vital budget item, at least as education.

Table 1 also reveals that the dominating rural households in our sample are relatively small and headed by relatively young, poorly educated, and risk-averse farmers. Approximately 72 % of the respondents believe that most people around them are trustworthy. On average, approximately 3 % and 18 % of members in the sampled households are children and elderly, respectively. About 18 % and 88 % of the sampled households report owning a car and farmland, respectively. Moreover, about 27 % of respondents perceive that their houses are congested. Finally, the descriptive statistics of year dummies and location variables indicate that sampled rural households are evenly distributed among survey years and regions, respectively.

5. Estimation strategies

5.1. Modeling the impact of SIOGE on energy poverty

According to our conceptual framework, a potential association exists between SIOGE and energy poverty to be unlocked. To mathematically link SIOGE to energy poverty, we assume that energy poverty is a function of SIOGE, a vector of control variables, and an error term. Energy poverty is captured by four dichotomous variables, including energy inaccessibility (EP1), energy unaffordability (EP2 and EP3), and multidimensional energy poverty (EP4); thus, we have the following four standard probit models:

Energy inaccessibility:

$$EP_{1i}^{*} = \alpha_1 GE_i + \alpha_2 X_i + \varepsilon_{1i}, EP_{1i} = \begin{cases} 1\ , & if\ EP_{1i}^{*} > 0 \\ 0, & otherwise \end{cases} \quad (2)$$

Energy unaffordability:

$$EP_{2i}^{*} = \alpha_3 GE_i + \alpha_4 X_i + \varepsilon_{2i}, EP_{2i} = \begin{cases} 1, & if\ EP_{2i}^{*} > 0 \\ 0, & otherwise \end{cases} \quad (3a)$$

Energy unaffordability:

$$EP_{3i}^{*} = \alpha_5 GE_i + \alpha_6 X_i + \varepsilon_{3i}, EP_{3i} = \begin{cases} 1, & if\ EP_{3i}^{*} > 0 \\ 0, & otherwise \end{cases} \quad (3b)$$

Multidimensional energy poverty:

$$EP_{4i}^{*} = \alpha_7 GE_i + \alpha_8 X_i + \varepsilon_{4i}, EP_{4i} = \begin{cases} 1, & if\ EP_{4i}^{*} > 0 \\ 0, & otherwise \end{cases} \quad (4)$$

where EP_{1i}^{*} refers to the probability that household i remains in energy inaccessibility, while EP_{1i} is the corresponding observed variable. EP_{2i}^{*} and EP_{3i}^{*} are the likelihoods of household i to be energy unaffordability, determined by EP_{2i} and EP_{3i}, respectively. Furthermore, EP_{4i}^{*} measures the likelihood of the incidence of multidimensional energy poverty determined by EP_{4i}, and GE_i measures SIOGE of household i. X_i refers to the vector of control variables, such as the household head's age, gender (i.e., male or not), education, household size, and car ownership. α_1, α_2, α_3, α_4, α_5, α_6, α_7, and α_8 are parameters to be estimated and ε_{1i}, ε_{2i}, ε_{3i}, and ε_{4i} denote the error terms.

The above four equations consider SIOGE (i.e., GE_i) an exogenous variable; however, SIOGE is supposed to be the outcome of autonomous behavior, which is gift-giving. Rural residents self-decide how much gift money to spend on social interactions [36]. Both observable factors (e.g., gender, education, and asset ownership) and unobservable factors (e.g., motivations and social skills) tend to influence their gift money spending behavior. For instance, rural residents with adequate energy consumption budgets may have more financial freedom and willingness to spend more on gifts than their counterparts facing budget-constraints. Conversely, those with energy poverty-fighting motivations may spend less on gifts to release their budget constraints. These facts indicate that

SIOGE is potentially endogenous, and failure to consider SIOGE's endogeneity issue would lead to biased estimates regarding its impact on energy poverty. Therefore, we utilize an appropriate econometric strategy (i.e., the CMP model in the present study) to account for the observed and unobserved endogeneities associated with SIOGE and assess the accurate impact of SIOGE on rural energy poverty.

5.2. CMP model

A few econometric approaches are used to analyze panel data in the context of dichotomous dependent variables, including the panel probit model, the panel logit model, and the multilevel probit model (MPM) [76–78]. The major drawback of these approaches is that they consider all explanatory variables as exogenous and neglect the observed and unobserved endogeneities associated with the key explanatory variable. In our study, a household's SIOGE, an endogenous continuous variable, could influence the dichotomous variables of energy poverty and vice versa. Therefore, a simultaneous equations model, such as the recursive bivariate probit (RBP) model [79,80] or the CMP model, which addresses both observed and unobserved endogeneities, could be suitable for determining the relationship between SIOGE and energy poverty. Regarding the distribution patterns of the dichotomous outcome variable (i.e., EP1, EP2, EP3, and EP4) and the continuous key explanatory variable (i.e., SIOGE), only the CMP model is a reasonable approach as the RBP model requires a binary key explanatory variable [80]; however, the CMP model is developed for cross-sectional data, which cannot estimate panel data without controlling the temporal and spatial effects. Given the absence of a suitable panel data model, we follow the strategy of Chamberlin and Ricker–Gilbert [30] and use the CMP model that controls the temporal and spatial effects as our main empirical strategy.

Unlike other econometric strategies, such as the endogenous switching regression model [81], endogenous treatment regression model [82], and RBP model [79], the CMP model is more flexible in estimating different equations simultaneously. Following Roodman [83] and Baum [84], this study uses the CMP model to jointly estimate the equations for energy poverty indices, i.e., Eqs. (2), (3a), (3b), and (4), and the equation for SIOGE. If we align with its continuous attribute, farmers' SIOGE can be formulated using the following linear regression model:

$$GE_i = \beta_1 X_i + \beta_2 IV_i + \mu_i \tag{5}$$

where GE_i and X_i are the same as previously defined. IV_i indicates the selected instrumental variable (IV) for the SIOGE equation. β_1 and β_2 are parameters to be estimated, while μ_i is the error term. In practice, given the specific focus of EP1, EP2, EP3, and EP4 on measuring energy poverty, we use the CMP model to jointly estimate Eqs. (5), (2), (3a), and (3b) to investigate the impact of SIOGE on energy inaccessibility and energy unaffordability. Subsequently, we jointly estimate Eqs. (5) and (4) to assess the association between SIOGE and multidimensional energy poverty.

To guarantee the consistency and efficiency of the estimation, the CMP model utilizes the maximum likelihood (ML) estimator to estimate the SIOGE equation and the energy poverty equations simultaneously. Furthermore, the ML estimator calculates the correlation coefficient ($\rho_{\mu\varepsilon}$) between μ_i and ε_i. As suggested by Baum [84], a significant $\rho_{\mu\varepsilon}$ indicates the presence of unobserved endogeneities, evidencing the validity of estimating the CMP model.

5.3. Instrumental variable identification

For the CMP model to be well specified, it is crucial to identify a valid IV correlated with the endogenous key explanatory variable, SIOGE, which is uncorrelated with the four energy poverty variables (i.e., EP1, EP2, EP3, and EP4). Thus, we instrument rural residents' SIOGE by a dummy, trustworthiness, representing a sampled rural household head's perception of the trustworthiness of others. The trustworthiness variable equals one if a household head reported that they trust most people around them and zero otherwise. Previous studies documented that trust creation is one of the primary goals of social interaction and people's SIOGE decreases with an increase in their trust in others [36,85]; therefore, one would expect that trustworthiness would be negatively correlated with SIOGE. Meanwhile, the trustworthiness variable cannot directly affect energy poverty but only through SIOGE; therefore, the IV we selected is theoretically valid.

Following Ma et al. [61] and Li et al. [73], we further conduct two econometric strategies to verify our IV. The first is a simple falsification test, and the results in Table A2 in the Appendix suggest that trustworthiness is significantly correlated with SIOGE but uncorrelated with energy poverty variables. Second, we run an OLS model for SIOGE and four probit models for EP1, EP2, EP3, and EP4, respectively. The estimates in Table A3 in the Appendix reveal that trustworthiness has a negative and significant impact on SIOGE but exerts no significant effect on the four energy poverty variables. These findings indicate that the trustworthiness variable for endogeneity mitigation is reliable.

5.4. Generalized structural equation model

Mediation analysis helps further understand the implication of a specific empirical study by unlocking the mechanisms through which the key explanatory variable influences the dependent variable. According to our conceptual framework, farmers' financial conditions could channel the relationship between SIOGE and energy poverty (i.e., the promoting pathway that we focus on). To comprehensively identify the role of SIOGE in rural energy poverty occurrence, it is necessary to confirm the mediation effects of the mediators considered. Since household deposits and indebtedness are widely recognized as two main dimensions of people's financial conditions [86,87], we [86,87] cast them as mediators in our mediation analysis.

Prior literature [5,88,89] suggested that the seemingly unrelated regression (SURE) model, structural equation models (SEM), and the generalized structural equation (GSE) model are the three most common methods for mediation analysis. Among them, the SURE model and the SEM approach require the dependent variable to be normally distributed [90,91]. In comparison, the GSE model relaxes this restriction, granting wider application scenarios and a higher estimation efficiency. Since our energy poverty variables are defined as dummies, this study uses the GSM model.

Let us proxy the mediators, household deposits and indebtedness using $Media_1$ and $Media_2$, respectively. Following previous studies [5,91], the GSE model can then be formulated as follows:

$$EP_{ni} = \begin{cases} EP_{ni}^* = \theta_1 GE_i + \rho Media_{1i} + \tau Media_{2i} + \varphi_1 X_i + \zeta_{1i}, \text{if } EP_{ni}^* > 0 \\ 0, \qquad \text{if } EP_{ni}^* \leq 0 \end{cases} \tag{6}$$

$$Media_{1i} = \theta_2 GE_i + \varphi_2 X_i + \zeta_{2i} \tag{7}$$

$$Media_{2i} = \theta_3 GE_i + \varphi_3 X_i + \zeta_{3i} \tag{8}$$

where EP_{ni}^* measures the occurrence of a specific kind of energy poverty defined above (i.e., EP1, EP2, EP3, and EP4), while EP_{ni} is the corresponding observed variable. $Media_{1i}$ and $Media_{2i}$ indicate the selected mediators of household i. GE_i and X_i are defined as above. θ_1, θ_2, θ_3, ρ, τ, φ_1, φ_2, and φ_3 are parameters to be estimated and ζ_{1i}, ζ_{2i}, and ζ_{3i} are error terms. Using the estimates derived from Eqs. (6)–(8), the specific indirect effects can be generated as follows:

The total indirect effect:

$$IE = \theta_2 {}^* \rho + \theta_3 {}^* \tau \tag{9}$$

The indirect effect through $Media_1$:

$$IE_{Media_1} = \theta_2 * \rho \quad (10)$$

The indirect effect through $Media_2$:

$$IE_{Media_2} = \theta_3 * \tau \quad (11)$$

6. Empirical results and discussions

Tables 2–5 present the empirical results. The estimates of $\rho_{\mu\varepsilon}$ in columns 3, 4, and 5 of Table 2 are negative and significantly different from 0, indicating the presence of unobserved endogeneities in our estimations [84]. Therefore, using the CMP model instead of estimating simple probit models for energy poverty equations is reasonable.

We begin with interpreting the factors affecting SIOGE in Section 6.1, followed by discussing the effects of SIOGE and some control variables on energy inaccessibility and unaffordability in Section 6.2. Notably, the coefficients of explanatory variables estimated by Eqs. (2), (3a), and (3b) cannot be interpreted as the impact magnitudes; therefore, we calculate and discuss the corresponding marginal effects in Section 6.3. We then discuss the impact of SIOGE on rural residents' multidimensional energy poverty measured by EP4 in Section 6.4. Finally, we discuss the robustness check and mediation analysis results in Sections 6.5 and 6.6, respectively.

6.1. Factors affecting SIOGE

The escalating SIOGE has posed paramount dual effects (i.e., promotion and hindrance) on rural development, making the identification of SIOGE's determinants helpful in designing appropriate policy strategies. Therefore, we emphasize the discussion of the factors affecting SIOGE. The second column of Table 2 shows the estimates of the factors affecting rural households' SIOGE. The coefficient of the age variable is positive and statistically significant, indicating that old rural residents are more prone to spend more on gifts. Social capital increases with age; therefore, older individuals spend significant money on social interaction events. This finding supports the theory of intertemporal exchange. The education variable positively and significantly impacts SIOGE, suggesting that educated farmers tend to spend more gift money. Better education enables farmers to recognize the importance of social capital (*Guanxi*) to obtain job opportunities and improve their objective well-being, encouraging them to present more gifts. The risk-averse variable exerts a negative and significant impact on SIOGE, suggesting that rural residents with risk-averse attitudes are more likely to spend less on social interaction events. Risk-averse people tend to reduce gift expenditures and reserve budgets for urgent items to cope with unexpected risks. This finding provides supportive evidence for Chen et al. [92], who concluded that risk pooling is not the key driver of Chinese villagers' giving monetary gifts. The variable representing household size

Table 3
Marginal effects of explanatory variables on energy inaccessibility (EP1) and energy unaffordability (EP2 and EP3).

Variables	Energy inaccessibility	Energy unaffordability	
	EP1	EP2	EP3
SIOGE	0.023 (0.004)***	0.021 (0.003)***	0.021 (0.007)***
Age	−0.001 (0.000)	−0.001 (0.000)	−0.000 (0.001)
Male	0.004 (0.006)	−0.015 (0.008)*	−0.004 (0.007)
Education	−0.010 (0.002)***	−0.001 (0.001)	−0.004 (0.001)***
Risk-averse	0.008 (0.011)	−0.000 (0.009)	0.002 (0.014)
Household size	0.040 (0.007)***	−0.001 (0.007)	0.022 (0.012)*
Child ratio	0.124 (0.053)**	0.075 (0.037)**	0.096 (0.046)**
Elderly ratio	0.105 (0.025)***	0.035 (0.020)*	0.083 (0.020)***
Car ownership	−0.166 (0.019)***	0.032 (0.019)*	−0.087 (0.009)***
Land ownership	0.156 (0.028)***	0.016 (0.027)	0.063 (0.023)***
Housing congestion	0.063 (0.019)***	0.012 (0.015)	0.040 (0.017)**
2018	−0.038 (0.021)*	−0.031 (0.017)*	0.002 (0.017)
Eastern region	−0.185 (0.061)***	−0.043 (0.058)	−0.050 (0.061)
Central region	0.130 (0.062)**	−0.031 (0.041)	−0.039 (0.046)
Observations	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita/year. Standard errors are in parentheses. The reference survey year is 2016. The reference region is western China.
*** <0.01.
** <0.05.
* <0.10.

Table 2
Determinants of SIOGE and its impact on energy inaccessibility (EP1) and energy unaffordability (EP2 and EP3): CMP model estimates.

Variables	SIOGE (coefficients)	Energy inaccessibility	Energy unaffordability	
		EP1 (coefficients)	EP2 (coefficients)	EP3 (coefficients)
SIOGE		0.072 (0.015)***	0.079 (0.010)***	0.078 (0.017)***
Age	0.039 (0.009)***	−0.002 (0.002)	−0.002 (0.001)	−0.002 (0.002)
Male	−0.113 (0.178)	0.013 (0.017)	−0.058 (0.032)*	−0.014 (0.024)
Education	0.143 (0.035)***	−0.032 (0.006)***	−0.004 (0.003)	−0.016 (0.003)***
Risk-averse	−0.781 (0.359)**	0.024 (0.035)	−0.001 (0.036)	0.009 (0.053)
Household size	−1.498 (0.147)***	0.125 (0.025)***	−0.002 (0.025)	0.083 (0.035)**
Child ratio	−4.221 (1.196)***	0.389 (0.171)**	0.291 (0.144)**	0.359 (0.157)**
Elderly ratio	−2.429 (0.687)***	0.328 (0.076)***	0.136 (0.076)*	0.311 (0.083)***
Car ownership	3.027 (0.481)***	−0.520 (0.048)***	0.125 (0.076)	−0.327 (0.039)***
Land ownership	−2.081 (0.913)**	0.489 (0.079)***	0.063 (0.104)	0.236 (0.084)***
Housing congestion	−1.684 (0.645)***	0.197 (0.055)***	0.045 (0.059)	0.151 (0.058)***
2018	0.654 (0.413)	−0.119 (0.069)*	−0.121 (0.064)*	0.008 (0.064)
Eastern region	2.272 (2.367)	−0.578 (0.200)***	−0.165 (0.226)	−0.188 (0.226)
Central region	1.374 (1.779)	−0.408 (0.199)**	−0.118 (0.159)	−0.145 (0.178)
Trustworthiness (IV)	−0.418 (0.118)***			
Constant	14.972 (1.689)***	−1.091 (0.262)***	−1.194 (0.170)***	−1.679 (0.158)***
$\rho_{\mu\varepsilon}$		−0.782 (0.124)***	−0.762 (0.067)***	−0.901 (0.101)***
Log-likelihood	−51,664.682			
Observations	10,068	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita. Provincial-level clustered standard errors in parentheses. The reference survey year is 2016. The reference region is western China.
*** <0.01.
** <0.05.
* <0.10.

Table 4
Determinants of SIOGE and its impact on multidimensional energy poverty (EP4): CMP model estimates.

Variables	SIOGE (coefficients)	Multidimensional energy poverty	
		EP4 (coefficients)	EP4 Marginal effects
SIOGE		0.077 (0.013)***	0.019 (0.004)***
Age	0.039 (0.009)***	−0.001 (0.002)	−0.000 (0.000)
Male	−0.113 (0.178)	−0.030 (0.026)	−0.008 (0.007)
Education	0.143 (0.035)***	−0.017 (0.003)***	−0.004 (0.001)***
Risk-averse	−0.781 (0.359)**	−0.007 (0.050)	−0.002 (0.012)
Household size	−1.498 (0.147)***	0.042 (0.029)	0.011 (0.008)
Child ratio	−4.222 (1.196)***	0.418 (0.152)***	0.105 (0.039)***
Elderly ratio	−2.430 (0.688)***	0.281 (0.082)***	0.071 (0.021)***
Car ownership	3.027 (0.481)***	−0.217 (0.035)***	−0.055 (0.011)***
Land ownership	−2.081 (0.913)**	0.307 (0.092)***	0.077 (0.023)***
Housing congestion	−1.684 (0.645)***	0.130 (0.048)***	0.033 (0.013)**
2018	0.657 (0.399)*	−0.063 (0.041)	−0.016 (0.011)
Eastern region	2.272 (2.367)	−0.287 (0.217)	−0.072 (0.056)
Central region	1.375 (1.780)	−0.232 (0.176)	−0.058 (0.045)
Trustworthiness (IV)	−0.409 (0.130)***		
Constant	14.964 (1.676)***	−1.591 (0.166)***	
$\rho_{\mu\varepsilon}$		−0.820 (0.077)***	
Log-likelihood	−41,715.651		
Observations	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita. Provincial-level clustered standard errors are in parentheses. The reference survey year is 2016. The reference region is western China.
*** <0.01.
** <0.05.
* <0.10.

Table 5
Mediation effects: GSE model estimates.

Energy poverty	Mediators	Observed		95 % Confidence intervals		
		Coefficients	Bias	Lower	Upper	
EP1	Total indirect effects	0.026 (0.012)**	−0.000	0.005	0.052	(P)
				0.006	0.052	(BC)
	Deposits	0.015 (0.008)*	0.000	0.001	0.030	(P)
				0.001	0.030	(BC)
	Indebtedness	0.012 (0.009)	−0.000	−0.003	0.030	(P)
				−0.001	0.035	(BC)
	Direct effect	0.107 (0.080)	0.009	−0.039	0.282	(P)
				−0.067	0.243	(BC)
EP2	Total indirect effects	0.036 (0.020)*	0.001	0.001	0.082	(P)
				0.001	0.081	(BC)
	Deposits	0.008 (0.004)*	−0.000	0.000	0.018	(P)
				0.002	0.021	(BC)
	Indebtedness	0.028 (0.019)	0.001	−0.005	0.074	(P)
				−0.005	0.071	(BC)
	Direct effect	0.113 (0.093)	−0.001	−0.079	0.282	(P)
				−0.079	0.282	(BC)
EP3	Total indirect effects	0.063 (0.030)**	−0.001	0.012	0.126	(P)
				0.017	0.142	(BC)
	Deposits	0.043 (0.025)*	−0.000	0.003	0.098	(P)
				0.004	0.103	(BC)
	Indebtedness	0.019 (0.014)	−0.000	−0.004	0.049	(P)
				−0.002	0.055	(BC)
	Direct effect	0.138 (0.110)	0.004	−0.085	0.349	(P)
				−0.114	0.325	(BC)
EP4	Total indirect effects	0.050 (0.024)**	0.001	0.005	0.104	(P)
				0.005	0.104	(BC)
	Deposits	0.024 (0.014)*	0.001	0.002	0.059	(P)
				0.001	0.057	(BC)
	Indebtedness	0.026 (0.019)	−0.000	−0.007	0.072	(P)
				−0.003	0.073	(BC)
	Direct effect	0.112 (0.100)	0.004	−0.075	0.312	(P)
				−0.075	0.312	(BC)

Note: The deposit variable is measured at 1000 CNY/capita/year. (P) refers to the percentile confidence interval and (BC) refers to the bias-corrected confidence interval. Controls include age, male, education, risk-averse, household size, child ratio, elderly ratio, car ownership, land ownership, housing congestion, year-dummies, and region variables. The reference survey year is 2016. The reference region is western China.
** <0.05.
* <0.10.

negatively and significantly impacts SIOGE, suggesting that large rural households may have lower gift expenditures per capita, which is not contrary to common belief as we measure SIOGE in a per capita term. SIOGE is negatively and significantly associated with the child ratio and the elderly ratio. Rural households with a large proportion of dependents are more likely to allocate more budgets to education, healthcare, and nutrition, thus crowding out gift money spending [93].

Table 2 shows that SIOGE tends to be significantly determined by a vector of control variables such as car ownership, land ownership, and housing congestion. As a typical vehicle of wealth, car ownership indicates that rural households are in good financial conditions [80], allowing them to spend more on gifts [5]. Land ownership significantly decreases SIOGE. Land cultivation requires farmers to allocate large budgets on agricultural input purchases, crowding out their gift money spending. The variable for housing congestion has a negative and significant impact on gift expenditure, which can be explained by the consensus that people residing in congested houses tend to be in poor financial conditions; thus, they are powerless to afford gift money spending. Finally, our IV shows a negative impact on SIOGE at the 1 % significance level, which aligns with the work of Schechter [85] for Paraguay. To some extent, this finding confirms the validity of the IV.

6.2. Impacts of SIOGE on energy inaccessibility and unaffordability

6.2.1. Impact on energy inaccessibility

We next discuss the impact of SIOGE on rural households' energy inaccessibility proxied by EP1. The third column of Table 2 presents the estimated coefficients of the SIOGE and control variables. The coefficient of SIOGE is positive and statistically significant at the 1 % level, indicating that gift money spending promoted EP1. This finding confirms the non-negligible role of SIOGE in inducing energy poverty by increasing farmers' exposure to energy inaccessibility. As previously discussed, an escalating SIOGE may present a significant financial burden to rural households, weakening their ability to access modern and clean energy (e.g., solar energy, natural gas, and biomass energy) and locking them into burning solid fuels. As a result, SIOGE promotes solid fuel lock-in and reduces rural energy accessibility from the demand side. Accordingly, beyond the factors (e.g., energy scarcity, increased energy prices, and income poverty) that affect energy poverty [6,22,23], our study unlocks a new factor, SIOGE, which is deeply associated with the low penetration of modern energy and the widespread rural energy inaccessibility.

Table 2 also shows that several control variables, including education, household size, child ratio, elderly ratio, car ownership, land ownership, and housing congestion, significantly influence EP1. Some interesting findings require careful elucidation. For instance, education exerts a negative and significant effect on EP1, suggesting that education improvement can enhance rural residents' energy accessibility. Good education drives rural residents to obtain well-paying jobs and brings them more income earnings, which enhances their ability to afford the costs of accessing modern energy. A similar finding has also been reported by Abbas et al. [67] for South Asia and Lin and Zhao [68] for China. Surprisingly, EP1 is positively and significantly associated with land ownership. This result is plausible as land cultivation increases rural households' budgets on agricultural inputs, thereby tightening farmers' budgets on the relatively expensive modern energy. We also find that rural households' energy inaccessibility is significantly associated with temporal and spatial factors captured by year and location dummies.

6.2.2. Impact on energy unaffordability

The last two columns of Table 2 present the results estimating the effects of SIOGE and control variables on the energy unaffordability measured by EP2 and EP3, respectively. We discuss them together for ease of interpretation. The coefficients of SIOGE on EP2 and EP3 are positive and statistically significant at the 1 % significance level, indicating that SIOGE exerts a non-negligible promotion on the incidence of energy unaffordability. This finding aligns with what we conclude from our conceptual framework. That is, escalating and competitive gift money spending deprives rural residents of their disposable income, squeezes their budgets on modern energy consumption, and reduces their ability to purchase enough energy. Therefore, SIOGE is a significant driver of rural residents' energy unaffordability. Beyond the works of Hu et al. [36] and Bulte et al. [37] for rural China, our findings add new evidence to the crowding-out effects of SIOGE on rural households' non-gift expenditures.

For the control variables, their effects on energy unaffordability align with classical economic theories and our expectations. Among them, the male variable exerts a negative and significant impact on EP2 measured by the LIHC index, suggesting that rural households headed by men are more likely to have better energy affordability. In most East Asian countries, men in households have more responsibility of participating in economic activities [73], increasing their disposable income (i.e., the "I" in the LIHC index) and lowering the proportion of energy costs to their income. Variables for the child ratio and the elderly ratio are positively and significantly associated with EP2. This result is understandable as the child and elderly ratios enlarge rural households' health, food, and education budgets, weakening their energy affordability. This is consistent with Bîrsănuc [94] and Chaudhry and Shafiullah [95], who argued that the dependency ratio hinders household energy consumption in Romania and 103 other countries, respectively.

6.3. Marginal effects of variables on energy inaccessibility and unaffordability

The estimated coefficients in columns 3, 4, and 5 in Table 2 cannot be interpreted as the magnitudes of explanatory variables' effects on energy inaccessibility and unaffordability; therefore, we calculate their marginal effects, as shown in Table 3. As we can see, every 100 CNY increase in SIOGE can induce a 2.3 %, 2.1 %, and 2.1 % increase in EP1, EP2, and EP3, respectively. In other words, a farmer who spends 100 CNY more on gifts could exacerbate their average energy inaccessibility and unaffordability by approximately 2.3 % and 2.1 % (on average), respectively. The marginal effects of SIOGE are supposed to be inconspicuous compared with those of other explanatory variables. Nonetheless, these tiny effects of SIOGE on energy inaccessibility and unaffordability are substantial enough to draw our attention to the importance of regulating rural gift money-giving behavior, which is a fundamental element of agrarian civilization, in the struggle to eliminate energy poverty.

The marginal effects of some control variables are remarkable. Relative to women, rural men are 1.5 % less likely to be energy unaffordable in terms of EP2. The significant and negative marginal effects of education on EP1 and EP3 suggest that the probabilities of a rural household being energy inaccessible and unaffordable could fall by 1.0 % and 0.4 %, respectively, with every additional year of schooling. An additional household member raises EP1 and EP3 by 4.0 % and 2.2 %, respectively, suggesting that small households are energy accessible and affordable. Housing congestion is associated with a 6.3 % increase in EP1 and a 4.0 % increase in EP3.

6.4. Impact of SIOGE on multidimensional energy poverty

Table 4 presents the results that estimate the impact of SIOGE and control variables on multidimensional energy poverty (EP4). The CMP jointly estimates the SIOGE and EP4 equations to generate the results presented in columns 2 and 3. Because the results of the coefficient estimates in column 3 of Table 4 cannot be directly interpreted, we calculate the marginal effects of variables and present the results in the last column.

The estimated coefficient of the SIOGE variable is positive and statistically significant, suggesting that escalating gift expenditure triggers multidimensional energy poverty. The corresponding marginal effect indicates that each 100 CNY per capita increase in SIOGE per year would increase the likelihood of a rural household being trapped in multidimensional energy poverty by 1.9 %. The results in Tables 2–4 suggest that our findings may provide solid evidence that increasing social interaction-oriented spending can induce energy poverty from multiple dimensions (not simply energy inaccessibility or unaffordability). In other words, SIOGE increases household financial burdens and can lead farmers to be energy inaccessible and unaffordable simultaneously.

For the estimates of control variables, some interesting findings are observed. For instance, car ownership negatively and significantly impacts multidimensional energy poverty measured by EP4. Compared with non-owners, car owners are 5.5 % less likely to be in multidimensional energy poverty. The logic behind this association is that car owners are in good financial conditions, making them freer to be accessible and affordable for energy, which supports the work of Dogan et al. [96] in Turkey. Moreover, EP4 is suggested to be positively and significantly associated with housing congestion. Relative to those living in spacious houses, farmers living in congested houses are 3.3 % more likely to be in multidimensional energy poverty. Congested living conditions limit farmers' ability to use improved facilities (which are always space-occupying and expensive) to access modern energy and decrease their energy use efficiency.

6.5. Robustness check

We conducted various robustness tests to reinforce the reliability of our main empirical results. First, we apply the MPM approach to examine the impact of SIOGE on energy poverty indices of interest (i.e., EP1, EP2, EP3, and EP4). Although the MPM approach can mitigate partial selection bias by controlling fixed effects, it cannot adequately address the unobserved endogeneity issues; therefore, we first regress the SIOGE equation on the set of control variables, i.e., X_i in Eq. (5), with the IV included and obtain the value of predicted SIOGE. This helps us to account for the unobserved endogeneity issues associated with SIOGE. Subsequently, we estimate the impacts of the predicted SIOGE on energy poverty indices by regressing the MPM approach. The results (Appendix Table A4) suggest that SIOGE exerts a positive and significant impact on EP1, EP2, EP3, and EP4. These findings verify that our main results in Tables 2 and 4 are robust.

Second, we re-estimate the impact of SIOGE on energy poverty by replacing the control variable "age" with "average age" of household members. The results (Table A5 in the Appendix) estimated by the CMP model show that the positive impacts of SIOGE on EP1, EP2, EP3, and EP4 hold, suggesting that SIOGE increases rural energy poverty. The findings further verify the robustness of our results in Tables 2 and 4, as illustrated in Appendix Table A5.

Third, we estimate the impact of SIOGE on multidimensional energy poverty by replacing "EP4" with "MEP." Table A6 in the Appendix presents the results, showing that SIOGE significantly and positively affects MEP. This finding confirms the positive association between SIOGE and multidimensional energy poverty and supports our findings in Table 4.

Finally, we estimate the impact of SIOGE on energy poverty using the two waves (i.e., the 2016 wave and the 2018 wave) of survey data, respectively. Table A7 in the Appendix presents the empirical results, showing that the marginal effects of the SIOGE variable, which are derived from the CMP model, are positively and statistically significant in both the 2016 and 2018 wave data. The findings further confirm that gift expenditure can significantly increase the probability of a rural household being in energy inaccessibility, unaffordability, and multidimensional energy poverty.

6.6. Mediation analysis

We then discuss the mediation analysis results to investigate the channels through which SIOGE causes rural energy poverty. As proposed in the conceptual framework, SIOGE can uplift farmers' financial burdens, which is assumed to be the main channel through which SIOGE induces energy poverty. Hence, our mediation analysis focuses on verifying the mediating role of farmers' financial conditions (proxied by household deposits and indebtedness) between SIOGE and energy poverty.

Table 5 presents the estimates of the mediation effects derived from the GSE model, indicating that for all of our energy poverty indices (i.e., EP1, EP2, EP3, and EP4), the indirect effects of deposits are positive and significant. The findings suggest that household deposits positively mediate the positive impacts of SIOGE on the incidence of energy poverty. An increasing SIOGE shrinks farmers' deposits and then traps farmers into energy inaccessibility, unaffordability, and multidimensional energy poverty. Furthermore, the indirect effects of indebtedness are insignificant, even at the 10 % significance level. The findings suggest that indebtedness does not mediate a positive relationship between SIOGE and energy poverty.

7. Conclusions, policy implications, and limitations

Energy poverty is a typical rural development social issue in many developing nations. Rural energy consumption could be fundamentally determined by informal mechanisms for rural areas with limited access to formal markets; therefore, SIOGE could be a root determinant of rural energy poverty. Additionally, the ongoing debate on the role of SIOGE in rural development makes policymakers hesitant to design relevant policies; therefore, clarifying the relationship between SIOGE and rural energy poverty has the dual significance of alleviating energy poverty and civilizing rural society.

Utilizing the 2016 and 2018 waves of cross-sectional data from CFPS, this study examined the association between SIOGE and rural energy poverty. To provide a comprehensive and accurate measurement of household energy poverty in developing nations such as China, we used the solid fuel measure to calculate energy inaccessibility. Furthermore, we used two alternative measures, the LIHC index and the expenditure-based budget share, to proxy energy unaffordability. Finally, we used the EDS-based index to reflect multidimensional energy poverty. After addressing endogeneity issues using the CMP model, we found that SIOGE could be a significant driver of rural households' energy inaccessibility, unaffordability, and multidimensional energy poverty. Furthermore, our mediation analysis based on the GSE model confirmed that SIOGE tends to trap rural residents into energy poverty mainly via its significant effect on household deposits.

Our findings provide significant policy implications for developing nations that aim to reduce energy poverty and build civilized villages. Rural energy poverty is heavily linked to ingrained SIOGE, which reminds stakeholders in developing nations (e.g., China, Vietnam, and Ghana) harassed by SIOGE and rural energy poverty to regulate rural gift-giving behaviors by blocking the role of SIOGE. Given that developing countries in East Asia, Southeast Asia, and West Africa share the two typical rural development issues, which are escalating SIOGE and energy poverty, we can refine some practical strategies for them all from the China case. In practice, the government in China can take steps to help weaken and even reverse the importance of SIOGE to rural residents' lives. More specifically, the central government of China should devote more efforts (e.g., promulgating laws and strengthening supervision) to constructing and improving the rural labor market and energy market to lower the costs associated with farmers' labor allocation and energy consumption. Thus, farmers, who are superstitious about relationship maintenance, can rely more on formal mechanisms to improve their resource acquisition and household welfare.

Furthermore, the country's regional government should take practices consistent with the central government, such as constructing related facilities (e.g., road and gas pipeline) and reinforcing market supervision to decrease the transaction costs of market participation. Since gift-giving has become a vital subculture in developing nations, the efforts devoted by non-government institutions should be involved. Specifically, non-government institutions, such as folklore associations, can strengthen the propaganda on the downside of gift expenditure and guide farmers to maintain their social capital using low-cost manners, such as kind greetings and sincere conversation. This approach is arduous to complete immediately in rural China, where the society is historically *Guanxi* based; therefore, the efforts to weaken the importance of SIOGE should be continuously devoted in the long run.

It is worth noting that our study is pioneering in bridging the phenomenon of gift-giving and energy poverty in rural areas, and it has two limitations. First, due to the absence of data on gift recipients, we only focus on the SIOGE of the gift givers, leaving the impact of recipients' SIOGE on energy poverty undetermined. Second, we cannot comprehensively and accurately reflect farmers' energy poverty status by involving indices of energy acceptability and energy consumption convenience, as some essential indicators are missing. Nevertheless, future studies can address these two research gaps to enrich our understanding of the associations between SIOGE and rural energy poverty when the required data are available.

Declaration of competing interest

The authors declare no known interests related to their submitted manuscript.

Data availability statement

The data that support the findings of this study are available from Junpeng Li upon request.

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Appendix A

Table A1
Dimensions of MEPI and indicators used to calculate it.

Dimensions	Indicators	Nussbaumer et al. (2012)		This study	
		Definitions	Weights	Definitions	Weights
Cooking	Modern cooking fuel	Any fuel used besides electricity, LPG, kerosene, natural gas, or biogas	0.20	Any fuel used besides electricity, LPG, kerosene, natural gas, or biogas	0.20
	Indoor pollution	Food cooked on a stove or open fire (no hood/chimney), indoors, if using any polluting fuels (e.g. firewood and coal)	0.20	Has no air cleaning facilities (e.g. ventilating system and air purifier)	0.20
Electricity access	Lighting	Has no electricity access	0.20	N.A.	N.A.
Education	Computer ownership	N.A.	N.A.	Has no computer	0.20
Ownership of assets	Fridge ownership	Has no fridge	0.13	N.A.	N.A.
	Agricultural machine ownership	N.A.	N.A.	Has no agricultural machine (e.g., cultivator, harvester, and tractor)	0.13
Entertainment	Television ownership	Has no television	0.13	Has no television	0.13
Communication	Mobile phone ownership	Has no landline and mobile phone	0.13	Has no landline and mobile phone	0.13
Total weight	–	–	1.00		1.00

Table A2
Falsification tests.

Variables	$\chi^2(1)$	*p*-Value
EP1	2.28	0.131
EP2	2.13	0.144
EP3	2.65	0.103
EP4	1.94	0.163
MEP	0.53	0.466
SIOGE	6.99**	0.014

Note: SIOGE is measured at 100 CNY/capita.
** <0.05.

Table A3
Effectiveness tests of the IV.

Variables	OLS model	Probit models				
	SIOGE	EP1	EP2	EP3	EP4	MEP
Trustworthiness (IV)	−0.404 (0.153)**	−0.081 (0.054)	−0.093 (0.064)	−0.132 (0.081)	−0.105 (0.075)	−0.048 (0.066)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	14.960 (1.711)***	−0.033 (0.147)	0.117 (0.172)	−1.910 (0.234)***	−1.236 (0.212)***	−4.688 (0.291)***
Observations	10,068	10,068	10,068	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita; standard errors are in parentheses.
*** <0.01.
** <0.05.

Table A4
Robustness check: MPM approach estimates.

Variables	OLS model	Multilevel probit model			
	SIOGE	EP1	EP2	EP3	EP4
SIOGE (predicted)		0.139 (0.084)*	0.156 (0.091)*	0.212 (0.108)**	0.191 (0.103)*
Controls	Yes	Yes	Yes	Yes	Yes
Trustworthiness (IV)	−0.404 (0.153)**				
Constant	14.960 (1.711)***	−2.453 (1.243)**	−2.339 (1.337)*	−4.390 (1.584)***	−3.809 (1.511)**
Observations	10,068	10,068	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita/year; standard errors are in parentheses; the MPM model is estimated using the STATA command '*meprobit*'.
*** <0.01
** <0.05.
* <0.10.

Table A5
Robustness check by replacing age with the average age of household members: CMP model estimates.

Variables	OLS model	Probit model			
	SIOGE	EP1	EP2	EP3	EP4
SIOGE		0.071 (0.015)***	0.079 (0.012)***	0.078 (0.016)***	0.072 (0.010)***
Average age	0.062 (0.014)***	0.001 (0.003)	−0.003 (0.002)*	−0.001 (0.003)	−0.000 (0.003)
Other controls	Yes	Yes	Yes	Yes	Yes
Trustworthiness (IV)	−0.411 (0.112)***				
Constant	14.001 (1.699)***	−1.224 (0.251)***	−1.129 (0.202)***	−1.700 (0.203)***	−1.633 (0.218)***
$\rho_{\mu\varepsilon}$		−0.775 (0.126)***	−0.764 (0.117)***	−0.901 (0.088)***	−0.817 (0.317)
Log-likelihood	−51,651.955				
Observations	10,068	10,068	10,068	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita.
*** <0.01.
* <0.10.

Table A6
Robustness check by replacing EP4 with MEP: CMP model estimates.

Variables	OLS model	Probit model
	SIOGE	MEP
SIOGE		0.057 (0.016)***
Age	0.039 (0.009)***	0.000 (0.001)
Other controls	Yes	Yes
Trustworthiness (IV)	−0.412 (0.149)***	
Constant	14.970 (1.713)***	−2.786 (0.246)***
$\rho_{\mu\varepsilon}$		−0.612 (0.159)***
Log-likelihood	−41,042.176	
Observations	10,068	10,068

Note: SIOGE is measured at 100 CNY/capita/year.
*** <0.01.

Table A7
Robustness check: marginal effects of SIOGE on energy poverty by survey waves.

Variables	Energy inaccessibility	Energy unaffordability		Multidimensional energy poverty
	EP1	EP2	EP3	EP4
The 2016 wave				
SIOGE	0.024 (0.004)***	0.021 (0.003)***	0.021 (0.007)***	0.020 (0.004)***
Controls	Yes	Yes	Yes	Yes
Observations	4833	4833	4833	4833
The 2018 wave				
SIOGE	0.022 (0.004)***	0.020 (0.003)***	0.020 (0.006)***	0.019 (0.004)***
Controls	Yes	Yes	Yes	Yes
Observations	5235	5235	5235	5235

Note: SIOGE is measured at 100 CNY/capita/year. Standard errors are in parentheses.
*** <0.01.

References

[1] S. Awaworyi Churchill, R. Smyth, Energy poverty and health: panel data evidence from Australia, Energy Econ. 97 (2021), 105219, https://doi.org/10.1016/j.eneco.2021.105219.

[2] D. Zhang, J. Li, P. Han, A multidimensional measure of energy poverty in China and its impacts on health: an empirical study based on the China family panel studies, Energy Policy 131 (2019) 72–81, https://doi.org/10.1016/j.enpol.2019.04.037.

[3] S.A. Sy, L. Mokaddem, Energy poverty in developing countries: a review of the concept and its measurements, Energy Res. Soc. Sci. 89 (2022), 102562, https://doi.org/10.1016/j.erss.2022.102562.

[4] C.P. Nguyen, M.A. Nasir, An inquiry into the nexus between energy poverty and income inequality in the light of global evidence, Energy Econ. 99 (2021), https://doi.org/10.1016/j.eneco.2021.105289.

[5] P. Nie, Q. Li, A. Sousa-Poza, Energy poverty and subjective well-being in China: new evidence from the China Family Panel Studies, Energy Econ. 103 (2021), https://doi.org/10.1016/j.eneco.2021.105548.

[6] D.W. Gafa, A.Y.G. Egbendewe, Energy poverty in rural West Africa and its determinants: evidence from Senegal and Togo, Energy Policy 156 (2021), https://doi.org/10.1016/j.enpol.2021.112476.

[7] B. Lin, M.A. Okyere, Haunted by the past: exploring the micro-level effects of childhood economic shocks on energy poverty in developing countries, Energy Res. Soc. Sci. 93 (2022), 102854, https://doi.org/10.1016/j.erss.2022.102854.

[8] H. Li, X. Leng, J. Hu, A. Cao, L. Guo, When cooking meets confucianism: exploring the role of traditional culture in cooking energy poverty, Energy Res. Soc. Sci. 97 (2023), 102956, https://doi.org/10.1016/j.erss.2023.102956.

[9] UNDP, The SDGs in action. https://www.undp.org/sustainable-development-goals, 2015.

[10] S. Awaworyi Churchill, R. Smyth, L. Farrell, Fuel poverty and subjective wellbeing, Energy Econ. 86 (2020), https://doi.org/10.1016/j.eneco.2019.104650.

[11] Y. Li, X. Ning, Z. Wang, J. Cheng, F. Li, Y. Hao, Would energy poverty affect the wellbeing of senior citizens? Evidence from China, Ecol. Econ. 200 (2022), https://doi.org/10.1016/j.ecolecon.2022.107515.

[12] M. Ucal, S. Günay, Household happiness and fuel poverty: a cross-sectional analysis on Turkey, Appl. Res. Qual. Life 17 (2022) 391–420, https://doi.org/10.1007/s11482-020-09894-3.

[13] Q. Zhang, S. Appau, P.L. Kodom, Energy poverty, children's wellbeing and the mediating role of academic performance: evidence from China, Energy Econ. 97 (2021), 105206, https://doi.org/10.1016/j.eneco.2021.105206.

[14] T. Kose, Energy poverty and health: the Turkish case, Energy Sources, Part B Econ. Plan. Policy 14 (2019) 201–213, https://doi.org/10.1080/15567249.2019.1653406.

[15] S. Oum, Energy poverty in the Lao PDR and its impacts on education and health, Energy Policy 132 (2019) 247–253, https://doi.org/10.1016/j.enpol.2019.05.030.
[16] K. Prakash, M.E. Munyanyi, Energy poverty and obesity, Energy Econ. 101 (2021), https://doi.org/10.1016/j.eneco.2021.105428.
[17] R. Bardazzi, L. Bortolotti, M.G. Pazienza, To eat and not to heat? Energy poverty and income inequality in Italian regions, Energy Res. Soc. Sci. 73 (2021), https://doi.org/10.1016/j.erss.2021.101946.
[18] M.T. Costa-Campi, E. Jové-Llopis, E. Trujillo-Baute, Energy poverty in Spain: an income approach analysis, Energy Sources, Part B Econ. Plan. Policy 14 (2019) 327–340, https://doi.org/10.1080/15567249.2019.1710624.
[19] H. Phoumin, F. Kimura, Cambodia's energy poverty and its effects on social wellbeing: empirical evidence and policy implications, Energy Policy 132 (2019) 283–289, https://doi.org/10.1016/j.enpol.2019.05.032.
[20] A.T. Aweke, S. Navrud, Valuing energy poverty costs: household welfare loss from electricity blackouts in developing countries, Energy Econ. 109 (2022), https://doi.org/10.1016/j.eneco.2022.105943.
[21] C. Bukari, S. Broermann, D. Okai, Energy poverty and health expenditure: evidence from Ghana, Energy Econ. 103 (2021), https://doi.org/10.1016/j.eneco.2021.105565.
[22] X.N. Ai, Y.F. Du, W.M. Li, H. Li, H. Liao, The pattern of household energy transition, Energy 234 (2021), https://doi.org/10.1016/j.energy.2021.121277.
[23] S. Ehsanullah, Q.H. Tran, M. Sadiq, S. Bashir, M. Mohsin, R. Iram, How energy insecurity leads to energy poverty? Do environmental consideration and climate change concerns matters, Environ. Sci. Pollut. Res. 28 (2021) 55041–55052, https://doi.org/10.1007/s11356-021-14415-2.
[24] W. Ma, H. Zheng, B. Gong, Rural income growth, ethnic differences, and household cooking fuel choice: evidence from China, Energy Econ. 107 (2022), https://doi.org/10.1016/j.eneco.2022.105851.
[25] P. Simshauser, T. Nelson, The consequences of retail electricity price rises: rethinking customer hardship, Aust. Econ. Rev. 47 (2014) 13–43, https://doi.org/10.1111/1467-8462.12043.
[26] Y. Alem, E. Demeke, The persistence of energy poverty: a dynamic probit analysis, Energy Econ. 90 (2020), https://doi.org/10.1016/j.eneco.2020.104789.
[27] K. Drescher, B. Janzen, Determinants, persistence, and dynamics of energy poverty: an empirical assessment using German household survey data, Energy Econ. 102 (2021), https://doi.org/10.1016/j.eneco.2021.105433.
[28] K. Dong, Q. Jiang, M. Shahbaz, J. Zhao, Does low-carbon energy transition mitigate energy poverty? The case of natural gas for China, Energy Econ. 99 (2021), https://doi.org/10.1016/j.eneco.2021.105324.
[29] S.V. Sharma, P. Han, V.K. Sharma, Socio-economic determinants of energy poverty amongst Indian households: a case study of Mumbai, Energy Policy 132 (2019) 1184–1190, https://doi.org/10.1016/j.enpol.2019.06.068.
[30] J. Chamberlin, J. Ricker-Gilbert, Participation in rural land rental markets in sub-Saharan Africa: who benefits and by how much? Evidence from Malawi and Zambia, Am. J. Agric. Econ. 98 (2016) 1507–1528, https://doi.org/10.1093/ajae/aaw021.
[31] M.J. Baker, K.J. Swope, Sharing, gift-giving, and optimal resource use in hunter-gatherer society, Econ. Gov. 22 (2021) 119–138, https://doi.org/10.1007/s10101-021-00254-x.
[32] H.S. Kaplan, E. Schniter, V.L. Smith, B.J. Wilson, Experimental tests of the tolerated theft and risk-reduction theories of resource exchange, Nat. Hum. Behav. 2 (2018) 383–388, https://doi.org/10.1038/s41562-018-0356-x.
[33] C.A. Aktipis, L. Cronk, R. de Aguiar, Risk-pooling and herd survival: an agent-based model of a Maasai gift-giving system, Hum. Ecol. 39 (2011) 131–140, https://doi.org/10.1007/s10745-010-9364-9.
[34] T. Bernard, M. Torero, Social interaction effects and connection to electricity: experimental evidence from rural Ethiopia, Econ. Dev. Cult. Chang. 63 (2015) 459–484, https://doi.org/10.1086/679746.
[35] B. Feigenberg, R. Pande, The economic returns to social interaction: experimental evidence from microfinance, Rev. Econ. Stud. 80 (2013) 1459–1483, https://doi.org/10.1093/restud/rdt016.
[36] M. Hu, G. Xiang, S. Zhong, The burden of social connectedness: do escalating gift expenditures make you happy? J. Happiness Stud. 22 (2021) 3479–3497, https://doi.org/10.1007/s10902-020-00341-6.
[37] E. Bulte, R. Wang, X. Zhang, Forced gifts: the burden of being a friend, J. Econ. Behav. Organ. 155 (2018) 79–98, https://doi.org/10.1016/j.jebo.2018.08.011.
[38] X. Giné, P. Jakiela, D. Karlan, J. Morduch, Microfinance games, Am. Econ. J. Appl. Econ. 2 (2010) 60–95, https://doi.org/10.1257/app.2.3.60.
[39] J. He, Q. Li, Can online social interaction improve the digital finance participation of rural households? China Agric. Econ. Rev. 12 (2020) 295–313, https://doi.org/10.1108/CAER-11-2019-0213.
[40] P. Liang, S. Guo, Social interaction, internet access and stock market participation-an empirical study in China, J. Comp. Econ. 43 (2015) 883–901, https://doi.org/10.1016/j.jce.2015.02.003.
[41] M.C.M. Vendrik, Adaptation, anticipation and social interaction in happiness: an integrated error-correction approach, J. Public Econ. 105 (2013) 131–149, https://doi.org/10.1016/j.jpubeco.2013.06.009.
[42] C.B. Mendoza, D.D.D. Cayonte, M.S. Leabres, L.R.A. Manaligod, Understanding multidimensional energy poverty in the Philippines, Energy Policy 133 (2019), 110886, https://doi.org/10.1016/j.enpol.2019.110886.
[43] B. Mirza, A. Szirmai, Towards a new measurment of energy poverty: a cross-community analysis of rural Pakistan, in: UNU-MERIT Work. Pap. Ser. 024 44, 2010, pp. 1–41.
[44] R. Nayan Yadava, B. Sinha, Developing energy access index for measuring energy poverty in forest fringe villages of Madhya Pradesh, India, Sustain. Energy Technol. Assess. 31 (2019) 167–178, https://doi.org/10.1016/j.seta.2018.12.013.
[45] L.H. Lin, Cultural and organizational antecedents of Guanxi: the Chinese cases, J. Bus. Ethics 99 (2011) 441–451, https://doi.org/10.1007/s10551-010-0662-3.
[46] E. Arampatzi, M.J. Burger, N. Novik, Social network sites, individual social capital and happiness, J. Happiness Stud. 19 (2018) 99–122, https://doi.org/10.1007/s10902-016-9808-z.
[47] X. Chen, Costly Posturing Relative Status, Ceremonies, and Early Child Development in China, IFPRI Discuss. Pap, 2012.
[48] J. Barbalet, Where does guanxi come from? Bao, shu, and renqing in Chinese connections, Asian J. Soc. Sci. 49 (2021) 31–37, https://doi.org/10.1016/j.ajss.2020.11.001.
[49] R. Wang, Who should I share risk with? Gifts can tell: theory and evidence from rural China, SSRN Electron. J. (2016), https://doi.org/10.2139/ssrn.2718104.
[50] NBSC, China Energy Statistical Yearbook 2020, 2021.
[51] X. Yun, G. Shen, H. Shen, W. Meng, Y. Chen, H. Xu, Y. Ren, Q. Zhong, W. Du, J. Ma, H. Cheng, X. Wang, J. Liu, X. Wang, B. Li, J. Hu, Y. Wan, S. Tao, Residential solid fuel emissions contribute significantly to air pollution and associated health impacts in China, Sci. Adv. 6 (2020), https://doi.org/10.1126/sciadv.aba7621.
[52] W. Ma, P. Vatsa, H. Zheng, Cooking fuel choices and subjective well-being in rural China: implications for a complete energy transition, Energy Policy 165 (2022), 112992, https://doi.org/10.1016/j.enpol.2022.112992.
[54] L. Farrell, J.M. Fry, Australia's gambling epidemic and energy poverty, Energy Econ. 97 (2021), 105218, https://doi.org/10.1016/j.eneco.2021.105218.
[55] P. Stirling, M. Sahlins, Stone Age Economics, 1975, https://doi.org/10.2307/2800518.
[56] L. Zhao, X. Yao, Does local social capital deter labour migration? Evidence from rural China, Appl. Econ. 49 (2017) 4363–4377, https://doi.org/10.1080/00036846.2017.1282146.
[57] M. Hudik, E.S. Fang, Money or in-kind gift? Evidence from red packets in China, J. Inst. Econ. 16 (2020) 731–746, https://doi.org/10.1017/S1744137419000717.
[58] H. Welsch, M. Binder, A.K. Blankenberg, Green behavior, green self-image, and subjective well-being: separating affective and cognitive relationships, Ecol. Econ. 179 (2021), 106854, https://doi.org/10.1016/j.ecolecon.2020.106854.
[59] F. Li, T. Zhou, Effects of objective and subjective environmental pollution on well-being in urban China: a structural equation model approach, Soc. Sci. Med. 249 (2020), 112859, https://doi.org/10.1016/j.socscimed.2020.112859.
[60] T. Piketty, L. Yang, G. Zucman, Capital accumulation, private property, and rising inequality in China, 1978-2015, Am. Econ. Rev. 109 (2019) 2469–2496, https://doi.org/10.1257/aer.20170973.
[61] W. Ma, H. Zheng, P. Yuan, Impacts of cooperative membership on banana yield and risk exposure: insights from China, J. Agric. Econ. (2021) 1–16, https://doi.org/10.1111/1477-9552.12465.
[62] S. Wu, H. Han, Energy transition, intensity growth, and policy evolution: evidence from rural China, Energy Econ. 105 (2022), 105746, https://doi.org/10.1016/j.eneco.2021.105746.
[63] H. Han, S. Wu, Z. Zhang, Factors underlying rural household energy transition: a case study of China, Energy Policy 114 (2018) 234–244, https://doi.org/10.1016/j.enpol.2017.11.052.
[64] P. Nussbaumer, M. Bazilian, V. Modi, Measuring energy poverty: focusing on what matters, Renew. Sust. Energ. Rev. 16 (2012) 231–243, https://doi.org/10.1016/j.rser.2011.07.150.
[65] G. Datt, Making every dimension count: multidimensional poverty without the "dual cut off". http://www.buseco.monash.edu.au/eco/research/papers/2013/3213makingdatt.pdf, 2013.
[66] S. Alkire, J.M. Roche, A. Vaz, Changes over time in multidimensional poverty: methodology and results for 34 countries, World Dev. 94 (2017) 232–249, https://doi.org/10.1016/j.worlddev.2017.01.011.
[67] K. Abbas, S. Li, D. Xu, K. Baz, A. Rakhmetova, Do socioeconomic factors determine household multidimensional energy poverty? Empirical evidence from South Asia, Energy Policy 146 (2020), 111754, https://doi.org/10.1016/j.enpol.2020.111754.
[68] B. Lin, H. Zhao, Does off-farm work reduce energy poverty? Evidence from rural China, Sustain. Prod. Consum. 27 (2021) 1822–1829, https://doi.org/10.1016/j.spc.2021.04.023.
[69] B. Wu, S. Liu, J. Wang, S. Tahir, A.K. Patwary, Assessing the mechanism of energy efficiency and energy poverty alleviation based on environmental regulation policy measures, Environ. Sci. Pollut. Res. 28 (2021) 40858–40870, https://doi.org/10.1007/s11356-021-13605-2.
[70] M. Hasanujzaman, M.A. Omar, Household and non-household factors influencing multidimensional energy poverty in Bangladesh: demographics, urbanization and regional differentiation via a multilevel modeling approach, Energy Res. Soc. Sci. 92 (2022), 102803, https://doi.org/10.1016/j.erss.2022.102803.
[71] K. Li, B. Lloyd, X.J. Liang, Y.M. Wei, Energy poor or fuel poor: what are the differences? Energy Policy 68 (2014) 476–481, https://doi.org/10.1016/j.enpol.2013.11.012.
[72] C. Li, W. Ma, A.K. Mishra, L. Gao, Access to credit and farmland rental market participation: evidence from rural China, China Econ. Rev. 63 (2020), 101523, https://doi.org/10.1016/j.chieco.2020.101523.
[73] J. Li, W. Ma, A. Renwick, H. Zheng, The impact of access to irrigation on rural incomes and diversification: evidence from China, China Agric. Econ. Rev. 12 (2020) 705–725, https://doi.org/10.1108/CAER-09-2019-0172.
[74] L. Liu, L. Fu, Y. Jiang, S. Guo, Major issues and solutions in the heat-metering reform in China, Renew. Sust. Energ. Rev. 15 (2011) 673–680, https://doi.org/10.1016/j.rser.2010.08.009.
[75] J. Zhang, L. Xu, V. Shabunko, S.E.R. Tay, H. Sun, S.S.Y. Lau, T. Reindl, Impact of urban block typology on building solar potential and energy use efficiency in tropical high-density city, Appl. Energy 240 (2019) 513–533, https://doi.org/10.1016/j.apenergy.2019.02.033.

[76] F.G. van Oort, M.J. Burger, J. Knoben, O. Raspe, Multilevel approaches and the firm-agglomeration ambiguity in economic growth studies, J. Econ. Surv. 26 (2012) 468–491, https://doi.org/10.1111/j.1467-6419.2012.00723.x.
[77] J. Wei, Y. Zhang, Panel probit models with time-varying individual effects: reestimating the effects of fertility on female labour participation*, Oxf. Bull. Econ. Stat. 84 (2022) 799–829, https://doi.org/10.1111/obes.12478.
[78] J.M. Wooldridge, Y. Zhu, Inference in approximately sparse correlated random effects probit models with panel data, J. Bus. Econ. Stat. 38 (2020) 1–18, https://doi.org/10.1080/07350015.2019.1681276.
[79] C. Li, W. Cheng, H. Shi, Early marriage and maternal health care utilisation: evidence from sub-Saharan Africa, Econ. Hum. Biol. 43 (2021), 101054, https://doi.org/10.1016/j.ehb.2021.101054.
[80] J. Li, W. Ma, P. Wang, X. Meng, Farmers' willingness to transform untreated livestock manure into organic fertilizer: does information technology adoption make a difference? Environ. Dev. Sustain. (2023) https://doi.org/10.1007/s10668-023-02920-y.
[81] Z. Liu, J. Li, J. Rommel, S. Feng, Health impacts of cooking fuel choice in rural China, Energy Econ. 89 (2020), 104811, https://doi.org/10.1016/j.eneco.2020.104811.
[82] I. Miroshnychenko, A. De Massis, Sustainability practices of family and nonfamily firms: a worldwide study, Technol. Forecast. Soc. Chang. 174 (2022), 121079, https://doi.org/10.1016/j.techfore.2021.121079.
[83] D. Roodman, Fitting fully observed recursive mixed-process models with cmp, Stata J. 11 (2011) 159–206, https://doi.org/10.1177/1536867x1101100202.
[84] C.F. Baum, Conditional mixed-process models. http://fmwww.bc.edu/EC-C/S2016/8823/ECON8823.S2016.nn14.slides.pdf, 2016.
[85] L. Schechter, Theft, gift-giving, and trustworthiness: honesty is its own reward in rural Paraguay, Am. Econ. Rev. 97 (2007) 1560–1582, https://doi.org/10.1257/aer.97.5.1560.
[86] A. Gök, The role of financial development on carbon emissions: a meta regression analysis, Environ. Sci. Pollut. Res. 27 (2020) 11618–11636, https://doi.org/10.1007/s11356-020-07641-7.
[87] S.U. Setiastuti, N.M.A. Purwanto, A. Sasongko, External debt management as macroprudential policy in a small open economy, Econ. Anal. Policy 71 (2021) 446–462, https://doi.org/10.1016/j.eap.2021.06.002.
[88] J. Zhang, M. Cheng, N. Yu, Internet use and lower life satisfaction: the mediating effect of environmental quality perception, Ecol. Econ. 176 (2020), 106725, https://doi.org/10.1016/j.ecolecon.2020.106725.
[89] B. Lee, S. Jeong, M. Roh, Association between body mass index and health outcomes among adolescents: the mediating role of traditional and cyber bullying victimization, BMC Public Health 18 (2018) 1–12, https://doi.org/10.1186/s12889-018-5390-0.
[90] N.M. Perez, W.G. Jennings, M.T. Baglivio, A path to serious, violent, chronic delinquency: the harmful aftermath of adverse childhood experiences, Crime Delinq. 64 (2018) 3–25, https://doi.org/10.1177/0011128716684806.
[91] K.J. Preacher, A.F. Hayes, Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models, Behav. Res. Methods 40 (2008) 879–891, https://doi.org/10.3758/BRM.40.3.879.
[92] X. Chen, R.K. Kanbur, X. Zhang, Peer Effects, Risk Pooling, and Status Seeking What Explains Gift Spending Escalation in Rural China?. www.ifpri.org/sites/default/files/publications/ifpridp01151.pdf, 2012.
[93] D. Zeng, J. Alwang, G.W. Norton, B. Shiferaw, M. Jaleta, C. Yirga, Agricultural technology adoption and child nutrition enhancement: improved maize varieties in rural Ethiopia, Agric. Econ. (UK) 48 (2017) 573–586, https://doi.org/10.1111/agec.12358.
[94] E.M. Bîrsănuc, Mapping gendered vulnerability to energy poverty in Romania, Appl. Spat. Anal. Policy (2022), https://doi.org/10.1007/s12061-022-09442-6.
[95] S.M. Chaudhry, M. Shafiullah, Does culture affect energy poverty? Evidence from a cross-country analysis, Energy Econ. 102 (2021), 105536, https://doi.org/10.1016/j.eneco.2021.105536.
[96] E. Dogan, M. Madaleno, D. Taskin, Which households are more energy vulnerable? Energy poverty and financial inclusion in Turkey, Energy Econ. 99 (2021), 105306, https://doi.org/10.1016/j.eneco.2021.105306.