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The role of financial inclusion in moderating the incidence of entrepreneurship on energy poverty in Ghana

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Abstract

This paper assesses the role of financial inclusion in moderating the incidence of entrepreneurship on energy poverty in Ghana. The assessment is made by using pooled data and two stage least squares. The exposition builds from the 7th (GLSS7) and 6th (GLSS6) rounds focusing on the Ghana Living Standards Survey (GSS, 2014, 2019) that is collected by the Ghana Statistical Service (GSS) from ten principal regions in the country. The findings show that entrepreneurship has an unconditional positive incidence on energy poverty while the interactive incidence between entrepreneurship and financial inclusion on energy poverty is negative. The corresponding financial inclusion policy thresholds that should be exceeded in order for financial inclusion to effectively moderate entrepreneurship for negative outcomes in energy poverty: (i) are between 0.154 and 0.280 index for the full sample; (ii) is between 0.187 index for the rural sub-sample; (iii) are between 0.200 and 0.333 index for the male sample. (iv) Thresholds are not computed for the rural and female sub-samples because at least one estimated coefficient that is needed for the computation of such thresholds is not significant. Policy implications are discussed. This study has complemented the existing literature by assessing how financial inclusion can be employed to influence the nexus between entrepreneurship and poverty in Ghana.

Keywords: Energy poverty; Financial inclusion; Consumption poverty; Education; Household income

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1. Introduction

The premise of this study on the role of financial inclusion in the incidence of entrepreneurship on energy poverty is motivated by four fundamental strands in the policy and scholarly literature on the subject, notably: (i) the importance of financial inclusion in the achievement of the Agenda 2063 of the African Union on the one hand and on the other, the United Nations sustainable development goals (SDGs); (ii) the importance of reducing energy poverty and mitigating extreme

poverty given the United Nations' SDG1 on reducing extreme poverty; (iii) the relevance of entrepreneurship in addressing concerns of poverty and (iv) gaps in the corresponding literature on the subject. These premises are substantiated in the same chronology as highlighted in what follows.

First, beyond the relevance of financial inclusion in achieving SDG1 in terms of reducing extreme poverty, the phenomenon has also been established to be fundamental in achieving other United Nations' SDGs (Asongu & Odhiambo, 2018; UNCDF, 2022; Asongu & Nting, 2022). According to the underlying narrative, financial inclusion provides avenues for inclusive channels through which other SDGs can be achieved, notably: SDG2 is oriented towards addressing food security issues and ending hunger; SDG3 which is focused on health and wellbeing; SDG5 focused on gender equality and the politico-economic empowerment of the female gender; SDG8 linked to economic prosperity promotion; SDG9 related to boosting infrastructure, innovation and the industry; SDG10 related to income inequality mitigation and SDG17 related to boosting implementation channels, especially as it concerns the prospects of financial inclusion in boosting sustainable development through mechanisms such as investment and consumption (Tchamyou *et al*., 2019a, 2019b; Asongu & le Roux, 2019; Achuo *et al*., 2021; UNCDF, 2022; Abdulqadir & Asongu, 2022). Hence, it is in view of the importance of financial inclusion in easing the achievement of a multitude of SDGs that the present exposition is positioned on understanding the role of financial inclusion in the incidence of entrepreneurship on energy poverty, not least, owing to the importance of energy poverty in extreme poverty.

Second, reducing energy poverty which is the outcome variable in this present study is by extension, a reduction of extreme poverty, not least, because positive linkages between energy poverty, poverty and exclusive development have been established in the literature (Listo, 2018; Pagliaro & Meneguzzo,2020; Biernat-Jarka et al., 2021; Sánchez et al., 2021). It follows that by focusing on energy poverty as it is done within the remit of the present study; there is also a broader concern of poverty that has to be dealt with, especially in view of a growing strand of studies on the importance of entrepreneurship and/or self-employment in addressing poverty and exclusive development concerns in Africa in the light the SDGs.

Third, whereas self-employment and/or entrepreneurship are fundamental in alleviating inequality and poverty especially in the light SDGs (Asongu & le Roux, 2023), considering evidence that the growing population and associated poverty and unemployment concerns in Africa cannot be absorbed by the public sector (Ngono, 2021), there has been a growing stream of literature on the importance of entrepreneurship and/or self-employment in addressing socio-economic concerns (Ngono, 2022; Yerrabati, 2022). In accordance with Yerrabati (2022), while much has been documented on poverty (Dollar & Kraay, 2002; Kraay, 2006; Ravallion, 1995, 1997, 2005) and entrepreneurship (Pietrobelli *et al*., 2004; Gindling & Newhouse, 2014; Poschke, 2019; Narita, 2020), there is yet no consensus as to how entrepreneurship can be promoted especially by means financial inclusion.

The closest study in the literature to the present exposition is Koomson and Danquah (2021, EP) which is positioned within the framework of non-interactive or linear regressions in order to conclude that financial inclusion reduces energy poverty. The present study extends the research by reconsidering the nexus within the framework of interactive or non-linear regressions by assessing how financial inclusion moderates the incidence of entrepreneurship on energy poverty. Instead of providing direct linkages between financial inclusion and energy poverty as concluded by the underlying study, the present research argues that, there are more policy options when actionable thresholds or critical masses of the moderating variables are provided in order to inform

policy makers of how the considered channels can more effectively affect energy poverty. Hence, contrary to the underlying study, the present study provides actionable financial inclusion policy thresholds that policy makers can act upon in order to determine how entrepreneurship or self-employment affects energy poverty.

The importance of revisiting Koomson and Danquah (2021), is consistent with the literature on the relevance of revisiting previous expositions in order to provide more room for policy implications (Cook, 2014; McEwan et al., 2018; Pridemore *et al*., 2018; Asongu *et al*., 2020, 2021). In order to articulate these points further: "*the replicability of research results is also a central tenet to the scientific research process*" (Cook, 2014, p. 233) and "*Replications are an important part of the research process because they allow for greater confidence in the findings*" (McEwan *et al*., 2018, p. 235). Hence, it is on the underlying premise that the present research extends Koomson and Danquah (2021) by asking the following research question: how does financial inclusion moderate the incidence of entrepreneurship on energy poverty?

In order to address the above question, the study builds from the 7th (GLSS7) and 6th (GLSS6) rounds on the Ghana Living Standards Survey (GSS, 2014, 2019) that is collected by the Ghana Statistical Service (GSS) from ten principal regions in the country. The empirical evidence is based on using pooled data and two stage least squares. The findings show that entrepreneurship has an unconditional positive incidence on energy poverty while the interactive incidence between entrepreneurship and financial inclusion on energy poverty is negative. The corresponding financial inclusion policy thresholds that should be exceeded in order for financial inclusion to effectively moderate entrepreneurship for negative outcomes in energy poverty: (i) are between 0.154 and 0.280 index for the full sample; (ii) is between 0.187 index for the rural sub-sample; (iii) are between 0.200 and 0.333 index for the male sample. (iv) Thresholds are not computed for the rural and female sub-samples because at least one estimated coefficient that is needed for the computation of such thresholds is not significant.

The intensive and extensive margin theoretical underpinnings are consistent with the empirical analysis, in accordance with contemporary literature on the nexus between financial inclusion and inclusive development outcomes (Tchamyou et al., 2019a). According to the intensive margin theory, when financial services are increased to existing users of financial services, they are likely to use such enhanced services in improving their socio-economic conditions (i.e. self-employment) in view of reducing their vulnerability to exclusive development outcomes such as poverty and inequality. In the same vein, according to the extensive margin theory, when the financial services are offered to previously unbanked customers, these services also avail them (i.e. customers) with opportunities of reducing their exposure to poverty outcomes such as energy poverty.

The rest of the study is organized as follows. The data and methodology are discussed in Section 2 while the empirical findings are disclosed in Section 3. The study concludes in Section 4 with implications and future research directions.

2. Data and methodology

2.1 Data

The present exposition builds from the 7th (GLSS7) and 6th (GLSS6) rounds focusing on the Ghana Living Standards Survey (GSS, 2014, 2019) that is collected by the Ghana Statistical Service (GSS) from ten principal regions in the country. It is imperative to articulate the premise that respectively, the GLSS6 and GLSS7 were gathered in 2012/2013 and 2016/2017. In accordance with the corresponding narrative, the corresponding surveys are premised on a probability

sampling approach in two stages which embody, *inter alia*, the following dimensions: housing conditions, fuel and energy, health, demography, sanitation and water, insurance services, employment, migration, financial access, agriculture and non-farm activities. The motivation for using the GLSS7 and GLSS6 is primarily based on the constraints in data availability at the time of the present study on the one hand and on the other, the motivation of this study which is partly based on extending Koomson and Danquah (2021) which is the closest to this research in the literature. Furthermore, in line with the underlying literature, these considered rounds of survey have consistently embodied the highlighted variables. In what follows, some specificity on data observations is engaged. As apparent in Appendix 1, entrepreneurship within the remit of this study is understood in terms of self-employment such that a household that is self-employed is associated with a value of 1 and 0 otherwise.

Initially, the GLSS6 (GLSS7) covered 18, 000 (15, 000) households with a response rate of 93.2% (93.4%) for the GLSS6(GLSS7). Given the insights, the adopted size for GLSS6 (GLSS7) is 16772(14 009). When the files/sections of the variables of interest are combined, the resulting sample size is a bit reduced to a pool total of 30, 606 which represents 16, 760 (13, 846) for GLSS6 (GLSS7). Furthermore, in view of the information that is missing, the regression analysis consists of 6,545 (16, 169) for the GLSS7 (GLSS6), making-up a pool consisting of 22, 714 households. The considerable observation drop after the estimation is linked to the proxy of financial inclusion in the GLSS7 for which, about 6,910 observations were missing because of constraints in the availability of data, given non-responses that were observed. The corresponding descriptive statistics of the considered variables is provided in Appendix 1.

2.1.1 Energy Poverty

Following Koomson and Danquah (2021), both objective and subjective measures are employed to measure energy poverty. First of all, within the objective remit, the energy expenditure-income framework is articulated in relation to energy poverty (as a percentage of income in the household) that is allocated to the purchase of energy and fuel. Consistent with Boardman (2013) and more contemporarily, Churchill and Smyth (2020), the proportion of the energy measure is a direction function of energy poverty, implying that the higher the former, the higher the latter. Furthermore, within the secondary remit or the objective premise, a 10% critical mass or threshold is employed as the cut-off point such that households that invest higher than 10% of their income in energy and fuel are considered as poor in energy (Bouzarovski & Petrova, 2015; Koomson & Danquah, 2021; Boardman, 2013). Second, with respect to the subjective premise, energy poverty can be considered in terms of deprivation in material conditions, especially when the weather is cold. In line with Koomson and Danquah (2021), this indicator for the most part, takes the value of 1 in cases where the considered households are unable to effectively keep the house hot owing to lack of heating facilities and 0 in the opposite scenario. It is worthwhile to note that the considered measures are largely employed in studies entailing developed nations in view of the existence of comprehensive measurements of heating and related expenditure in household energy and fuel.

An indicator that entails both the objective and subjective poverty measurement in energy is the multidimensional energy poverty index (MEPI), which is largely used in developing countries, not least, because it is consistent with conceptualization of such poverty in corresponding countries on the one hand and on the other, in line with the rate of clean energy adoption as well as the socio-economic conditions in these developing countries (Nussbaumer *et al*., 2013; Churchill & Smyth, 2020). In line with the considered literature which is premised on developing countries

(Nussbaumer *et al*., 2013; Crentsil *et al*., 2019; Adusah-Poku & Takeuchi, 2019), the MEPI indicator is employed considering data availability constraints, especially as it pertains to the GLSS poverty measures.

Consistent with the studies on the subject (Nussbaumer et al., 2013; Adusah-Poku & Takeuchi, 2019; Crentsil *et al*., 2019; Koomson & Danquah, 2021), the MEPI embodies five dimensions which entail six indicators, summarized in Appendix 2. The five dimensions in the appendix are: cooking, lighting, services provided through household appliance, entertainment/education and communication.

As documented in Alkire and Foster (2011), the MEPI is based on an evaluation of multidimensional poverty by the Oxford Poverty and Human Development Initiative which is founded on the works of Amartya Sen on capabilities and deprivations in the literature. Following Koomson and Danquah (2021), the corresponding five dimensions are each assigned equal weights of 0.20. Notwithstanding this consideration, the cooking and lighting dimensions are assigned more weights relative to the three dimensions given the relative relevance of energy in poverty, consistent with Nussbaumer et al. (2013) and Adusah-Poku and Takeuchi (2019). Upon comparing lighting and cooking, more weight is assigned to cooking given the fact that it is a fundamental requirement in household energy in developing nations. On this background, the two measurements in the dimension of cooking are assigned an equal weight of 0.205 while 0.200 is assigned to the dimension of lighting. The remaining three dimensions are each assigned a weight of 0.13. The considered indicators are provided in Appendix 2 in order to enhance clarity on the discussed relative deprivations. For each household, the score of deprivation is measured as the sum of deprivations that range from 0 to 1 and denoted as follows:

$$d_i = w_1 I_1 + w_2 I_2 + \cdots + w_n I_n \qquad (1)$$

where d_i denotes the household energy deprivation score, $I_i = 1$ in a situation where the household is relatively deprived in indicator i and $I_i = 0$ if otherwise. w_i shows the weight linked to indicator i with $\sum_{i=1}^{d} w_i = 1$. Consistent with Nussbaumer et al. (2013), a critical mass of 0.33 is employed, implying that a household that is characterized by an energy deprivation score of at least 0.33 is a household that is poor in terms of energy.

2.1.2 Financial inclusion (FI)

Still building on Koomson and Danquah (2021), the present exposition uses a multidimensional proxy for FI. Such an adoption of a multidimensional proxy is also consistent with the literature on energy poverty (Zhang & Posso, 2019; Churchill & Marisetty, 2020; Churchill *et al*., 2020). Therefore, building on the underlying study, four FI dimensions are used in the present research, notably; bank account ownership, credit/loan access, insurance ownership and receipt of remittances in financial institutions through mobile money innovations. The corresponding measurement is disclosed in Appendix 3. With regard to weight attribution, 0.25 is assigned to every dimension used to calculate that score on household deprivation in Equation (1). Yet, in accordance with the underlying literature, 1 is assigned to households that are linked to a relative deprivation score of below 0.50 while 0 is considered when the corresponding financial deprivation score of the household is higher than 0.50.

2.2. Methodology

Still following Koomson and Danquah (2021), the present research uses the linear probability model (LPM) that is tailored in such a way that financial inclusion moderates the incidence of entrepreneurship on energy poverty. Note should be taken of the fact that in line with the corresponding narrative from the underlying literature, the adopted technique is the pooled ordinary least squares approach contrary to the fixed effects and random effects estimation approaches. The adoption of the pooled technique is essentially motivated by the fact that the data collected from the GLSS6 and GLSS7 consist of repeated cross sections that do not consist of a panel data structure requiring the employment of either fixed effects or random effects models that are consistent with such panel data structures. Accordingly, as argued in the literature (Churchill & Marisetty, 2020; Koomson *et al*., 2020), the simultaneity concern of endogeneity is addressed with a complementary approach by instrumental variables as apparent in Equations (2) and (3). In the considered equations, whereas financial inclusion is hypothesized to mitigated energy poverty, such can exclusively be apparent from the entrepreneurship mechanism, in the light of the motivation of the present research. The simultaneity or reverse causality concern of endogeneity is premised the foundations that financial inclusion reduces poverty through entrepreneurship on the one hand and on the other, motivations for entrepreneurship and financial inclusion can also motivate individuals to be more connected to financial institutions in view of ultimately mitigating energy poverty.

The first stage and second stage, respectively of the instrumental variable estimation process are disclosed in Equation (1) and Equation (2).

Reduced form equation (stage 1)

$$FI_{it} = \delta + \gamma Dist_{it} + \eta X_{it} + \vartheta_r + \mu_t + \varepsilon_{it} \quad (2)$$

Structural equation (stage 2)

$$EPov_{it} = \alpha + \beta \widehat{FI}_{it} + \lambda X_{it} + \vartheta_r + \mu_t + \nu_{it} \quad (3)$$

where $EPov_{it}$ shows the energy poverty status of a household i at time t, with time denoting the period of each GLSS round; FI_{it} represents an i household's status of financial inclusion at time t; whereas X shows a vector of covariates that have been documented in the energy poverty literature covered in the previous sections, notably: age, gender, marital status, education, location, household size, and employment status of head of household. δ *and* α respectively, denote constant values; ϑ_r and μ_t reflects fixed effects characteristics, respectively, of the region and round of GLSS, while ε and ν are the random error terms.

It is imperative to further clarify that in accordance with Koomson and Danquah (2021), in the disclosed Equation (2) above, 'distance to the nearest bank' (i.e. $Dist$) is employed as financial inclusion instrument. The considered instrument has been employed in the literature that is focused on the linkage between poverty and financial inclusion (Churchill *et al*., 2020; Churchill & Marisetty, 2020; Koomson *et al*., 2020). Consistent with the underlying literature, financial inclusion and entrepreneurship are connected to the nearest bank because people living near a financial institution are more likely to benefits from financial services and by extension, possibilities of engaging in entrepreneurship activities (Demirgüç-Kunt & Klapper, 2012; Churchill *et al*., 2020; Koomson *et al*., 2020). The validity of the considered instrument of "distance to the nearest bank" has been validated in the literature focusing on microfinance modalities of operations as well as other rural-based financial institutions (Reiter & Peprah, 2015; Churchill *et al*., 2020; Churchill & Marisetty, 2020; Koomson et al., 2020; Koomson & Danquah, 2021). It is important to note that the Stata16 software was used for the data analysis. Moreover, as clarified above, the estimation technique is adopted for the analysis of the data because it has

been documented in the literature to be consistent with the behavior of data, especially as it pertains to the outcome variable.

3. Empirical results

This section discloses the empirical findings that are captured in Tables 1-5. Whereas Table 1 focuses on the full sample, the other tables are concerned with the sub-samples, notably: (i) Table 2 and Table 3 respectively, for the rural and urban sub-samples and Table 4 and Table 5 respectively, for the male and female sub-samples. Each table is characterized with three main specifications: the first specification pertaining to pooled regressions and the second and third specification, respectively for the GLSS6 and GLSS7. The format of presentation is in line with Koomson and Danquah (2021). Hence, considering the replication nature of the present study, the discussion of results fundamentally focus on the problem statement being examined and not on the expected signs from variables in the conditioning information set which have been covered by Koomson and Danquah (2021). This element of style is thus to avoid duplication of research findings by directly engaging the contribution of the present research to the literature. Hence, in what follows, the present study discusses how the main problem statement is addressed, notably: how financial inclusion moderates the incidence of entrepreneurship on energy poverty.

Given the above, in order to assess the problem statement being considered in the present study, the empirical analysis is tailored to avoid pitfalls of interactive regressions documented by Brambor *et al*. (2006). Such tailoring to avoid pitfalls of interactive regressions is consistent with contemporary literature on interactive regressions (Nchofoung *et al*., 2021,2022; Nchofoung & Asongu, 2022a, 2022b). To put the threshold computation in more perspective, in the first specification of Table 1, the financial inclusion thresholds that is needed to reverse the positive unconditional incidence of entrepreneurship on energy poverty is 0.154(0.019/0.123). In the computation, 0.019 is the unconditional incidence of entrepreneurship on energy poverty while 0.123 corresponds to the absolute value of the conditional or interactive incidence (i.e. interaction between financial inclusion and entrepreneurship) on energy poverty. Hence, in order for financial inclusion to effectively moderate entrepreneurship for an overall negative incidence on energy poverty, the corresponding financial inclusion threshold is 0.154. In other words, when the financial inclusion threshold exceeds 0.154, an overall negative effect on energy poverty should be expected.

Table 1: Full sample

Dependent variable: Energy Poverty			
	(1)	(2)	(3)
Variables	Pooled	GLSS6	GLSS7
age	0.001***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)
	0.062	0.066	0.052
female	-0.014**	-0.015**	-0.012
	(0.006)	(0.007)	(0.011)
	-0.016	-0.018	-0.015
married	-0.026***	-0.019***	-0.044***
	(0.006)	(0.006)	(0.011)
	-0.033	-0.024	-0.057

edu	-0.159***	-0.148***	-0.185***
	(0.005)	(0.006)	(0.009)
	-0.208	-0.194	-0.240
hhsize	0.012***	0.011***	0.013***
	(0.001)	(0.001)	(0.001)
	0.085	0.081	0.096
rural	0.195***	0.196***	0.191***
	(0.005)	(0.006)	(0.010)
	0.252	0.254	0.245
1.empstat	-0.039***	-0.027	-0.046***
	(0.012)	(0.019)	(0.017)
	-0.029	-0.019	-0.039
2.empstat	-0.076***	-0.057***	-0.093***
	(0.014)	(0.019)	(0.020)
	-0.081	-0.060	-0.101
3.empstat	0.019*	0.037**	0.001
	(0.010)	(0.015)	(0.013)
	0.023	0.044	0.002
rounds	-0.010**		
	(0.005)		
	-0.012		
FI_mpi	-0.036***	-0.041***	-0.025***
	(0.005)	(0.006)	(0.009)
	-0.045	-0.052	-0.030
finclusion_selfemp	-0.123***	-0.132***	-0.102***
	(0.014)	(0.017)	(0.026)
	-0.100	-0.110	-0.078
Constant	0.721***	0.694***	0.748***
	(0.014)	(0.019)	(0.022)
F.I Threshold	0.154	0.280	na
Observations	22,706	16,161	6,545
R-squared	0.276	0.282	0.266

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Age=Age of household head, FI_mpi=financial inclusion, female=female-headed household, married, edu=educated, hhsize=household size, rural=rural area, 1.empstat=retired/inactive, 2.empstat=employee, 3.empstat=self-employment, finclusion_selfemp=financial inclusion*selfemployment. na: not significant because at least one estimated coefficient needed for the computation of net effect is not significant.

Table 2: Rural sample

Dependent variable: Energy Poverty			
	(1)	(2)	(3)
Variables	Pooled	GLSS6	GLSS7
age	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
	0.055	0.064	0.044

female	-0.015***	-0.019***	-0.008
	(0.005)	(0.006)	(0.010)
	-0.031	-0.040	-0.015
married	-0.006	-0.004	-0.011
	(0.005)	(0.005)	(0.010)
	-0.013	-0.010	-0.023
edu	-0.065***	-0.057***	-0.086***
	(0.004)	(0.005)	(0.009)
	-0.145	-0.134	-0.171
hhsize	0.005***	0.005***	0.007***
	(0.001)	(0.001)	(0.001)
	0.076	0.067	0.091
1.empstat	-0.016*	-0.016	-0.012
	(0.009)	(0.015)	(0.011)
	-0.020	-0.019	-0.017
2.empstat	-0.098***	-0.056***	-0.143***
	(0.015)	(0.019)	(0.024)
	-0.144	-0.083	-0.208
3.empstat	0.011	0.024**	0.005
	(0.007)	(0.011)	(0.009)
	0.021	0.046	0.011
rounds	-0.010**		
	(0.004)		
	-0.021		
FI_mpi	-0.020***	-0.023***	-0.014**
	(0.004)	(0.005)	(0.007)
	-0.041	-0.050	-0.027
finclusion_selfemp	-0.120***	-0.128***	-0.126***
	(0.022)	(0.026)	(0.040)
	-0.127	-0.140	-0.122
Constant	0.941***	0.924***	0.943***
	(0.010)	(0.014)	(0.016)
F.I Threshold	na	0.187	na
Observations	12,966	9,143	3,823
R-squared	0.143	0.125	0.187

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Age=Age of household head, FI_mpi=financial inclusion, female=female-headed household, married, edu=educated, hhsize=household size, rural=rural area, 1.empstat=retired/inactive, 2.empstat=employee, 3.empstat=self-employment, finclusion_selfemp=financial inclusion*selfemployment. . na: not significant because at least one estimated coefficient needed for the computation of net effect is not significant.

Table 3: Urban sample

Dependent variable: Energy Poverty			
	(1)	(2)	(3)
Variables	Pooled	GLSS6	GLSS7
age	0.003***	0.003***	0.002***
	(0.000)	(0.000)	(0.001)
	0.079	0.084	0.068

female	-0.024**	-0.028**	-0.015
	(0.011)	(0.013)	(0.021)
	-0.024	-0.028	-0.015
married	-0.062***	-0.054***	-0.083***
	(0.011)	(0.013)	(0.021)
	-0.065	-0.056	-0.086
edu	-0.286***	-0.277***	-0.306***
	(0.009)	(0.011)	(0.018)
	-0.285	-0.273	-0.310
hhsize	0.027***	0.028***	0.026***
	(0.002)	(0.002)	(0.004)
	0.134	0.136	0.130
1.empstat	-0.082***	-0.066*	-0.106***
	(0.025)	(0.035)	(0.039)
	-0.052	-0.041	-0.070
2.empstat	-0.087***	-0.089***	-0.073**
	(0.024)	(0.034)	(0.035)
	-0.086	-0.088	-0.073
3.empstat	0.000	0.015	-0.027
	(0.022)	(0.032)	(0.029)
	0.000	0.016	-0.028
rounds	-0.017*		
	(0.010)		
	-0.016		
FI_mpi	-0.070***	-0.084***	-0.038*
	(0.011)	(0.013)	(0.021)
	-0.073	-0.087	-0.040
finclusion_selfemp	-0.090***	-0.089***	-0.084**
	(0.019)	(0.023)	(0.037)
	-0.073	-0.073	-0.063
Constant	0.750***	0.730***	0.771***
	(0.028)	(0.037)	(0.045)
F.I Threshold	na	na	na
Observations	9,740	7,018	2,722
R-squared	0.186	0.194	0.173

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Age=Age of household head, FI_mpi=financial inclusion, female=female-headed household, married, edu=educated, hhsize=household size, rural=rural area, 1.empstat=retired/inactive, 2.empstat=employee, 3.empstat=self-employment, finclusion_selfemp=financial inclusion*selfemployment. . na: not significant because at least one estimated coefficient needed for the computation of net effect is not significant.

Table 4: Male sample

Dependent variable: Energy Poverty			
	(1)	(2)	(3)
Variables	Pooled	GLSS6	GLSS7
age	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
	0.051	0.054	0.050

married	-0.018***	-0.013*	-0.035**
	(0.007)	(0.008)	(0.014)
	-0.021	-0.015	-0.039
edu	-0.135***	-0.124***	-0.162***
	(0.005)	(0.006)	(0.011)
	-0.176	-0.162	-0.208
hhsize	0.011***	0.011***	0.013***
	(0.001)	(0.001)	(0.002)
	0.087	0.082	0.101
rural	0.219***	0.218***	0.215***
	(0.007)	(0.008)	(0.013)
	0.278	0.280	0.269
1.empstat	-0.040**	-0.042*	-0.032
	(0.016)	(0.023)	(0.021)
	-0.026	-0.025	-0.025
2.empstat	-0.067***	-0.055**	-0.073***
	(0.016)	(0.022)	(0.024)
	-0.076	-0.062	-0.083
3.empstat	0.022*	0.038**	0.005
	(0.012)	(0.018)	(0.016)
	0.027	0.046	0.006
rounds	-0.016***		
	(0.006)		
	-0.018		
FI_mpi	-0.041***	-0.046***	-0.028**
	(0.006)	(0.007)	(0.012)
	-0.050	-0.058	-0.033
finclusion_selfemp	-0.110***	-0.114***	-0.099***
	(0.016)	(0.019)	(0.030)
	-0.095	-0.101	-0.079
Constant	0.697***	0.677***	0.707***
	(0.016)	(0.022)	(0.027)
F.I Threshold	0.200	0.333	na
Observations	15,905	11,499	4,406
R-squared	0.284	0.292	0.266

Robust standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1. Age=Age of household head, FI_mpi=financial inclusion, female=female-headed household, married, edu=educated, hhsize=household size, rural=rural area, 1.empstat=retired/inactive, 2.empstat=employee, 3.empstat=self-employment, finclusion_selfemp=financial inclusion*selfemployment. na: not significant because at least one estimated coefficient needed for the computation of net effect is not significant.

Table 5: Female sample

Dependent variable: Energy Poverty			
	(1)	(2)	(3)
Variables	Pooled	GLSS6	GLSS7
age	0.002***	0.002***	0.001**

	(0.000)	(0.000)	(0.000)
	0.071	0.084	0.044
married	-0.030***	-0.019	-0.054***
	(0.010)	(0.012)	(0.018)
	-0.033	-0.021	-0.060
edu	-0.212***	-0.201***	-0.232***
	(0.011)	(0.013)	(0.019)
	-0.268	-0.254	-0.296
hhsize	0.013***	0.014***	0.012***
	(0.002)	(0.002)	(0.003)
	0.074	0.077	0.067
rural	0.151***	0.150***	0.152***
	(0.008)	(0.010)	(0.014)
	0.198	0.193	0.203
1.empstat	-0.044**	-0.020	-0.069**
	(0.020)	(0.031)	(0.027)
	-0.039	-0.017	-0.067
2.empstat	-0.101***	-0.057	-0.152***
	(0.028)	(0.040)	(0.040)
	-0.087	-0.048	-0.140
3.empstat	0.009	0.029	-0.010
	(0.018)	(0.028)	(0.022)
	0.011	0.034	-0.013
rounds	0.003		
	(0.009)		
	0.004		
FI_mpi	-0.029***	-0.033***	-0.020
	(0.009)	(0.011)	(0.016)
	-0.037	-0.042	-0.026
finclusion_selfemp	-0.157***	-0.197***	-0.090*
	(0.032)	(0.040)	(0.053)
	-0.106	-0.132	-0.063
Constant	0.743***	0.700***	0.809***
	(0.024)	(0.034)	(0.033)
F.I Threshold	na	na	na
Observations	6,801	4,662	2,139
R-squared	0.271	0.271	0.276

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Age=Age of household head, FI_mpi=financial inclusion, female=female-headed household, married, edu=educated, hhsize=household size, rural=rural area, 1.empstat=retired/inactive, 2.empstat=employee, 3.empstat=self-employment, finclusion_selfemp=financial inclusion*selfemployment. . na: not significant because at least one estimated coefficient needed for the computation of net effect is not significant.

The corresponding policy financial inclusion thresholds that should be exceeded in order for financial inclusion to effectively moderate entrepreneurship for negative outcomes in energy poverty: (i) are between 0.154 and 0.280 for the full sample; (ii) is between 0.187 for the rural sub-sample; (iii) are between 0.200 and 0.333 for the male sample. (iv) It is worthwhile to note that

thresholds are not computed for the rural and female sub-samples because at least one estimated coefficient needed for the computation of such thresholds is not significant.

Regarding the nexus with the literature, it is worthwhile to articulate that though the study is based on interactive or nonlinear regressions, the finding that financial inclusion is relevant in reducing energy poverty is broadly consistent with prior studies on the subject (Levaï *et al*., 2011; Boutabba *et al*., 2020; Koomson & Danquah, 2021) as well as studies on the nexus between financial inclusion and less socio-economic exclusion (Sarma Pais, 2011; Kuri &Laha, 2011 ; Sharma, 2016; Danquah *et al*., 2017; Li, 2018 ; Koomson & Ibrahim, 2018 ; Park & Mercado, 2018; Stein & Yannelis, 2019; Matekenya *et al*., 2020 ; Omar & Inaba, 2020). Moreover, the fact that financial inclusion affects energy poverty indirectly via the entrepreneurship channel is consistent with the literature on channels by which development outcomes are reached (Alesina & Zhuravskaya, 2011; Churchill & Smyth, 2020). It follows that contrary to the first strand of literature on the direct nexus between financial inclusion and poverty outcomes, this study has shown that such a nexus is indirect, not least, because the relevance of financial inclusion is only apparent when a certain thresholds of financial inclusion has been reached.

To put the above into perspective, it is worthwhile to articulate that the finding in this study is distinct from Koomson and Danquah (2021) on the premise that contrary to the underlying study, the nexus between financial inclusion and energy poverty is not direct, but contingent on entrepreneurship such that some critical masses of financial inclusion are essential for entrepreneurship to mitigate energy poverty. On this basis, the policy relevance of the present study is articulated in the fact that policy makers have to work towards making sure that financial inclusion penetration increases in order for a complementary mechanism of entrepreneurship to induce favorable outcomes in terms of reducing energy poverty. The policy requirement is consistent with the corresponding literature on the importance of financial inclusion in achieving the extreme poverty target of the United Nations by 2030, especially owing to documented evidence that most countries in sub-Saharan Africa (i.e. including Ghana) are not likely to achieve this target unless the underlying concern of extreme poverty is addressed (Bicaba *et al*., 2017; Asongu & Odhiambo, 2018; UNCDF, 2022).

Beyond the above empirical and policy relevance of the study, the findings are also consistent with the strand of theoretical literature discussed in the introduction (Tchamyou et al., 2019a), especially as it pertains to the importance of financial inclusion in providing opportunities for inclusive development within the remit of reducing energy poverty. Accordingly, improving of financial opportunities to existing bank customers (i.e. intensive margin theory) as well as new bank customers (i.e. extensive margin theory), enhances opportunities for the mitigation of energy poverty, especially within the channel of self-employment.

4. Concluding implications and future research directions

The paper assesses the role of financial inclusion in moderating the incidence of entrepreneurship on energy poverty in Ghana. The assessment is made by using pooled data and two stage least squares. The findings show that entrepreneurship has an unconditional positive incidence on energy poverty while the interactive incidence between entrepreneurship and financial inclusion on energy poverty is negative. The corresponding financial inclusion policy thresholds that should be exceeded in order for financial inclusion to effectively moderate entrepreneurship for negative outcomes in energy poverty: (i) are between 0.154 and 0.280 for the full sample; (ii) is between

0.187 for the rural sub-sample; (iii) are between 0.200 and 0.333 for the male sample. (iv) Thresholds are not computed for the rural and female sub-samples because at least one estimated coefficient needed for the computation of such thresholds is not significant. The main policy implication is discussed in what follows.

Building on the above, by disclosing financial inclusion actionable thresholds that policy makers can leverage upon in view of mobilizing entrepreneurship externalities for energy poverty reduction, the present research has improved the policy and scholarly literature on the subject. First of all, on the scholarly premise, it is imperative to enhance energy poverty studies by providing evidence of indirect linkages not least, because financial inclusion and energy poverty do not act in isolation in the real world but are contingent on a plethora of factors and channels, *inter alia*, entrepreneurship. On the policy front, policy makers should work towards improving their initial conditions of financial inclusion to reach the prescribed thresholds in order for energy poverty to be mitigated through activities of self-employed. As apparent in the findings, such policy threshold prescriptions are contingent on sub-samples.

Moreover, financial inclusion penetration levels can be improved to the prescribed thresholds by *inter alia*: (i) better access to bank accounts especially as it pertains to the previously unbanked fraction of the population. Such could be done by encouraging traditional banks to provide special access conditions for the poorer segment of the population as well as encouraging mobile banking accounts to the same fraction of the population without ownership of bank accounts. (ii) Policies should be tailored at encouraging the transformation of deposits that are mobilized by banks into credit for households as well as economic operators. Such can be done by implementing policies that are designed reduce information asymmetry between households and financial institutions. (iii) Insurance policies should also be encouraged for households, especially as it pertains to medical insurance, life insurance, property insurance and unemployment insurance. (iv) Households should be provided with enhanced means of receiving financial remittances especially as it pertains to mobile money opportunities as well as banking possibilities.

Future research can improve the underlying literature by examining other channels through which financial inclusion affects energy poverty. Further, reconsidering the analysis within remit of alternative mechanisms and moderating variables in view of achieving sustainable development objectives is a worthwhile future research endeavour.

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Appendices

Appendix 1: Summary statistics

Variable	Description	Mean	SD

Energy poverty	Dummy variable equals 1 if household's energy deprivation score exceeds 0.33	0.81	0.39
Financial inclusion	Dummy variable equals 1 if household financial deprivation score is less than 0.5	0.38	0.49
Age of head	Age of the household head	46.9	14.11
Female household head	Binary variable equals 1 if household head is female	0.26	0.44
Married head	Binary variable equals 1 if household head is married	0.68	0.47
Educated head	Binary variable equals 1 if household head is educated	0.52	0.5
Household size	Number of persons in the household	5.74	3.12
Household size squared	Number of persons in the household squared	42.7	53.46
Rural	Binary variable equals 1 if household is located in a rural area	0.5	0.5
Unemployed	Binary variable equals 1 if household head is unemployed	0.04	0.19
Retired/inactive	Binary variable equals 1 if household head is retired/inactive	0.07	0.26
Employee	Binary variable equals 1 if household head is an employee	0.22	0.42
Self-employed	Binary variable equals 1 if household head is self-employed	0.67	0.47
Distance to the nearest bank	Average distance to the nearest bank measured in kilometres	13.11	6.62
Poor	Binary variable equals 1 if household is head owns a bank or mobile money account	0.24	0.43
Net income	Continuous variable for household's total net income	155.0648	546083.9
Exp on education	Continuous variable for household's total expenditure on children's basic and secondary education	756.3471	1799.569
Account	Binary variable equals 1 if household head owns a bank or mobile money account	0.56	0.5
Insurance	Binary variable equals 1 if household head owns an insurance product	0.31	0.46
Credit	Binary variable equals 1 if household head has access to credit	0.13	0.33
Remittance	Binary variable equals 1 if household received financial remittance from financial institution or through mobile money	0.26	0.44

Source: Koomson and Danquah (2021).

Appendix 2: **Dimensions, indicators and weights for multidimensional energy poverty**

Dimension	Indicator (weight)	Variables	Deprivation cut-off (energy poor if….)
Cooking	Modern cooking fuel *(0.205)*	Type of cooking fuel	Any fuel use besides electricity, LPG, kerosene, natural gas, or biogas.
	Indoor pollution *(0.205)*	Food cooked on stove or open fire (no hood/chimney), indoor, if using any fuel beside electricity, LPG, natural gas, or biogas	True
Lighting	Electricity access *(0.20)*	Has access to electricity	False
Services provided by means of household appliances	Household appliance ownership *(0.13)*	Has a fridge	False
Entertainment/education	Entertainment/education appliance ownership *(0.13)*	Has a radio OR television	False
Communication	Telecommunication means *(0.13)*	Has a phone land line OR mobile phone	False

Source: Adopted from: (Nussbaumer et al., 2012) and Koomson and Danquah (2021).

Appendix 3: Dimensions, indicators and weights for multidimensional financial inclusion

Dimension (weight)	
Bank account (1/4)	Household does not have a bank account (bank account includes savings, current, fixed deposit or microfinance account) or mobile money account
Loan/Credit (1/4)	Household does not have access to loan/credit from bank, microfinance institution or other formal institution
Insurance (1/4)	Household does not have access to medical, life, property, unemployment/income or family insurance
Financial remittance (1/4)	Household does not receive financial remittance from the bank, money transfer service provider or through mobile money

Source: Koomson and Danquah (2021).