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DISCUSSION PAPER SERIES

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ABSTRACT

Energy Poverty and Entrepreneurship

We use the 2012-2018 China Family Panel Studies data to examine the relationship between household energy poverty and an individual's probability of becoming an entrepreneur. Consistent with the theory of underdog entrepreneurship that negative personal circumstances can foster self-reliance, resourcefulness and other skills and personality traits conducive to entrepreneurship, we find that spending a higher share of household income on energy consumption or being energy poor increases the probability of being an entrepreneur. The results are robust to various checks, including alternative measures of energy poverty, non-linear effects of the share of energy spending in household income, past entrepreneurial experience, alternative estimation methods and potential omitted variable bias. We also explore the channels through which energy poverty influences whether one chooses to become an entrepreneur. We find that cognitive functions, mental health and self-confidence negatively mediate, while self-belief, extroversion and openness positively mediate, the relationship between energy poverty and entrepreneurship.

JEL Classification: I32, L26, Q41

Keywords: energy poverty, entrepreneurship, China

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1. Introduction

Access to energy is essential for socioeconomic development because it makes it possible to use resources, technology and time more efficiently to generate output for consumption, investment and exchange. The strong and positive correlation between energy consumption and economic growth underpins the United Nations' Sustainable Development Goal 7, which aims to promote access to affordable, reliable and modern energy services.

A growing body of literature has focused on the relationship between access to energy and economic development, providing new data and rigorous analyses of the link between the two (see Lee *et al.*, 2020 for a survey). Studies have documented the effects of new energy infrastructures and more efficient and reliable energy sources on households and communities that had no prior access to them, finding substantive improvements in the environment and the health of affected individuals (Barnes *et al.*, 1994; Manibog, 1984). Recent work has also highlighted that better access to energy, provided through projects such as rural electrification, the promotion of modern cooking fuels and adoption of improved biomass stoves, also enhances labour supply via higher female labour market participation, reduced sickness and mortality, and greater human capital accumulation thanks to rising schooling rates (Khandker *et al.*, 2013; Salmon & Tanguy, 2016; Tagliapietra *et al.*, 2020). These improved circumstances, in turn, enable communities to diversify away from subsistence agriculture in favour of higher value-added production in manufacturing and services.

A smaller literature investigates the opposite case of missing economic development arising when the supply of energy does not correspondingly trigger an increase in the number of consumers – typically because some of them are constrained by a low level of income. Indeed, poor households cannot take advantage of more efficient energy sources such as electricity or gas and the technology associated with them when the relative price of energy or connection charges cannot be afforded (Njiru & Letema, 2018) or if they cannot finance the purchase of modern energy-efficient equipment (Mainali & Silveira, 2011). Disparities in energy access and spending contribute to lower subjective wellbeing and poorer mental health among low-income households vis-à-vis wealthier ones, who benefit from better access to energy. This disparity reinforces persistence in poverty and social inequality (Awaworyi Churchill *et al.*, 2020; Bhattacharyya, 2006).

In contrast, little attention has been given to the interplay between energy poverty –, i.e., being unable to have regular and sufficient access to energy due to its high cost relative to household income or inadequate energy infrastructures (Boardman, 2010; Thomson *et al.*, 2017a; Thomson *et al.*, 2016) – and labour market outcomes. However, understanding the labour market consequences of people in energy poverty may help better identify the need for more tailored public interventions than generic labour market support or poverty relief programmes.

This study builds on recent work pointing out that personal disadvantages, such as those experienced early in life, can strengthen resilience, self-determination and other personal qualities that are essential ingredients for creating new business ventures (Awaworyi Churchill *et al.*, 2021; Cheng *et al.*, 2021a). In particular, the 'underdog' model of entrepreneurship of Miller and Le Breton-Miller (2017: 7) states that 'negative personal circumstances of an economic, sociocultural, cognitive, and physical/emotional nature may have an equally powerful role to play in getting

people to become effective entrepreneurs'.[1] While poverty status is an underdog attribute, little is known about the link between energy poverty, as an underdog characteristic, and one's propensity for entrepreneurship: for example, it is unclear whether such link is direct or mediated through other underdog characteristics associated with being energy poor. This is an important distinction because energy poverty is common, affecting more than one billion people in the world, but entrepreneurship is increasingly viewed as a viable solution to combat poverty (International Energy Agency, 2018; Lee & Rodríguez-Pose, 2020; Sutter *et al.*, 2019). If energy poverty has a direct, identifiable influence on entrepreneurship, then making it a target of policy intervention will be effective for enhancing entrepreneurial activity. This outcome is weakened and possibly voided if energy poverty relates to entrepreneurship through intermediate variables that are nonconductive to entrepreneurship.

We hence apply underdog entrepreneurship theory to study whether energy poverty induces underdog entrepreneurship, with a focus on the mechanisms through which this link may operate. In particular, we explore the possible mediating role of cognitive functions, mental health, non-cognitive abilities and personality traits. Our empirical analysis uses the case of China as a country that, on the one hand, has implemented the infrastructure required to supply electricity across all its regions over the past decade but, on the other hand, is still characterised by systematic levels of energy poverty across its provinces – for instance, in Qinghai, one of the least developed provinces in China, more than half of rural households are still energy poor (Jiang *et al.*, 2020). We use panel data from the 2012-2018 China Family Panel Studies (CFPS) and apply an instrumental variable approach to account for errors in measuring energy poverty and possible reverse causality with respect to entrepreneurial choices.

The results suggest that being energy poor significantly raises the probability of becoming an entrepreneur, especially in the retail and service sectors. We also find that the effect is negatively mediated by cognitive functions, self-confidence and mental health. In other words, we find evidence of 'competitive' mediation where direct and mediated effects both exist but are in opposing directions.

We interpret the direct positive effect as stemming from the inherent abilities, resourcefulness, motivations and resilience triggered by energy poverty on people otherwise classified as poor because of their socioeconomic conditions rather than the simplistic and misleading idea that energy poverty is a desirable precondition for entrepreneurship. Indeed, the boundary conditions under which underdog entrepreneurship operates suggest the need to mitigate the negative effects of other underdog statuses in strengthening the positive role of being energy poor in creating new businesses. Overall, our findings support the view that the resourcefulness and other personal qualities of those experiencing energy poverty could be harnessed more systematically and effectively through targeted institutional support to further advance their economic wellbeing. By doing so, the wellbeing of society at large is also enhanced through increased entrepreneurial activity.

[1] A featured example is the story of William Kamkwamba, a 13-year-old from Malawi whose observation of the light produced by the dynamo of a bicycle led him to build a windmill from scrap material to generate energy for water extraction in his drought-stricken village (Vidal, 2009). Despite the poor conditions in which he operated and his own poverty, his application secured the survival of his and other farming families in the village, replacing an otherwise inevitable future of famine or migration with hope and optimism. The levers of his success were a book on electricity to acquire knowledge and some basic material to build the windmill rather than brand new equipment, food vouchers, or financial support for migration. In addition, his story illustrates his resourcefulness, resilience, experiential learning ability, risk-taking and livelihood management skills in adverse conditions.

2. Energy poverty and entrepreneurship

Energy poverty and entrepreneurship are largely studied by separate studies. Energy poverty is a concept that stems from international efforts to promote economic development via better access to energy across the globe (González-Eguino, 2015). Energy is essential to the provision of services underpinning individual wellbeing, health, education and employment, which determine the living standards of a society (Lee *et al.*, 2020), through the creation of new firms (Vernet *et al.*, 2019). The literature documents direct and indirect benefits associated with energy, correspondingly highlighting the negative effects of inadequate access on poor households (Awaworyi Churchill & Smyth, 2020; Bridge *et al.*, 2016; Krauss, 2016). Energy poverty can be the outcome of disadvantaged personal circumstances that reflect income inequality and low socio-economic conditions (Nguyen & Nasir, 2021; Recalde *et al.*, 2019). In turn, energy poverty is a determinant of poor health (Thomson *et al.*, 2017b; Zhang *et al.*, 2019), malnutrition and limited intellectual development (Brown & Pollitt, 1996; Dercon & Sánchez, 2013; Schick & Steckel, 2010), schooling (Andadari *et al.*, 2014; Bridge, 2017), and cognitive and non-cognitive skills (Howard, 2011; Sánchez, 2017).

Entrepreneurship has traditionally been viewed as the result of certain favourable conditions and personality traits, such as the propensity to seek control over work-related decisions and demographic characteristics such as family background and history, specific training and formal education (Cheng & Smyth, 2021; Dickson *et al.*, 2008; Doms *et al.*, 2010; Gartner, 1985; Hayward *et al.*, 2021). Other studies, however, suggest that entrepreneurship responds to contingent circumstances (Gilad & Levine, 1986). There is also evidence that early life experiences mould cognitive and non-cognitive skills that influence subsequent socioeconomic choices (Doyle *et al.*, 2009; Heckman *et al.*, 2013; Heckman, 2006). These findings have contributed to a new line of research to investigate the role of unfavourable personal circumstances in fostering resilience and other necessary skills to successfully enter the labour market via self-employment (Awaworyi Churchill *et al.*, 2021; Cheng *et al.*, 2021a; Maalaoui *et al.*, 2020; Miller & Le Breton-Miller, 2017; Powell & Baker, 2014; Shepherd & Williams, 2020). Adversity and challenges in life can spark the initiative and tenacity needed for entrepreneurship (Miller & Le Breton-Miller, 2017; Shepherd & Williams, 2020) in response to a major life shock, such as war (Awaworyi Churchill *et al.*, 2021) or famine (Cheng *et al.*, 2021), or as a break from persistent negative circumstances, such as living in poverty (Bruton *et al.*, 2013; Morris *et al.*, 2020a; Sutter *et al.*, 2019).

Consistent with the Miller and Le Breton-Miller (2017) theory of underdog entrepreneurship, poverty experiences can nurture favourable survival capabilities that are beneficial for an entrepreneurial mindset (Morris & Tucker, 2021a). These survival capabilities cultivated from poverty manifest as 'self-confidence, creative problem-solving, resource leveraging and resiliency', which are central for overcoming the 'liability of poorness' in creating new ventures (Morris & Tucker, 2021a: 18).

Being in poverty may also negatively influence personal capabilities, desires and aspirations for economic independence through entrepreneurship (Morris, 2020; Morris & Tucker, 2021a; Pidduck & Clark, 2021). Poverty also leads to other recognised features of an individual's underdog status. For example, poverty can impede cognitive and non-cognitive abilities by limiting access to formal education opportunities and consuming mental resources (Mani *et al.*, 2013). Experiencing poverty can raise stress, anxiety and other poor mental health conditions that negatively affect one's earning ability (Cheng, 2014; Cheng & Beresford, 2012; Haushofer &

Fehr, 2014). Being poor can also hamper self-confidence through internal constraints and systematic dependence on social welfare (Wuepper & Lybbert, 2017). Nonetheless, it is unclear how these underdog characteristics interact with poverty, which is the cause and an underdog characteristic itself, in determining entrepreneurial behaviour. In other words, it remains largely unknown whether the experience of energy poverty may act as a catalyst to prompt those affected to embrace entrepreneurship as an outcome to aspire to, especially if other options such as migration or paid employment are out of reach.

We contribute to bridging these two streams of studies by analysing several possible channels through which energy poverty may affect entrepreneurship, shedding light on the 'black box' in which the drivers of low socioeconomic status can be overcome. Far from concluding that energy poverty represents an irreversible status, we build on the notion that such adversity can prompt a response with wide-ranging positive effects on the organisation of one's life and on economic activity and society overall. In doing so, we rely entirely on positive analysis principles rather than normative rationales that might imply that energy poverty is desirable or is an objective to be encouraged through government intervention. However, our findings suggest that interventions that aim to improve cognitive functions, self-confidence and mental health may be effective ways to meditate the positive effects of energy poverty on underdog entrepreneurship.

3. Data and measurement of energy poverty

The empirical analysis uses panel data from the 2012-2018 CFPS, with the analytical sample restricted to those aged between 18 and 65. The resulting panel is unbalanced, with 69,550 (repeated) observations from 13,493 respondents in 2012, 18,513 in 2014, 20,122 in 2016 and 17,422 in 2018.

There are different approaches to define energy poverty. The 'objective' approach is based on the relationship between household income and energy expenditure, while the 'subjective' approach aims to capture the feelings of material deprivation perceived by individuals. Some argue that objective measures are more accurate than subjective measures and provide useful references for social policy-making (Charlier & Legendre, 2019; Hills, 2012). Others argue that subjective measures can better evaluate the individual needs and perceptions of the energy poor (Fahmy *et al.*, 2011; Thomson *et al.*, 2017b). The subjective measure of energy poverty is also in line with the development in the research area of subjective poverty (Cheng, 2014; Wang *et al.*, 2020).

Comparing objective and subjective approaches to measuring energy poverty, Waddams Price *et al.* (2012) suggest that the two measures are positively related but do not coincide in many cases. Similarly, Fizaine and Kahouli (2019) suggest that profiles of fuel-poor households vary depending on the objective and subjective measures and thresholds employed. Thus, recent studies suggest the use of both objective and subjective measures of energy poverty in the same study (Awaworyi Churchill & Smyth, 2020, 2021; Llorca *et al.*, 2020).

We acknowledge the potential advantages of employing both objective and subjective measures of energy poverty in a single study. Unfortunately, the CFPS does not provide any subjective measures of energy poverty.[2] Thus, we can only rely on objective measures. Following the

[2] Zhang *et al.* (2021) use the 2014 CFPS to construct a multidimensional energy poverty index, which covers not only access to electricity and gas/LPG/biogas but also ownership of mobile phone, TV and fridge. In addition to

literature, we employ three such objective measures. Two measures follow the energy expenditure–income approach. The first measure is the share of annual energy expenditure on electricity, gas, heating and other energy in household income. The second is a dummy variable indicating whether the share of energy expenditure in household income is higher than 10% (yes=1; no=0). The so-called 10% indicator was first used in the UK (Boardman, 1991). In robustness checks, we also use other thresholds for this indicator of energy poverty in the context of China as a developing country, where the share of energy consumption in household income is generally lower (Wang *et al.*, 2015).

The third measure follows the low-income high-cost (LIHC) indicator of energy poverty proposed by Hills (2012), which classifies households as energy poor if their energy costs are above the median level of energy costs in their province and in a particular year (wave), while their residual household income per capita is below 50% of the median household income per capita in their province and year. The LIHC indicator effectively circumvents the impacts of high-income and high-energy consumption households. This feature of the LIHC is particularly useful because it mitigates the potential bias introduced by high-income entrepreneurs who consume a large amount of energy for productive use. Both the 10% and LIHC indicators have been found to be effective and valid in evaluating the impacts of energy poverty in China (Lin & Wang, 2020).

A descriptive analysis of the 2012-2018 CFPS data confirms the substantial variations in energy poverty across provinces. Figure 1 shows that in general, households in the less developed western and central regions spent a higher proportion of their annual household income on energy than those in the more developed eastern region. Figure 2 confirms that those regions are also where households in energy poverty, that is, those who spend more than 10% of their annual household income on energy consumption, are located.

[Figure 1 here]

[Figure 2 here]

Table 1 presents the summary statistics on energy poverty measures in the CFPS samples across waves. On average, between 2012 and 2018, households spent 7-8% of household income on energy, while the share of households that spent more than 10% of their income on energy decreased from approximately 21% to 18%. The LIHC indicator of energy poverty identifies 26-30% of households in energy poverty in the same period.

[Table 1 here]

4. Methods

The empirical strategy develops from the following model:

$$Ent_{ijt} = \alpha + \beta EP_{jt} + \gamma X_{ijpt} + \delta_i + \mu_p + \pi_t + \varepsilon_{ijt} \qquad (1)$$

where Ent_{it} is a dichotomy outcome variable on whether respondent i in household j is a solo or employer entrepreneur at time t (yes=1; no=0). Table 1 shows that the proportion of entrepreneurs increased from approximately 7.8% to 10.3% from 2012-2018.

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that these variables are only available in one wave of CFPS, such index is not suitable in the context of the present study because ownership of mobile phone and household appliance may be used as productive inputs in entrepreneurial activities.

Of the right-hand side variables, EP_{jt} is one of the three alternative energy poverty measures in respondent household j at time t, depending on the exact specification. X is a vector of control variables, including individual demographics and household characteristics. Table A1 in the Appendix presents the definitions and summary statistics for the control variables. The parameters δ_i, μ_p and π_t capture individual, province and time (wave) fixed effects, respectively. The term ε_{ijt} is the error term.

We use a set of linear probability models to predict the probability of being an entrepreneur in equation 1. We first use an ordinary least squares (OLS) model to analyse pooled cross-sectional data with province and time fixed effects. We then use a two-way fixed effects (FE) model to analyse the CFPS panel data, incorporating province, time and individual fixed effects.

One limitation of using OLS and FE is that the key variable of interest, energy poverty, may be endogenous, and this may bias its estimates downward due to measurement errors, simultaneity bias or reverse causation. Measurement error occurs if respondents do not perfectly recall household energy expenditure, and its magnitude may be substantial. For example, survey respondents in Australia underestimate their household energy expenditure by 13-20% (Wilkins & Sun, 2010). Awaworyi Churchill and Smyth (2021) also find that their pooled OLS and FE estimates on the effect of energy poverty and health are biased downward, possibly as a result of measurement error. Measurement error due to underestimated energy spending can underestimate the effects of energy poverty on the probability of becoming an entrepreneur, leading to downward bias. Simultaneity bias or reverse causation may be present if, for example, some low-skilled entrepreneurs who were recently in energy poverty earn more than they could have in a low-skilled waged job, resulting in a reduction in the share of energy spending in household income at the time of survey. In this case, the OLS and FE estimates of the effects of energy poverty on the propensity for entrepreneurship will be biased downward because the share of energy spending in household income is reduced because of participation in entrepreneurship. Another potential source of endogeneity is omitted variable bias. For example, unobserved ability may lead to downward bias in estimating the effects of human capital on labour market outcomes (Chiswick & Miller, 1995; Wang *et al.*, 2016b, 2019; Wang *et al.*, 2017). This may be the case if being energy poor as an underdog characteristic has a positive effect on entrepreneurship.

The literature generally employs an instrumental variable (IV) to address the potential endogeneity of energy poverty. Awaworyi Churchill *et al.* (2020) use the state-level fuel price in Australia as an IV to estimate the causal impact of fuel poverty on happiness, as state-level prices for electricity and gas determine household expenditure on energy. Awaworyi Churchill *et al.* (2020) find that the state-level fuel price is a valid IV, but the resulting estimated coefficients are too large. This outcome leads Awaworyi Churchill *et al.* (2020) to use an alternative approach discussed by Lewbel (2012) and based on internally generated IVs reflecting a heteroskedastic covariance restriction. The advantage of Lewbel's (2012) internally generated IVs is that they do not rely on satisfying the exclusion restriction, which normally applies to IV estimators. In particular, Awaworyi Churchill *et al.* (2020) compare their IV results from an external IV (i.e., the state-level fuel price) to those from generated and external IVs (i.e., Lewbel (2012)-generated IVs and the state-level fuel price), concluding that the results from the combination of the generated and external IVs are more plausible.

Using the CFPS, Zhang *et al.* (2019) employ the average provincial share of people in energy poverty, which proxies for energy affordability, as an IV to estimate the impact of energy poverty

on health. However, this IV may not fully satisfy the exclusion restriction because it is derived from responses of the same households that required instrumentation. Another potential issue is that using the provincial measure as an IV alone may cause more variations in the estimated model, resulting in a non-significant and biased estimated impact of energy poverty (Zhang *et al.*, 2019).

Following these studies, we use two external IVs based on the provincial energy price and provincial energy poverty rates. The first external IV is the annual consumer price index (CPI) for electricity and fuel at the province level. This is similar to the employment of the state-level fuel prices as an IV in Awaworyi Churchill and Smyth (2021), Awaworyi Churchill *et al.* (2020) and Kahouli (2020), which are based on the existing evidence that there is a significant relationship between energy prices and energy demand (He *et al.*, 2011; Narayan & Smyth, 2005). This is also similar to the use of provincial-level electricity prices as an IV to instrument for energy poverty in Zhang *et al.* (2021). The rationale of employing provincial electricity and fuel CPI as an IV is that an increase in the energy price directly affects energy consumption for a given household budget. In other words, the mechanism through which energy price changes affect entrepreneurship should be through the share of energy expenditure in household income, which can be captured by the measures of energy poverty used in this study.

One potential concern is that if an energy price change is directly related to the propensity for entrepreneurship, it will violate the exclusion restriction. For example, an increase in energy prices may cause competition between energy and entrepreneurship expenditure under household budget constraints and that a household that prefers energy consumption over potential incomes from entrepreneurship may increase spending on energy at the expense of (potential) spending on entrepreneurship, thus lowering the propensity for entrepreneurship. This should be of less concern for two main reasons. First, in analysing the potential effect of an increase in energy prices on the competition between energy and health expenditure in Australia, Awaworyi Churchill and Smyth (2021) suggest that an increase in energy prices will engender a substitution effect away from higher spending on energy and that the substitution effect will be bolstered by the income effect as a result of reduced household budget due to higher energy prices; nonetheless, these authors argue that the effect of higher energy prices on health expenditure would be purely due to the negative income effect. Awaworyi Churchill and Smyth (2021: 3) further argue that 'energy expenditure is unlikely to represent a significantly large share of the household budget to generate a large enough income effect to substantially effect other items of the budget.' This argument applies to the context of the present study in China where the mean share of energy expenditure in household income is approximately 7-8 percent and is stable over the survey period (see Table 1). In addition, the CPI for electricity and fuel at the province level used in the present study has a mean of 101.3 and a standard deviation of 2.4, showing low fluctuations in energy prices in China. The share of energy expenditure in household income and the energy price changes are low and stable in China compared to developed countries such as Australia, where there was a 35 percent increase in household bills and a 56 percent increase in the price of electricity for the period from 2007 to 2018 (Australian Competition and Consumer Commission, 2018). Thus, Chinese households are unlikely to face dramatic changes in allocating household budgets to energy and entrepreneurship expenditures simply due to energy price changes. Second, entrepreneurship is mainly an income-generating activity in the context of the present study rather than a consumption activity such as health expenditure in the contexts of Awaworyi Churchill and Smyth (2021) and Kahouli (2020). Thus, it is unlikely that a household would reduce their entrepreneurial spending to forgo potential

incomes simply due to energy price changes. The most plausible channel through which energy prices affect entrepreneurial behaviour is energy expenditure.

The second external IV is the leave-one-out mean county-level energy poverty rates within a province, which is defined as the mean county-level energy poverty rate in the respondent's province excluding the county where the respondent resides. The underlying assumption is that energy poverty rates in other counties capture the general level of energy infrastructure and affordability within the province, which impact household energy access and consumption (Zhang *et al.*, 2019). Nonetheless, energy poverty rates in counties other than the respondent's residential county should not directly affect the household's entrepreneurial decision. In addition, using the leave-one-out mean county poverty rate as an IV can rule out the impacts of peer effects of other households in the same county in determining the energy consumption of the respondent's household.

We combine these two external IVs with Lewbel (2012) internally generated IVs and use a two-way fixed effects two-stage least squares (FE-2SLS) estimator to produce IV results to remove time-invariant individual unobservables and wave-specific shocks common to all individuals (Awaworyi Churchill *et al.*, 2020).

In the robustness check, we also use a limited information maximum likelihood (LIML) estimator and a two-step generalised method of moments (GMM). To address the potential omitted variable bias, we adopt the Oster (2019) test to examine whether our FE results for the three objective measures of energy poverty are biased by unobserved heterogeneity.

5. Main results

Table 2 presents the OLS, FE and FE-2SLS. Panel A in Table 2 presents the results related to the share of energy expenditure as a measure of energy poverty. In models A1 and A2, the OLS and FE results show that a 10% increase in the share of energy expenses in household income is associated with a 1.1 percentage point increase in the probability of becoming an entrepreneur.

Following Awaworyi Churchill *et al.* (2020), our model A3 employs both the generated and external instruments in 2SLS, showing that a 10% increase in the share of energy expenses in household income increases the probability of becoming an entrepreneur by 1.7 percentage points. In general, the findings from OLS, FE and FE-2SLS are consistent in that there is a positive relationship between the share of energy expenditure in household income and entrepreneurship. In addition, the findings from our preferred FE-2SLS model using generated and external instruments are consistent with our predictions that OLS and FE bias the estimates downward due to the endogeneity of energy poverty.

[Table 2 here]

Panel B in Table 2 presents the results obtained when we measure energy poverty and reflects whether the share of energy expenditure in household income is greater than 10%. In models B1 and B2, the OLS and FE results show that energy poverty is associated with a 1.3- and 2.7-percentage-point increase in the probability of becoming an entrepreneur, respectively. The FE-2SLS results using generated and external instruments suggest that spending more than 10% of household income on energy increases the probability of becoming an entrepreneur by 6.8 percentage points. Again, OLS and FE bias the estimates of the effects of energy poverty downward.

Panel C presents the results based on the LIHC indicator of energy poverty. In models C1 and C2, the OLS and FE results show that being energy poor as defined by the LIHC measure is associated with a 5- and 2.3-percentage-point increase in the probability of becoming an entrepreneur, respectively. The FE-2SLS results using the generated and external instruments suggest that being energy poor, as defined by the LIHC indicator, increases the probability of becoming an entrepreneur by 9.4 percentage points. These results also show that OLS and FE bias the estimates downward.

In general, the results from our preferred FE-2SLS model using generated and external IVs from panels A, B and C are consistent. They all suggest that being energy poor has a positive impact on the probability of becoming an entrepreneur.

6. Potential mechanisms

We test seven potential mechanisms through which energy poverty is associated with entrepreneurial choice. The first two mechanisms, namely, memory and cognitive ability, are related to cognitive functions. The CFPS measures cognitive functions through self-assessed memory and interviewer-assessed fundamental cognitive ability. Memory is measured on a 5-point scale by the self-response to the question on whether the respondent can remember the important things happened to her/him within a week (only a little bit = 1; all of them = 5). Basic numeracy as a fundamental cognitive ability is measured by the sum of the scores from the maths tests administered by interviewers, with a higher value indicating a better performance in these tests.[3]

The negative effects of poverty on cognitive functions are well documented (Bergen, 2008; Dean *et al.*, 2019; Mani *et al.*, 2013). For example, uncertainty about material resources causes toxic stress that negatively affects memory (Noble *et al.*, 2012). Poverty depletes cognitive control by making economic decision-making more difficult (Spears, 2011). In addition, DellaValle (2019) finds that people in energy poverty are more susceptible to cognitive biases in decision-making. Cedeño Laurent *et al.* (2018) find that residents in non-air-conditioning buildings had reduced cognitive functioning during a heat wave. Individuals with high cognitive functions are more likely to become entrepreneurs. For instance, national differences in cognitive skills predict a nation's likelihood of generating entrepreneurs (Hafer & Jones, 2015; Hafer, 2017). Other studies find that lower levels of literacy and numeracy are a barrier for the poor to acquire other skills for successful entrepreneurship (Cho, 2015). Thus, we conjecture that memory or cognitive ability as a mediator is negatively associated with energy poverty but positively associated with the probability of becoming an entrepreneur, while energy poverty has a positive impact on the probability of becoming an entrepreneur. This type of so-called 'competitive' or 'inconsistent' mediation, a situation in which the mediated effect and direct effect both exist but are in opposing directions, may lead to a negative proportion mediated (MacKinnon *et al.*, 2000; Shrout & Bolger, 2002; Zhao *et al.*, 2010). Competitive mediation is different from complementary mediation in which the mediated effect and direct effect both exist and point in the same direction (Zhao *et al.*, 2010).

The results in Panels A and B in Table 3 are consistent with the prediction of a competitive mediation model. Panel A shows that having better memory negatively mediates the relationship

[3] The problems in the math test include addition, subtraction, multiplication, division, exponents, logarithms, trigonometric functions, sequence, permutation and combination. Scores for the tests are calculated by the CFPS.

between being in energy poverty and the probability of being an entrepreneur. Panel B shows that having better numeracy negatively mediates the relationship between being in energy poverty and the probability of being an entrepreneur.[4] Panels A and B suggest that exposure to energy poverty leads to poorer cognitive functions, while having better cognitive functions increases the probability of being an entrepreneur after adjusting for exposure to energy poverty, resulting in a negative mediation effect (i.e., the product of a negative and positive is negative). Put differently, while we find a positive direct and overall effect of being in energy poverty on entrepreneurship, energy poverty negatively impacts cognitive functions and thereby reduces the magnitude of the direct effect found.

[Table 3 here]

The third potential mechanism is mental health, as proxied by symptoms of depression. Depression is measured by the total score of responses to the Center for Epidemiological Studies-Depression scale (CES-D). The total score of self-reported items is reverse coded and normalised to zero with a standard deviation of one. A higher score presents a lower level of depression symptoms (i.e., better mental health). Poverty often leads to depression as a result of loss of income (Ridley *et al.*, 2020). The poor are also more exposed to environmental stresses, including temperature extremes, which can cause mental illness (Ridley *et al.*, 2020). For example, an increase in energy poverty is associated with a decline in general and mental health due to stress associated with the inability to pay energy bills (Awaworyi Churchill & Smyth, 2021; Liddell & Morris, 2010; Oliveras *et al.*, 2021). Mental health can function as a personal resource or strength that can facilitate entrepreneurship endeavours and improve entrepreneurial outputs (Hatak, 2021; Shepherd & Patzelt, 2015). Depression can lead to a lower entrepreneurial intention (Leung *et al.*, 2020) and, among entrepreneurs, a higher chance of entrepreneurial exit (Hessels *et al.*, 2018) and a lower productivity (Hatak & Zhou, 2021). The results in Panel C show that depression negatively mediates the positive impact of energy poverty on the propensity for entrepreneurship.

With reference to non-cognitive abilities as possible mediators, the fourth potential mechanism is self-confidence. Self-confidence is measured on a 5-point scale by self-response to a question on whether the respondent is confident in her/his own future (not confident at all = 1; very confident = 5). Poverty often results in lower self-confidence among the poor (Cheng, 2014; Cheng & Beresford, 2012; Engle & Black, 2008; Galbraith, 1979). A higher degree of self-confidence is positively associated with the propensity for entrepreneurship (Hayward *et al.*, 2006; Miller & Sardais, 2015; Villasana *et al.*, 2016). A higher level of self-confidence as a psychological resource is particularly important for disadvantaged populations to secure a job and achieve career success (Cheng *et al.*, 2021b). The results in panel C confirm the existence of competitive mediation, where self-confidence negatively mediates the positive impact of energy poverty on the propensity for entrepreneurship.

The fifth potential mechanism is self-belief in one's opportunity to improve living conditions. This is measured on a 5-point scale by self-response to a question on whether the respondent believes that people like him/herself have a great opportunity to improve their living conditions in today's society (strongly disagree=1; strongly agree=5) in the 2018 CFPS. China's fast economic development provides ample opportunities for the poor to escape poverty (Ravallion, 2021). In addition, the Chinese government has implemented numerous targeted anti-poverty

[4] We also test basic literacy measured by word test as a potential mediator but the results are not significant.

programs, including entrepreneurial training to uplift the poor's labour market skills and solar photovoltaic deployment to address energy poverty (Zhang *et al.*, 2020). The strong performance of the antipoverty campaign in China has a positive effect on the poor's political trust and the general enabling environment for the poor to pursue better lives (Zuo *et al.*, 2021) and, thus, on their self-belief in the opportunity to improve their living conditions. Those with stronger self-belief in their capabilities are more likely to become entrepreneurs (Henderson & Robertson, 1999; Laguna, 2013). The results in Panel E show that being in energy poverty is associated with a higher level of self-belief and that a higher level of self-belief positively mediates the relationship between energy poverty and entrepreneurship. This finding is consistent with the theory of underdog entrepreneurship that challenged conditions can lead to some beneficial characteristics for entrepreneurship.

Finally, we examine personality traits as potential mediators. The 2018 CFPS collects information on the Big Five personality traits (i.e., extraversion, agreeableness, openness, conscientiousness and neuroticism), which are measured by scores from principal component analysis. Panels F and G show that being in energy poverty is positively associated with higher levels of extroversion and openness, respectively. A higher level of extroversion or openness is positively associated with a higher probability of becoming an entrepreneur, consistent with the general findings in the literature (Brandstätter, 2011). Again, these findings are consistent with the theory of underdog entrepreneurship that difficulties can breed personal qualities that are beneficial for entrepreneurship.[5]

7. Extensions

We examine whether being energy poor is associated with the sector in which an entrepreneur works. Table 4 presents the results from the panel fixed effects multinomial logit model, in which the base choice available to an entrepreneur is the sector comprising science, education, culture, health and other social organisations and the other available choices are the manufacturing, mining and retail and service sectors. The existing literature suggests that poor working conditions, payment arrears and rights violations are more prevalent in the manufacturing, mining and retail and service sectors in China (Cheng *et al.*, 2015; Guo *et al.*, 2014; Wang *et al.*, 2016a). The results suggest that among entrepreneurs, a higher proportion of energy spending in household income is associated with a higher probability of working in the retail and service sectors than in the base sector. This is consistent with the existing literature that the retail and service sectors provide the poor with entrepreneurial opportunities to work as street vendors, cleaners, kitchen hands, nannies and so on (Cheng, 2014; Cheng & Beresford, 2012; Solinger, 2013).

[Table 4]

We also examine heterogeneity in subsamples across gender and region. Panel A in Table 5 shows that the positive effect of energy poverty on the probability of being an entrepreneur is significant among males but not females. One potential explanation is that women face more obstacles and family and resource constraints than men in setting up businesses (Zhang & Zhou, 2021). Panel B shows that the positive effect of energy poverty is significant in urban areas but

[5] We also test the other three Big Five personality traits (i.e., agreeableness, conscientiousness and neuroticism) but do not find them playing any mediating roles. The results are available from the authors upon request.

not rural areas. This reflects that entrepreneurial activities are more concentrated in urban China (Liu & Zhang, 2021; Troilo & Zhang, 2012).

[Table 5]

8. Robustness checks

We conduct several robustness checks. As the relationships between consumption and individual outcomes may not be linear, we rerun model A3 in Table 2 with an additional squared term for the share of energy expenditure in household income. The results in Table A2 show an inverted U-shaped relationship between the share of energy expenditure in household income and the probability of becoming an entrepreneur. The turning point of the inverted U-shaped relationship is at an energy expenditure–income ratio of approximately 30%. In other words, those who spend a share larger than 30% of their household income on energy consumption are less likely to become entrepreneurs. This suggests that relatively severe energy poverty beyond the turning point inhibits entrepreneurship. One potential explanation for the inverted U-shaped relationship is that those who spend a higher proportion – in our case, more than 30% – of household income on energy lack the minimum capital required to engage in business venturing. This finding also suggests that the positive impact of a higher share of energy expenditure in household income on the propensity to engage in entrepreneurship is not simply due to higher energy consumption spending relative to household income in the process of entrepreneurial activities (e.g., producing goods for sale).

Table A3 presents the results using alternative cut-offs for the indicator of energy poverty based on the share of energy expenditure in household income. It shows that energy poverty has a positive effect on entrepreneurship when energy expenditure is greater than 5%, 10% or 20% of household income (models 1-3). However, the coefficients for cut-offs at 30% and 40% are not significant. These findings are consistent with those in Table A3 that the turning point of the inverted U-shaped relationship between energy poverty and entrepreneurship is at approximately the cut-off of 30% of household income.

Moreover, current entrepreneurial choices may be influenced by past entrepreneurial experience, which may also have dynamic flow-on effects on current energy consumption. For example, an expanding business operation may result in increased energy consumption in later periods. To explore this possibility, we further control for past entrepreneurial choice in the preferred FE-2SLS model using the generated and external IVs. Table A4 presents the results from a model further controlling for lagged entrepreneurship. In both models 1 and 2, the coefficients for energy poverty are positive. This suggests that energy poverty still impacts current entrepreneurial choice even after we control for past entrepreneurial choice.

Table A5 presents the results from the LIML and GMM estimators, which can be more effective in eliminating potential biases associated with weak instruments. The LIML and GMM results are qualitatively consistent with those from 2SLS.

We further employ the Oster (2019) test to check whether our FE results for the three objective measures of energy poverty are biased by unobserved heterogeneity.[6] Columns 1-3 in Table A6

[6] For a detailed discussion on this approach, see Oster (2019).

report the estimated association between energy poverty and individual entrepreneurship with no controls, a full set of controls listed in Table A1, and both a full set of controls and unobservables, respectively. The bias-adjusted treatment effects in column 3 show that being in energy poverty is associated with a higher probability of becoming an entrepreneur. The magnitude of the bias-adjusted treatment effects is very close to that of FE estimates. The results meet the robustness standards proposed by Oster (2019), as the bounds of the set $[\tilde{\beta}, \beta^*(R_{max}, 1)]$ do not include zero and fall within ±2.8 standard errors of the controlled estimates. Oster (2019) suggests that a value of δ greater than one (i.e., that selection on observables is at least as important as selection on unobservables) indicates a result that is robust to omitted variable bias. Given that the inclusion of controls moves the coefficients on energy poverty away from zero instead of towards zero, the values of δ are all negative, while their absolute values exceed one. This finding is consistent with the FE-2SLS estimates, suggesting that the OLS estimates are likely to underestimate the true effect of household energy poverty. The Oster (2019) test results suggest that the estimated FE results presented in Table 2 are robust and unlikely to be severely confounded by unobserved characteristics.

9. Discussion

In the theory of underdog entrepreneurship, Miller and Le Breton-Miller (2017) argue that specific conditions and experiences can increase the likelihood that one becomes an entrepreneur. They include mental and physical health problems, cognitive disabilities and a lack of human capital. However, Miller and Le Breton-Miller (2017) do not explore in-depth the root source of such conditions and experiences. This study builds on the theory of underdog entrepreneurship by extending it to energy poverty, one of the most prevalent forms of poverty and material deprivation in contemporary societies. We also add to other recent studies that extend the theory to the roles of early childhood conditions in generating some of these conditions and experiences (Awaworyi Churchill *et al.*, 2021; Cheng *et al.*, 2021a).

In addition to finding that energy poverty has a positive effect on the propensity for entrepreneurship, we find that the positive effect is mediated through multiple channels, which produce antagonistic effects. While poverty or any other socioeconomic difficulties can nurture some positive personal characteristics, they also produce some negative personal characteristics that may impede the positive effects of poverty experiences on entrepreneurship (Morris *et al.*, 2020a).

These results contribute to the literature in two distinct ways. First, they extend the literature on the implications of energy poverty by examining the relationship between being energy poor and entrepreneurial choices. Previous studies have examined the relationships between energy poverty and a series of individual and societal outcomes, such as physical and mental health (Awaworyi Churchill & Smyth, 2021; Mohan, 2021; Oliveras *et al.*, 2021), happiness (Awaworyi Churchill *et al.*, 2020), mortality (Recalde *et al.*, 2019), experience of physical violence (Hailemariam *et al.*, 2021), and income inequality (Bardazzi *et al.*, 2021). However, none of these studies focuses on the effects of energy poverty on entrepreneurship as a labour market outcome. While a body of literature has investigated the productive use of energy in promoting the growth and performance of entrepreneurial firms established by the poor and disadvantaged (Akpan *et al.*, 2013; de Groot *et al.*, 2017; Gray *et al.*, 2019; Meadows *et al.*, 2003; Pueyo *et al.*, 2020), there is little research on the relationship between household energy poverty and individual entrepreneurship. We contribute to fill this gap.

Second, the results extend the literature on the causes of entrepreneurship by exploring the energy poor's probability of becoming an entrepreneur and the mechanisms through which this outcome arises. A large body of literature has examined a wide range of socioeconomic and socio-demographic factors that lead to entrepreneurship, such as education (Cheng & Smyth, 2021; Huber *et al.*, 2014; Van der Sluis *et al.*, 2008), age (Lévesque & Minniti, 2011; Liang *et al.*, 2018), gender (Babbitt *et al.*, 2015; Henry *et al.*, 2016), migration status (Baycan-Levent & Nijkamp, 2009), wealth (Hurst & Lusardi, 2004), and race (Wingfield & Taylor, 2016). Different from the existing studies that mainly focus on entrepreneurship as a solution to poverty (Bruton *et al.*, 2013; Morris *et al.*, 2020b; Sutter *et al.*, 2019), we examine poverty as a cause of entrepreneurship – an emerging literature (Morris, 2020; Morris *et al.*, 2020a; Morris & Tucker, 2021a) – and analyse why people who have underdog entrepreneurs' characteristics end up being entrepreneurs and through which mechanisms their underdog characteristics favour the emergence of entrepreneurship.

10. Conclusion

We find that energy poverty raises the probability of entrepreneurship in China. Our findings are consistent with the literature suggesting that adversity may be a catalyst that fosters resilience and resourcefulness in overcoming difficult circumstances. These findings are robust to alternative measures of energy poverty, i.e., the share of energy expenditure in household income, an indicator for whether the household spends more than 10% of household income on energy, and an indicator for whether the household is classed as experiencing LIHC energy poverty.

We also find that the relationship between energy poverty and the propensity to engage in entrepreneurship has an inverted-U shape, with the turning point occurring when the household spends more than 30% of household income on energy expenditure. Among entrepreneurs, those who spend a higher share of household income on energy are more likely to work in the retail and service sectors than in the science, education, culture, health, and social organisations sectors, which generally offer better economic returns.

Our results are robust to several tests, including defining different cut-offs for the indicator for the energy expenditure share, controlling for the flow-on effects of lagged entrepreneurship, employing alternative estimators and testing for omitted variable bias.

Entrepreneurship provides 'a worthy path of self-empowerment, where the individual creates and captures value, addresses needs and can contribute to the fabric of a community' (Morris, 2021: 523). Entrepreneurship is a means of breaking out the vicious cycle of poverty. Nobel Peace prize laureate Muhammad Yunus (2008) suggested that 'the poor themselves can create a poverty-free world. All we have to do is to free them from the chains that we have put around them.' However, the 'playfield is not level for poverty entrepreneurs' because the 'complex, multi-faceted nature of the poverty experience' creates a barrier – the liability of poorness – in addition to the universal liabilities of newness and smallness for poor entrepreneurs (Morris, 2020; Morris *et al.*, 2020a).

To assist the poor in creating their own jobs and securing their own futures through entrepreneurial action, some form of government support may be needed (Li *et al.*, 2020; Morris & Tucker, 2021b). Our findings support such interventions for entrepreneurs in energy poverty, especially those in severe energy poverty, who may benefit from subsidies, discounted energy prices and free use of a particular amount of energy, among other initiatives. The mechanisms

through which energy poverty impacts entrepreneurship also suggest that targeted interventions should aim at improving cognitive functions, mental health and self-confidence.

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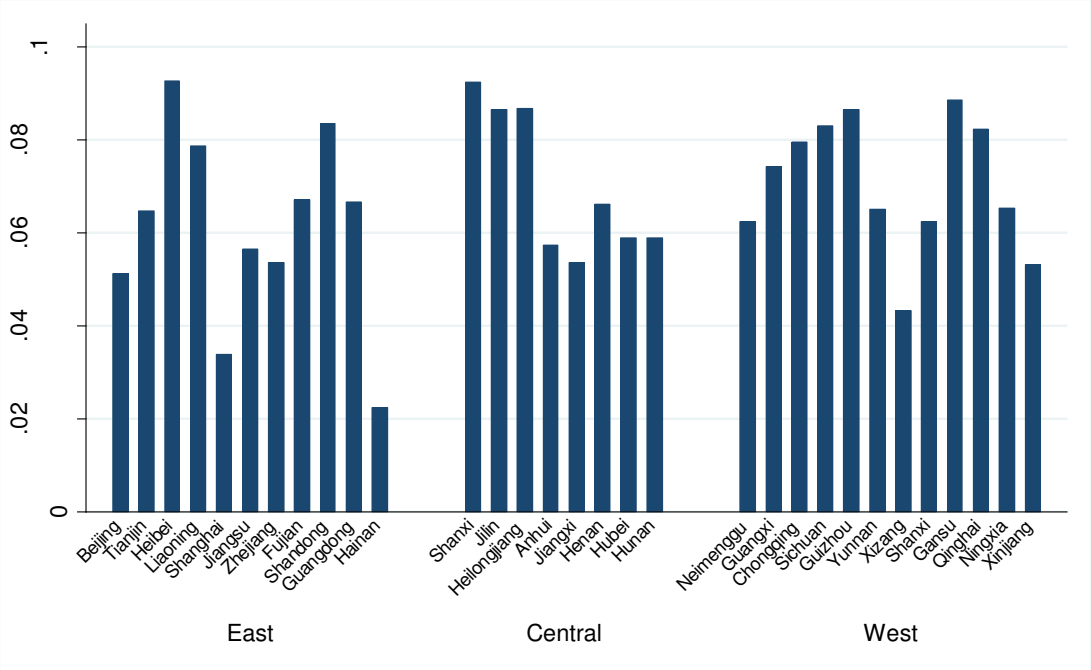
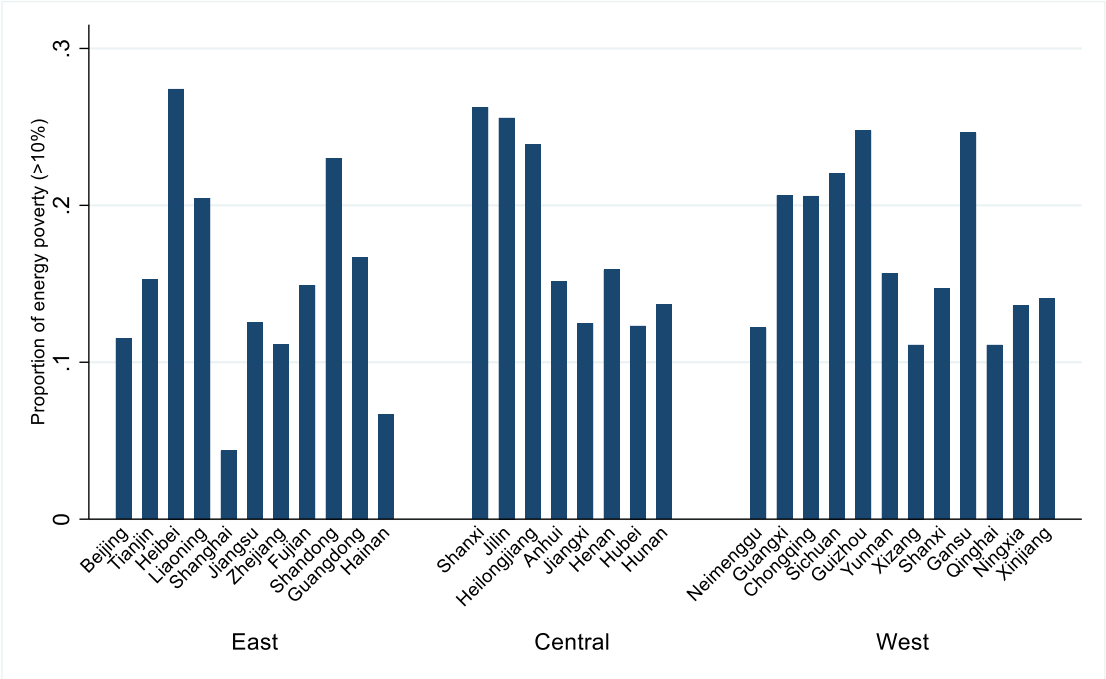
Figure 1. Share of annual energy expenditure in household income by province, 2012-2018



Data source: 2012-2018 China Family Panel Studies.

Figure 2. Proportion of households with an energy expenditure/income ratio >10% by province, 2012-2018



Data source: 2012-2018 China Family Panel Studies.

Table 1. Summary statistics for energy poverty and entrepreneurship, 2012-2018 China Family Panel Studies

	2012		2014		2016		2018	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Household energy expenditure per annum (in thousands)	1.80	1.83	2.26	2.32	2.24	2.10	2.56	2.30
Household income per annum (in thousands)	44.08	44.35	51.72	44.86	57.66	51.04	67.17	59.56
Energy poverty								
Share of energy expenditure in household income	0.08	0.10	0.08	0.10	0.07	0.09	0.07	0.10
Whether the share of energy expenditure in household income exceeds 10% (yes=1; no=0)	20.63%		21.02%		18.00%		17.51%	
Low-income-high-cost (LIHC) indicator of energy poverty (yes=1; no=0)	27.01%		25.56%		26.91%		30.10%	
Entrepreneurship								
Entrepreneur (solo or employer entrepreneur)	7.82%		9.99%		10.19%		10.26%	

Table 2. Energy poverty and entrepreneurship

	Outcome variable: Being an entrepreneur					
	OLS		FE		FE-2SLS with generated and external instruments	
Panel A		(A1)		(A2)		(A3)
Share of energy expenditure in household income	0.114***	(7.80)	0.113***	(7.75)	0.171**	(2.29)
Observations	69,550		69,550		69,547	
Kleibergen-Paap rk Wald F-statistic					11.32	
Hansen J statistic *p*-value					0.884	
First-stage results						
CPI for electricity and fuel prices					0.00743***	(2.72)
Average county energy poverty					0.0492***	(4.05)
Panel B		(B1)		(B2)		(B3)
Indicator for share of energy expenditure>10% (yes=1)	0.013***	(7.84)	0.027***	(7.94)	0.068*	(1.69)
Observations	69,550		69,550		69,547	
Kleibergen-Paap rk Wald F-statistic					16.39	
Hansen J statistic *p*-value					0.939	
First-stage results						
CPI for electricity and fuel prices					0.00387***	(3.39)
Average county energy poverty					0.155***	(3.05)
Panel C		(C1)		(C2)		(C3)
LIHC indicator (yes=1)	0.050***	(13.17)	0.023***	(7.68)	0.0942*	(1.74)
Observations	69,550		69,550		69,547	
Kleibergen-Paap rk Wald F-statistic					11.160	
Hansen J statistic *p*-value					0.967	
First-stage results						
CPI for electricity and fuel prices					-0.000287	(-0.24)
Average county energy poverty					-0.153***	(-2.92)

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust *t* statistics in parentheses for OLS and FE. Robust z statistics in parentheses for FE-2SLS. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results, including the results for generated instruments, are available from the authors.

Table 3. Potential Mechanisms between Energy Poverty and Entrepreneurship

	(1) Mediator	(2) Being an entrepreneur	(3) Being an entrepreneur
Panel A: Memory as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	-0.0871***	0.0820**	0.0825***
	(-7.37)	(24.70)	(24.85)
Better memory			0.0059***
			(6.34)
Indirect effect	-0.0005***	(-4.81)	
Proportion of indirect effect	-0.0062		
Panel B: Cognitive ability as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	-0.0344***	0.0892***	0.0896***
	(-4.67)	(23.58)	(23.67)
Higher level of numeracy			0.0093***
			(5.10)
Indirect effect	-0.0003***	(-3.44)	
Proportion of indirect effect	-0.0036		
Panel C: Mental health as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	-0.0512*	0.0799***	0.0801***
	(-4.76)	(21.32)	(21.38)
Lower level of depression symptoms			0.0044***
			(3.37)
Indirect effect	-0.0002***	(-2.75)	
Proportion of indirect effect	-0.0028		
Panel D: Self-confidence as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	-0.0176*	0.0821***	0.0822***
	(-1.84)	(24.72)	(24.75)
Higher level of self-confidence			0.0065***
			(5.80)
Indirect effect	-0.0001*	(-1.75)	
Proportion of indirect effect	-0.0014		
Panel E: Self-belief as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	0.0467***	0.0910***	0.0905***
	(2.76)	(12.66)	(12.60)
Higher level of self-belief			0.0106***
			(4.09)
Indirect effect	0.0005**	(2.29)	
Proportion of indirect effect	0.0054		
Panel F: Extroversion as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	0.0407**	0.0911***	0.0906***
	(1.99)	(12.64)	(12.59)
Higher level of extroversion			0.0106***
			(4.70)
Indirect effect	0.0004*	(1.83)	
Proportion of indirect effect	0.0047		
Panel G: Openness as a mediator			
Indicator for share of energy expenditure>10% (yes=1)	0.0585***	0.0909***	0.0903***
	(2.88)	(12.59)	(12.51)
Higher level of openness			0.0106***
			(4.54)
Indirect effect	0.0006**	(2.43)	
Proportion of indirect effect	0.0069		

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are obtained from the Lewbel (2012) 2SLS. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Table 4. Share of energy expenditure in household income and sector of entrepreneurship

	Outcome variable: Being an entrepreneur	
Base sector: Science, education, culture, health and social organisations		
Manufacturing sector		
Share of energy expenditure in household income	0.083	(0.15)
Mining sector		
Share of energy expenditure in household income	-0.690	(-1.06)
Retail and service sector		
Share of energy expenditure in household income	1.467***	(2.81)
Other sectors		
Share of energy expenditure in household income	0.166	(0.19)
Observations	22,411	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are based on FE-multinomial logit regression. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Table 5. Share of energy expenditure in household income and entrepreneurship by gender and region

	Outcome variable: Being an entrepreneur	
Panel A: Gender		
Male	0.3062**	(2.53)
Female	-0.0069	(-0.07)
Panel B: Region		
Urban area	0.4280**	(2.39)
Rural area	0.0781	(0.91)

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are based on the Lewbel (2012) 2SLS. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Appendix

Table A1. Summary statistics for control variables, 2012-2018 China Family Panel Studies

Variable	Definition	Mean	S.D.
Male	Male =1, female=0	52.44%	
Age	Years	42.87	12.40
Education	Years of education	7.53	4.88
Marital status			
Unmarried	Reference group	10.13%	
Married		85.97%	
Other		3.90%	
Agricultural *hukou*	Agricultural *hukou*=1; non-agricultural *hukou*=0	77.22%	
Social status	Self-assessed social status. Scale: very low=1; very high=5	2.86	1.03
Economic status	Self-assessed economic status. Scale: very low=1; very high=5	2.57	1.00
Health status	Scale: very unhealthy=5; very healthy=1	2.95	1.20
Medical insurance	Has medical insurance: yes=1; no=0	91.57%	
Superannuation	Has superannuation: yes=1; no=0	50.06%	
Homeownership	Number of houses owned	1.12	0.58
Family size	Number of family members	4.38	1.95
Urban area	Urban area=1; rural area=0	44.82%	
Province	31 provinces		
Wave	4 waves		

Table A2. Non-linear relationship between share of energy expenditure in household income and entrepreneurship

	Outcome variable: Being an entrepreneur	
Share of energy expenditure in household income	0.571***	(2.09)
Share of energy expenditure in household income^2	-0.943***	(-2.23)
Observations	66,549	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are based on FE-2SLS with
generated and external instruments. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Table A3. Alternative thresholds of indicator for share of energy expenditure in household income

Indicator for share of energy expenditure (yes=1)	Outcome variable: Being an entrepreneur									
	(1)		(2)		(3)		(4)		(5)	
>5%	0.106***	(2.61)								
>10%			0.068*	(1.69)						
>20%					0.081**	(2.00)				
>30%							0.022	(0.51)		
>40%									-0.068	(-1.13)
Observations	69,547		69,547		69,547		69,547		69,547	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are based on FE-2SLS with
generated and external instruments. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Table A4. Energy poverty and entrepreneurship with controls for lagged entrepreneurship

	Outcome variable: Being an entrepreneur	
	(1) Share of energy expenditure in household income	(2) Indicator for share of energy expenditure>10%
Lagged entrepreneurship	-0.124***	-0.124***
	(-41.49)	(-41.46)
Energy poverty	0.056***	0.010***
	(2.62)	(3.24)
Observations	40,834	40,834

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. The results are based on 2SLS with generated and external instruments. All specifications control for the variables in Appendix Table A1 and include province and wave fixed effects. Full results are available from the authors.

Table A5. Alternative estimators

	Outcome variable: Being an entrepreneur			
	LIML with generated and external instruments		GMM with generated and external instruments	
Panel A	(A1)		(A2)	
Share of energy expenditure in household income	0.176*	(1.76)	0.171*	(1.67)
Observations	69,547		69,547	
Panel B	(B1)		(B2)	
Indicator for share of energy expenditure>10% (yes=1)	0.076*	(1.73)	0.068*	(1.69)
Observations	69,547		69,547	
Panel C	(C1)		(C3)	
LIHC indicator (yes=1)	0.114*	(1.86)	0.094*	(1.74)
Observations	69,547		69,547	

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust z statistics in parentheses. All specifications control for the variables in Appendix Table A1 and include individual, province and wave fixed effects. Full results are available from the authors.

Table A6. The Oster (2019) test

	(1) Baseline effect $\dot{\beta}$ (S.E.) [R^2]	(2) Controlled effect $\tilde{\beta}$ (S.E.) [R^2]	(3) Bias-adjusted β^* R_{max}=1.3R (bootstrapped S.E.)	(4) δ for β=0 given R_{max}
Share of energy expenditure in household income	0.108(0.015) [0.002]	0.113(0.015) [0.006]	0.114(0.012)	-93.275
Indicator for share of energy expenditure>10% (yes=1)	0.026(0.003) [0.002]	0.027(0.003) [0.006]	0.027(0.003)	-83.419
LIHC indicator (yes=1)	0.023(0.003) [0.002]	0.023(0.003) [0.006]	0.024(0.002)	-88.816