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Can energy transition interventions promote financial inclusion? Measuring unintended effects of Ghana's energy transition program

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ABSTRACT

Global concerns about climate change and its effects and the quest for sustainable development have necessitated policy actions, including energy interventions. Besides the intended goal of energy transition, these interventions often have unintended impacts, which ought to be measured when assessing the overall effects of these energy interventions. This study investigated the impact of a clean cooking fuel transition program in Ghana on financial inclusion. It used a cross-sectional survey of over 900 households in two districts in Ghana where a clean energy transition intervention had been implemented. The study employed linear probability and matching techniques and found that clean energy interventions can promote financial inclusion among beneficiary households. The probability of being significantly associated with financial inclusion is at least 6.6% higher for treated households than it is for households that did not benefit from the program. The findings are robust across different outcome variables and the potential transmission mechanisms are discussed. The study provides evidence for policy-makers to count the effect of financial inclusion in measuring the program's overall impact. Furthermore, the findings underscore the need for policies that provide the needed infrastructure and financial 'ecosystem' to support financial inclusion, particularly in rural areas where the energy interventions are implemented.

Introduction

This study seeks to examine the unintended effect Ghana's energy intervention program, the Rural Liquified Petroleum Gas Promotion Programme (RLPGPP), on financial inclusion. In a bid to promote sustainable energy use and to protect the forest, the government of Ghana embarked on a cooking fuel transition program for rural households – the RLPGPP. The program involved the free distribution of Liquified Petroleum Gas (LPG) cylinders, cook stoves, and related accessories to rural households. The first of such programs actually started in 1989, but only in urban cities, where the government distributed free gas cylinders and stoves to help consumers switch to LPG as domestic cooking fuel. Considering that urban areas are more developed and the energy infrastructure is more advanced relative to rural areas in Ghana, in 2013, the government sought to focus the energy transition program on some rural areas. The major strategies underpinning the RLPGPP include the free distribution of gas cylinders, stoves, and other related accessories to households in low-access rural areas.[1] The major purpose is for the government to swallow the initial investment cost of the LPG transition and facilitate the setting up of mini-gas refill outlets in every beneficiary district. The objective is to bring gas filling stations close to households to prevent long traveling times to access energy.

The main objectives of such programs have been to aid the transition to cleaner energy and the subsequent mitigation of climate change effects [1–3]. Specifically, for the government of Ghana, the main intended outcomes of the energy transition program are to improve the quality of life and health, fight deforestation, and reduce the time wasted in searching for firewood (Ministry of Energy [4]). In similar vein, evaluation of energy transition intervention programs has focused on the direct effect on energy choices and the intended purposes of these programs [5]. However, some studies [6–9] have shown that many policy programs could generate unintended effects. Hence, the benefits of energy intervention programs could transcend their immediate intended purposes and generate other economic benefits. This is

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[1] For a more comprehensive discussion of the program, see [5]

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something the literature has virtually not focused on yet, and this study intends to fill this gap. In view of this, the main research question under scrutiny is: could the energy transition program (the RLPGPP) implemented by the Government of Ghana have an unintended effect on financial inclusion?

A few studies have sought to test this program's impact on energy choice [5,10,11]. For example, Asante et al. [11] evaluated the RLPGPP and found that the program was not achieving its stated objectives. They found that about 58% of households that initially received filled LPG cylinders for free under the program had yet to refill them nine months after the distribution. They also found that only 18% continued to use the LPG 18 months after the free LPG cylinder distribution. Adjei-Mantey et al. [10] investigated the effect of the RLPGPP on primary fuel choice and found that the intervention led to higher LPG patronage. However, the distance to refill the cylinder significantly affects LPG usage and the willingness to pay for it. Adjei-Mantey and Takeuchi [5] also assessed the spillover impact of the program and found that it did not have any significant spillover effects on primary household cooking fuel. While these previous studies have focused on analyzing the impact of the program on its intended outcome, which is fuel choice, the present research aims to investigate the program's effect on an unintended outcome, namely financial inclusion.

In the current study, we focus on an unexplored unintended effect, financial inclusion, which the energy transition program may have. Hence, the study seeks to investigate the impact of a clean cooking fuel transition program in Ghana on financial inclusion. We used a cross-sectional survey (conducted in August 2020) of over 900 households in two districts in Ghana and employed linear probability and matching methods. Financial inclusion connotes access to finance and financial services by all [12]. It captures the ease of access to, availability, and usage of financial services, including banking and insurance [13] . The unintended impact of an energy transition program on financial inclusion could stem from the effect of energy on time saving and money. In many developing countries, mainly in rural areas, access to energy can be tedious and time-consuming [14,15]. People could walk long hours in search of biomass. It is estimated that about 5 hours are spent a day collecting biomass for household cooking in rural Sierra Leone, 4 hours in rural Niger, 3.1 hours in rural Senegal, 1.7 hours in rural Sudan and Nigeria, 1.6 hours in rural Ghana, and 1.1 hours in rural India [16]. The proportion of the population that uses biomass for cooking in these countries is 97.4%, 95.8%, 67.6%, 64.8%, 70%, 71.2%, and 59.5%, respectively [16]. In rural India, Parikh [17] finds that women could walk an average of 30km a month in search of biomass for household energy needs. Considering the significant amount of time spent in harvesting fuel for household needs, access to modern and clean energy could lessen the search time, freeing up more time for productive activities such as work and business [15,18].

As the time spent on work and business increases, households can expect to see improvements in their incomes, resulting in better opportunities to save money and access financial services. The saved time form modern and clean energy usage could i) make people work longer periods, increasing their earnings from paid jobs, ii) decrease health bills related to household pollution as the use of cleaner energy would generate reduced or "zero" emissions [3], iii) enhance food reservation and preservation through refrigeration, and this reduces waste indirectly leading to increased savings [19]. Time released from energy search could give more time for households to engage in paid jobs that can increase their earning capacity [20–22]. The importance of time cannot be undermined in any human endeavor, and as a result, its effective usage is paramount for the attainment of value. Generally, access to modern and clean energy enhances a poor economy's productivity and generates more wages for poor households [23–25].

Access to clean energy, through the energy intervention program, can thus have an effect on financial inclusion through the following ways: i) since households can now engage more in economic activities, they have a greater incentive to get a bank or mobile money account to support their transactions (transfers and receipt of money), ii) since households could earn more from having more time to engage in income generating activities, they may have a greater incentive of getting a bank or mobile money account to save, iii) because they can engage in economic activities more now, they can get themselves included in the financial system so they could access loans or other such credit facilities to help their economic activities.

The use of clean cooking fuels is relatively more expensive than using biomass for cooking, which could potentially undermine the argument of household savings. However, the program under assessment involves the government covering a significant portion of the cost of the energy transition, offering free initial LPG cylinders, stoves, and other necessary accessories. This significantly reduces the financial burden on households. Additionally, as mentioned earlier, access to clean cooking fuels frees up a substantial amount of time for households that would have been spent collecting biomass. This increased access to time enhances productivity and income-generating opportunities for households. The resulting increase in income from time saving could potentially offset the cost of clean fuels and still leave room for households to save money. Moreover, the use of clean cooking fuels could reduce health bills due to the significant reduction in emissions, providing further opportunities for households to save money.

Regarding the contribution to literature; first, we contribute to the literature on financial inclusion. In this study, we move away from the usual determinants of financial inclusion (such as income, gender, education, access to banks, etc.) examined in the literature [12,26] and focus on how a seemingly unrelated (energy) policy intervention affects it. Second, we contribute to the literature examining the unintended purposes of policy interventions. In this case, we examine the benefits of energy intervention programs beyond what is stated on paper and the obvious. Scrutiny of the extant literature reveals that no study has examined the RLPGPP's unintended impacts. Usually, such programs have their goals (in this case, to promote the use of LPG as primary cooking fuel), but there are often other (unintended) effects that accompany the implementation of these programs [27,28]. In this study we focus on the unintended effect of financial inclusion. Our focus on financial inclusion stems from its potential to empower households to achieve economic independence, improve their financial management, and increase their income. Additionally, financial inclusion is seen as a key driver in achieving several Sustainable Development Goals, including the eradication of poverty (SDG1), attainment of food security (SDG2), promotion of healthy lifestyles and wellbeing (SDG3), empowerment of women and attainment of gender equality (SDG5), promotion of economic growth (SDG8), and reduction of inequality (SDG10).

The rest of the paper proceeds as follows: section two reviews the literature, while section three discusses the study's methodology. Sections four and five discuss the results and conclude the study, respectively.

Literature review

Rural households' search and collection of energy/fuel take significant time, distorting their time use and allocation [15,29]. The determinants of time use have generated enormous literature considering that time used up at home reduces time spent on the market to generate income [22,30]. Besides, time is a resource, and the more it is used in one activity, the less it remains for other activities [31]. The analysis of household time use is an examination of the time allocation of households to various activities such as work on the market (for income), work on family enterprises, the performance of household chores (childcare, cooking, etc.), performance of "outside" chores (search and collection of fuel, water, etc.), and leisure [32,33]. The availability of time and its allocation to these activities can fundamentally determine the relative prices of goods and services, total production levels, and income distribution.

How individuals trade off time and income among diverse activities subject to their time and budget constraints is explained by time and money allocation models [22]. One of the earliest models is the one by Becker [34]. In the model, Becker attempted to explain why people tend to spend some time on a number of activities and how they allocate time to these activities. The crux of Becker's model was the inclusion of nonworking time into the traditional utility function of household consumption. This hinges on the premise that engaging in nonworking activities (such as the search for fuel or water) not only takes up market goods but also eats up the scarce time that could have been used in income-generating activities (working) to earn more money. Considering this, Becker suggested an extension to the conventional consumer theory by incorporating a time element into the utility function. With this, the utility derived from an activity is expressed as a function of market goods and time [30]. In the model, consumers maximize welfare subject to time and budget constraints, where welfare is a function of goods produced using market goods and time. A central conjecture of Becker's model is that time can be transformed into goods by using less time for consumption and more time for work. This conjecture, however, was criticized as it was argued that an individual's working time could be determined by other factors beyond their control, i.e., biological constraints, employers, and government regulations [22].

Time allocation is considered necessary in developing countries, especially in rural areas where a substantial amount of time could be saved if some basic infrastructure (such as water and energy infrastructure) existed. In many rural areas of Sub-Saharan Africa, infrastructure for providing water and energy is poor or, in some cases, nonexistent. As a result, time has to be allocated between searching for water and energy and other activities that demand time. Geere & Cortobius [32], examining rural areas in 23 countries, found that about 50% of the population access water from a source outside their homes, which could take up to about 78 minutes per trip. Collecting firewood, crop residues, and other biomass as household cooking fuel is common in rural areas of many developing countries. Kumar & Hotchkiss [35], using data from a sample of rural households in Nepal, find that the harder it takes to search and collect a standard headload of firewood from the forest, the more time women spend collecting fuel, and this reduces their time spent on farm activities. Examining data from rural Ethiopia, Scheurlen [33] finds that households living in areas with lower firewood availability spend more time collecting fuel, which negatively affects time allocation to off-farm activities.

In the spirit of time allocation and saving, many empirical studies have considered some direct impact of electrification or intervention programs that increase access to electricity. For example, Dinkelman [36], in his study of rural South Africa, finds that the provision of electricity increased women's employment by about 9%. In Nicaragua, Grogan and Sadanand [37] find a 23% higher possibility for women to be engaged in non-household chores with access to electricity. Nguyen and Su [38] found in a sample of 51 developing countries that access to electricity increases employment opportunities for women. Freeing up time can be used in income-generating activities and could help households better contribute to growth [21]. However, Ilahi & Jafarey [39], examining data from rural regions of Pakistan, find results indicating that though deteriorating access to firewood increases the time women spend collecting fuel, it does not affect their time allocated to income-generating activities. Generally, by reducing the time spent on engaging in "outside" chores (such as collection of water and fuel), households can enhance their participation in market-based activities due to the freeing up of time [40,41]. Regarding education and literacy, Porcaro and Tadaka [42], Sovacool [43], Nguyen and Su [38], and Barkat et al. [44] show how access to modern energy enhances education and literacy particularly for girls and women in Philippines, Myanmar, a sample of 51 countries, and Bangladesh, respectively. Bensch et al. [45] nevertheless found no significant evidence that access to electricity fosters learning at home for children in Rwanda.

From the above exposition, a policy intervention to provide infrastructure or meet the basic needs of rural households could save households a great deal of time. Hence, providing cleaner energy to rural households would drastically cut fuel search and collection time. The provision of cleaner energy is a great step in the energy transition agenda. Fossil fuel continues to form the chunk of energy consumption globally, exacerbating greenhouse gas emissions and the consequent climate change effect [46]. Energy transition involves a shift from the reliance on primitive sources of energy and the transitioning from fossil fuels to sustainable and renewable energy sources [46]. The African region, for example, has the highest estimated woodfuel usage in the world; an estimated 63% of the population uses it, relative to 38% in Asia and Oceania, and 15% in Latin America and the Caribbean [47]. The FAO [47] estimates that nearly 90% of the wood harvested in Africa is used as fuel. However, in Ghana, the World Bank [48] recounts that despite a drop in the percentage of wood fuel in the energy mix from 70% to 35% (between 1990 and 2019), the demand has started to rise due to population growth. An estimated

4.5 million households in the country continue to use wood fuel as their main cooking fuel.

As highlighted earlier, households commit a substantial amount of time in obtaining fuel, specifically wood fuel or biomass. Transitioning to cleaner and modern energy sources would enable households to save time, which they could then use to engage in income-generating activities [33]. Participation in or increasing working hours in paid jobs generates more income. One of the benefits that comes with access to income and increased income is financial inclusion. Income has been the most researched determinant of financial inclusion, and the literature generally shows that access to and high income are positively related to financial inclusion [12,13,49,50]. One of the reasons for this is that access to income and high income promote savings [26].

Financial inclusion connotes the access to, availability, and usage of financial services for all [12,13]. Financial inclusion is also considered to be the access to finance and financial services for all, fairly, transparently, and equitably at an affordable cost [51]. Financial inclusion has many indicators; the main indicator has been the ownership of an account in a formal financial institution [49]. However, in recent years, mobile banking (Mobile Money) has been instrumental in enhancing financial inclusion in developing countries, especially in Sub-Saharan Africa [52]. Mobile Money has drawn many more people in Sub-Saharan Africa to be financially included. Forbes [53] recounts that in 2020, Mobile Money accounted for 43% of all new accounts in Sub-Saharan Africa. In this period, registered Mobile Money accounts increased by 12% to 548 million [53]. Sub-Saharan Africa leads the global usage and growth of Mobile Money [54,55]. In 2020, about $490 billion was exchanged using Mobile Money in Africa [52].

Mobile Money has become a major payment and saving platform in Ghana for the unbanked and the underserved (Bank of Ghana,[56]). It is the country's most popular digital financial service, and its wide usage has made Ghana one of the biggest Mobile Money markets and the fastest-growing in Africa (Ifeanyi-Ajufo, [57]). Mobile Money is promoting financial inclusion in Ghana. From 2012 to 2016, Mobile Money's volume of transactions recorded a growth rate of 737.4 % (Bank of Ghana [56]). Statista [58] indicates that as of January 2022, about 38.9% of Ghana's population (aged 15 years and above) had Mobile Money accounts. This is a country where about 80% of the population is unbanked (Boateng [59]). In February 2021, there were about 40.9 million Mobile Money accounts (Bank of Ghana [60]). Lowe et al. [61] note that though women and men are just as likely to use Mobile Money, women, particularly women entrepreneurs, are more likely to learn about mobile money services while Atta-Ankomah et al. [62] have shown that mobile money offers an avenue for rural households to diversify their livelihoods and reallocate productive resources into higher return-yielding activities.

Mobile Money provides many services that traditional banking institutions do, such as savings, money transfers, granting of loans to subscribers, payment of utility and shopping bills, etc. [52–55]. It does

not require a formal account with banks; all that one needs is a mobile phone (need not necessarily be a smartphone) and a subscription to a mobile communication provider that provides Mobile Money services. Financial inclusion is considered important, especially in developing countries, because it increases the chances of getting credit access and makes the poor financially active as they get to own accounts that enhance their savings [13]. When people are involved in the financial system, they stand a better chance of starting and/or expanding their businesses, investing in their children's education, and absorbing financial shocks due to access to credit and the promotion of savings [55].

The analysis above pictures a trajectory of the fuel transition policy, enabling households to save more time from searching and collecting firewood and other biomass. The saving of time creates more time for engagement in income-generating activities that could increase household incomes and savings. Access to and high income enhances financial inclusion [12,50]. Financial inclusion is considered vital as it enhances access to safe, easy, and affordable financial services for the poor, vulnerable, and those in disadvantaged areas and reduces poverty and income inequality, hence accelerating economic growth and sustainable development [12,63,64]. Considering this, financial inclusion has become a policy priority in many countries [51], and Ghana is no exception. Based on the preceding discussion, we put forth the following hypothesis:

Hypothesis. The transition to cleaner energy has a positive impact on financial inclusion.

Earlier studies on the determinants of financial inclusion have focused on the direct impact of income, gender, education, distance to financial institutions, availability of financial institutions, etc. [12,13, 26,50]. This study however concerns the nexus between energy transition and financial inclusion. Related studies include those examining the impact of clean or renewable energy on financial inclusion. For example, Pang et al. [65] find that green investment (which includes energy and environmental protection expenditures) is positively associated with financial inclusion in China. Other studies have also looked at how financial inclusion enhances access to clean energy. For example, Dogan, Madaleno and Taskin [66] show that financial inclusion alleviates energy poverty and enhances access to modern energy in Turkey. Koomson & Danquah [67] found similar results for Ghana. For China, Li et al. [68] find results indicating that financial inclusion accelerates the uptake of renewable energy. Also in China, Dong et al. [69] find that inclusive financial development reduces energy poverty. Relatedly, Croutzet and Dabbous [70] indicate that FinTech can incentivize the use of renewable energy in OECD countries. Some other studies have focused on energy efficiency. Chen et al. [71] find that financial inclusion is one of the important factors of attaining energy efficiency in the United States. Similarly, Chang et al. [72] show that financial inclusion enhances energy efficiency in 7 emerging economies including China.

The studies above do not directly relate to particular energy transition programs, and do not examine the unintended effect of these programs. In this paper, we examine the unintended impact of a policy intervention on financial inclusion. Specifically, we investigate how a policy of transitioning rural households in Ghana from traditional and unsustainable sources of fuel to more sustainable and clean fuel can impact their financial inclusion. A scrutiny of the extant literature revealed virtually no study relating an unintended outcome of a policy intervention (especially energy transition) to financial inclusion. An unintended outcome is an unplanned outcome that occurs due to the execution of a policy or an initiative [27,28]. There, however, exists a vast literature on unintended outcomes of programs/policy interventions on other subjects. For example, Cho et al. [7] examined the unintended impact of an educational policy (High School Equalization Policy (HSEP)) in South Korea. Though the HSEP has/had an objective of ensuring equal opportunities in education for all students, Cho et al. [7] investigated the impact of the HSEP on the housing market. They found that the policy had an opposite spillover effect of reducing the gap of the average house prices by 5%-9% across regions. Canavire-Bacarreza et al. [6] show how a protected areas policy meant to conserve ecosystems had an unintended outcome of increasing illegal activities in Colombia. Li and Sekhri [8] evaluate the unintended outcome of an employment program (the National Rural Employment Guarantee Scheme) on school enrolment in India. Blau et al. [73] show how childcare regulation meant to improve childcare quality had the unintended outcome of reducing staff wages. Miner [9]examines how the introduction of the Internet in Malaysia had an unintended outcome of accounting for a swing against an incumbent political party. Though the unintended outcomes could be positive or negative [27,28], we focus on the positive aspect in this study.

Methodology and data

Conceptual framework

This study adopts the model of time allocation and productivity by Koolwal and van de Walle [21] with a slight modification. The model suggests that time is allocated to various activities that yield goods and services from which the household derives utility. Adopting the framework to this study, we assume a household that allocates time to two activities[2]: a proportion of time available for firewood (or other biomass fuel) collection, t_1, and the remaining proportion of time for market activities (or economic activities) that yield wages, t_2 Thus,

$$t_1 + t_2 = 1$$

with the household deriving utility from consuming biomass fuel (and, by extension, goods produced using biomass fuel) and other goods. Thus,

$$u(X1, X2).$$

where $X1$ is biomass fuel, and X2 represents all other goods. X_2 also captures market goods the household can purchase with income earned from their market activities. Now, suppose that a household benefits from the RLPGPP and hence switches from firewood or other biomass fuel use to using LPG, whether exclusively or partially, the time allocated to firewood collection, t_1, reduces. The time saved could then be allocated to market activities, t_2. The increased time devoted to market activities is expected to have an effect on financial inclusion in at least three ways. First, households engaged in active economic activities are more likely to open bank or mobile money accounts to transfer and receive payments for their economic activities. Secondly, more time devoted to market activities is expected to yield increased incomes. Households now need a safe place to save their incomes and, hence, open bank or mobile money accounts to save their earnings. Thirdly, in a bid to access credit and appear loan worthy, households associate themselves with a bank or telecommunication service provider by opening accounts with them so that they increase their chances of accessing credit facilities from these agents to support their market activities. This is different for similar households who do not benefit from the program. The latter households continue to allocate substantial time to firewood collection, leaving less time for economic activities. As a limitation, this framework ignores the potential for part of the saved time from biomass fuel collection to be used to engage in non-market or domestic activities such as child care and family agriculture for own consumption, among others. Secondly, generally, there may be socio-

[2] Typically, households may also allocate time to unpaid household work and leisure. These have been left out of the time allocation model in this study in order to place the emphasis on the two activities that matter for the objective of this study. It is important to note that including all time allocations such as unpaid work and leisure do not change the conclusions we arrive at.

cultural reasons why women in some communities might still not engage in market activities despite freeing up time from biomass collection. However, in our study areas, there is no evidence of such socio-cultural practices that prevent women from engaging in market activities. In fact, the sample includes women who participate actively in the labor market, and thus, we rule out the possibility of the latter perceived limitation.

Empirical strategy

To estimate the effect of the RLPGPP on financial inclusion, the study employs two approaches. A household is determined to be financially included if they own an account with a bank, savings and loans company, microfinance company, or other financial institution, or a registered mobile money account with any telecommunication service provider. This produces a binary variable, y, such that $(y_i | \textit{the above condition is true} = 1;\ \textit{otherwise}\ 0)$. First, we examine the impact of treatment on financial inclusion by estimating the following model:

$$y_i = \beta_0 T_i + \beta_1 X_i + e_i \quad (1)$$

where T is treatment under the RLPGPP, X is a vector of control variables, e is the error term, βs are parameters to be estimated, and subscript i refers to household i. X includes factors that are likely to influence financial inclusion such as income – which measures the total household income - [13], years of schooling – which measures the educational attainment of the household head - [13,74], location of household – whether rural or urban - [75], and access to information – measured by whether the household listens to the radio or watches television regularly among other socio-economic factors. Eq. (1) is estimated by a linear probability model (LPM) regression controlling for district fixed effects. This estimation technique is preferred over the widely used logit and probit models for binary dependent variables due to biased estimates of the logit or probit models in the presence of fixed effects [76]. Furthermore, the LPM prevents identification issues via the specific functional form usually assumed in a typical probit or logit estimation [77,78]. This approach estimates the extent to which treatment in the program is associated with the probability of financial inclusion to the extent that treatment was sufficiently random with no selectivity bias, which could weaken or neutralize the potential of confounding variables clouding the true effect on financial inclusion. Information obtained via key informant interviews with the Ministry of Energy and the district assemblies where the program was implemented suggests that beneficiaries were selected randomly in each district with no criteria to deny any particular groups of persons. In other words, all residents within a district had an equal chance of benefitting from the program. In that case, the above strategy is sufficient to unearth the program's effect on financial inclusion. To confirm randomization in treatment, we estimate (1) for a sub-sample of respondents whereby the treated group consisted only of first-time owners of LPG equipment under the program. In other words, treated households who already owned LPG cylinders and cookstoves before benefitting from the program were dropped to examine the program's effect on first-time LPG owners under the RLPGPP. If the treatment was random and not conditioned on, for example, prior ownership or experience in the use of LPG, beneficiary households would receive free LPG equipment and accessories whether they already owned one or not. If the sub-sample analysis on the effect of the program on financial inclusion for first-time LPG owners produces results consistent with the full sample analysis, it would provide some evidence of the random nature of the treatment.

On the other hand, if the randomization during program implementation was insufficient or nonexistent, the above estimation strategy fails to reveal the true effect of the program on financial inclusion. In that case, we employ matching techniques as a second approach to estimate the treatment effect on financial inclusion. Matching techniques mitigate against selection bias by comparing similar households that differ only on the basis of treatment. Treated households are households that benefitted from the RLPGPP and received free LPG cylinders and cookstoves with other accessories, while control households are those households that did not benefit. Treated households are matched with control households on similar characteristics such that the only difference between the two sets of households is the element of treatment. Any difference in financial inclusion between treated and control households can, therefore, be attributed to the treatment. This difference, known as the treatment effect, is the impact of the fuel transition program on financial inclusion. Matching was done on covariates that were likely to affect selection. The Propensity Score Matching (PSM) and the Nearest Neighbour Matching (NNM) estimators were used. The PSM estimates the probability of being treated (also known as the propensity score) based on a household's characteristic features [79], after which matching was done for households in the two groups that had similar propensity scores. The propensity score is given by

$$P(x) = Pr(W = 1|x) \quad (2)$$

Eq. (2) gives the probability that a household is treated under the program given its characteristics. An implicit assumption here is that for households with the same propensity scores, the distribution of the outcome variable is the same for the treatment and control groups. The NNM (also known as the Mahalanobis Distance Matching), on the other hand, measures the distance between covariates of treated households and control households and matches households from the two groups that have the shortest distance or that are nearest neighbors. Covariates used for matching include occupation (whether agricultural worker or otherwise), access to information (whether listening to the radio or watching television in the household), level of education of household head, age of household head, and location of household (rural or urban).

Data

The study uses cross-sectional household-level data obtained by a survey of 904 households sampled from the Ada West district and the Ga South municipality, both in the Greater Accra Region of Ghana. The RLPGPP had been implemented in these two areas where 1,000 households from each of Ada West and Ga South had benefitted from the program. According to the Ministry of Energy, the implementing agency for the RLPGPP, households were selected randomly to benefit from the program. Given that the LPG equipment and accessories were free to the household, there is no motivation for or a record of a household self-selecting themselves from the beneficiary list. The survey interviewed both households that had benefitted from the program and households that did not benefit from the program. A list of beneficiaries was obtained from the respective district assembly for the treatment group. From this list, potential respondents were randomly selected from seven out of 15 electoral areas in Ada West and 13 out of 23 electoral areas in Ga South to reflect geographical balance. Simple random sampling was complemented with the snowballing approach to select non-beneficiaries within the same electoral areas as the control group. Table 1 shows the summary statistics of the data.

Financial inclusion is measured by the ownership of an account in a commercial bank, savings, and loans company, a microfinance institution, or any such formal establishment providing financial services or the ownership of a mobile money account with any telecommunication service operator by any member of the household. From the full sample, about two-thirds (65.6%) of respondents were included in the financial system. The survey further asked respondents to self-assess whether they or any member of their household would be able to secure a loan or credit from a financial institution if they applied for one. This subjective measure is used as an alternative response variable to confirm the findings from the more objective financial inclusion variable. About three-quarters (74.3%) of respondents self-adjudged their household to be creditworthy. Household income averaged GHS1,781. Overall, 45%

Table 1
Summary statistics.

Panel A (Full sample)					
Variable	Obs	Mean/ Proportion	Std. Dev.	Min	Max
Financial inclusion	904	0.656	0.475	0	1
Treatment	904	0.452	0.498	0	1
Income (GHS)	904	1781	1698	0	22600
Years of schooling	904	7.4	4.5	0	16
Location (1=rural)	904	0.774	0.418	0	1
Occupation (1=agric)	904	0.281	0.450	0	1
Access to information	904	0.844	0.363	0	1
Age of hh head					
26-35	904	0.176	0.381	0	1
36-45	904	0.325	0.469	0	1
46-55	904	0.291	0.454	0	1
>55	904	0.181	0.386	0	1
Self-assessed creditworthiness	904	0.743	0.437	0	1
District (1=Ga South)	904	0.504	0.5	0	1
Panel B (Treated sample)					
Variable	Obs	Mean/ Proportion	Std. Dev.	Min	Max
Financial inclusion	409	0.719	0.450	0	1
Income (GHS)	409	1951	2066	0	22600
Years of schooling	409	7.6	4.3	0	16
Location (1=rural)	409	0.756	0.430	0	1
Occupation (1=agric)	409	0.293	0.456	0	1
Access to information	409	0.892	0.310	0	1
Age of hh head					
26-35	409	0.139	0.347	0	1
36-45	409	0.333	0.472	0	1
46-55	409	0.303	0.460	0	1
>55	409	0.220	0.415	0	1
Self-assessed creditworthiness	409	0.790	0.408	0	1
District (1=Ga South)	409	0.511	0.5	0	1
Panel C (Control sample)					
Variable	Obs	Mean/ Proportion	Std. Dev.	Min	Max
Financial inclusion	495	0.604	0.490	0	1
Income (GHS)	495	1641	1304	0	15500
Years of schooling	495	7.2	4.6	0	16
Location (1=rural)	495	0.790	0.408	0	1
Occupation (1=agric)	495	0.271	0.445	0	1
Access to information	495	0.804	0.397	0	1
Age of hh head					
26-35	495	0.206	0.405	0	1
36-45	495	0.319	0.467	0	1
46-55	495	0.281	0.450	0	1
>55	495	0.149	0.357	0	1
Self-assessed creditworthiness	495	0.705	0.456	0	1
District (1=Ga South)	495	0.499	0.501	0	1

of the sample had benefitted from the RLPGPP. Panels B and C show the summary statistics computed for the disaggregated sub-samples of treated and control groups.

Results and discussion

This section presents results from the empirical analyses and discusses them. Results from the linear probability estimation of Eq. (1) are presented in Table 2. Column (3) has the full set of control variables.

Treatment is positive and has a statistically significant relationship with financial inclusion. Treated households are associated with a 6.6% higher likelihood of being registered in the financial system compared to control households. As explained earlier, the households that benefitted from the program are expected to spend less time collecting biomass fuel, which they could channel into economic or market activities. This imposes the need for a bank account or a mobile money account to facilitate the transfer and receipt of funds, access credit to fund their market activities, and/or to save their expected increased incomes from the increased time devoted to economic activities. The study finds that income, years of schooling, and access to information all have a positive and significant association with financial inclusion and affirms previous findings by Adetunji and David-West [26], Park and Mercado [12], and Zins and Weill [13]. Residing in a rural area has a negative association with financial inclusion confirming the findings of Lenka and Barik [75]. This is potentially because rural areas in developing countries usually suffer infrastructure deficits, including electricity, internet services, and the local siting of financial institutions and telecommunication service provider offices. These services promote financial inclusion and financial development [75,80]; thus, their absence in rural areas potentially inhibits financial inclusion in those areas. Agricultural workers are less likely to be registered in the financial system. At the same time, households whose heads are middle-aged (36 – 55 years) are more likely to be in the financial system relative to households with younger heads. Table 3 presents the results of the sub-sample analysis that excludes previous owners of LPG equipment prior to the program. The findings are consistent with the full sample analysis and confirm that treatment was sufficiently randomized without care of who owned LPG prior or otherwise.

Table 2
Probability of financial inclusion.

Variables	(1) Financial inclusion	(2) Financial inclusion	(3) Financial inclusion
Treatment	0.117***	0.101***	0.066**
	(0.031)	(0.030)	(0.028)
Income		0.005***	0.003***
		(0.001)	(0.001)
Years of schooling			0.022***
			(0.003)
Location (1=rural)			-0.330***
			(0.039)
Access to information			0.166***
			(0.039)
Age of hh head			
26-35			0.068
			(0.089)
36-45			0.159*
			(0.087)
46-55			0.228***
			(0.088)
>55			0.112
			(0.091)
Occupation (1=agric)			-0.072**
			(0.033)
Constant	0.702***	0.613***	0.582***
	(0.026)	(0.029)	(0.101)
District effects	Yes	Yes	Yes
Observations	904	904	904
R-squared	0.057	0.093	0.292

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

The findings from the second estimation strategy are presented in Table 4, Columns (1) and (2). It shows results from the matching techniques on the effect of the program on financial inclusion[3].

The findings from the matching techniques confirm the positive and statistically significant results obtained from the first estimation strategy, thus lending further credence to sufficient randomization of

[3] A summary of the balancing properties of covariates is provided in Appendix A

Table 3
Probability of financial inclusion for sub-sample.

Variables	(1) Financial inclusion	(2) Financial inclusion	(3) Financial inclusion
Treatment	0.079**	0.078**	0.060*
	(0.034)	(0.034)	(0.031)
Income		0.001**	0.001*
		(0.001)	(0.001)
Years of schooling			0.023***
			(0.003)
Location (1=rural)			-0.334***
			(0.043)
Access to information			0.202***
			(0.041)
Age of hh head			0.055
26-35			(0.093)
			0.145
36-45			(0.091)
			0.215**
46-55			(0.092)
			0.085
>55			(0.095)
Occupation (1=agric)			-0.086**
			(0.035)
Constant	0.711***	0.687***	0.602***
	(0.027)	(0.029)	(0.105)
District effects	Yes	Yes	Yes
Observations	792	792	792
R-squared	0.056	0.061	0.285

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

Table 4
Results from matching techniques.

Variables	(1) PSM Financial inclusion	(2) NNM Financial inclusion	(3) PSM Self-assessed Creditworthiness	(4) NNM Self-assessed Creditworthiness
Treatment	0.108***	0.098***	0.056*	0.054*
	(0.031)	(0.031)	(0.031)	(0.031)
Observations	904	904	904	904

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

treatment under the program. Hence, relying on the LPM to measure the effect of the program has a basis. To further test the robustness of the findings, the financial inclusion variable was replaced with a self-assessed variable of the creditworthiness of the household. Survey respondents were asked to evaluate if a loan application made to an accredited loan-granting institution would be approved if they applied for one. While this may be subjective, it is useful since it confirms one of the reasons mentioned earlier for which benefit from the program was expected to lead to financial inclusion. As explained, households would be motivated to get included in the financial system as they participate more in economic activities in order to be able to attract credit to support those economic activities. The findings are in Columns (3) and (4) of Table 4. Treated households rated their creditworthiness higher than control households rated theirs. Treated households are 5.4% to 5.6% times more likely to rate themselves credit-worthy compared to control households. Thus, the hypothesis that benefiting from the program was likely to lead to financial inclusion potentially through increased time allocation to market activities is supported [33].

Further analyses

As further analyses, using the two indicators - financial inclusion and self-assessed credit worthiness- we construct an additive index where persons who are both financially included, as earlier defined, and assessed themselves as credit-worthy ranked highest on the index, followed by persons who passed on only one indicator (i.e., either financially included but not credit worthy or were credit worthy but not financially included). This was followed by the lowest ranked on the index – those who were neither financially included nor were creditworthy. The index was used as an outcome variable to measure the effect of the treatment with findings presented in Table 5. The results show that households that benefitted from the clean energy intervention have a positive and significant association with financial inclusion. This implies that treated households would tend to score higher on the index of financial inclusion compared to households that did not benefit from the intervention and confirms earlier findings.

Conclusion

Climate change concerns and the global quest for sustainable development have resulted in various policy interventions on sustainable energy usage, especially in developing countries. These interventions are implemented mainly to achieve goals with respect to energy use. However, the interventions also potentially lead to other outcomes, albeit unintended. This study sought to investigate one of such unintended impacts of a clean cooking fuel transition programme in Ghana. The study examined the effect of a clean fuel intervention on financial inclusion. The study finds a positive and significant relationship between the fuel transition intervention and financial inclusion; thus, energy interventions have the potential to promote financial inclusion among beneficiary households. This is likely to result from the increased time allocation to market activities due to reduced time spent on biomass fuel collection. The increased time spent on market activities leads to increased incomes and highlights the need for creditworthiness, thus motivating households to include themselves in the financial system. Based on the evidence provided in this study, the positive effects on financial inclusion can be counted when assessing the benefits of fuel intervention programs such as the RLPGPP. Therefore, we recommend that rural areas that benefit from such intervention programs be provided with the needed infrastructure that enables inclusion in the financial system. These may include increasing access to electricity, access to mobile technology and internet services, as well as the siting of financial institutions locally and the decentralization of telecommunication services provision.

Banks and other financial institutions, as well as telecommunication companies, can be partnered by the government to extend their services to rural areas so that the full complement of benefits in the

Table 5
Effect of treatment on financial inclusion index.

VARIABLES	(1) Index of financial inclusion	(2)	(3)
Treatment	0.202***	0.168***	0.101**
	(0.051)	(0.049)	(0.044)
Income		0.011***	0.006***
		(0.001)	(0.001)
Constant	1.421***	1.237***	0.959***
	(0.042)	(0.048)	(0.162)
District effects	Yes	Yes	Yes
Other controls	No	No	Yes
Observations	904	904	904
R-squared	0.038	0.096	0.303

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

implementation of such energy interventions will be achieved. Based on the findings, it will be mutually beneficial for financial institutions and intermediaries to consider partnering with governments and energy transition advocates in developing countries by supporting the efforts toward clean energy transition. The findings from the study point to the fact that in addition to impact of interventions on intended outcomes, the effects on unintended outcomes ought to be measured to arrive at the full impacts of the interventions. For policy makers, the findings indicate that the potential for multiple benefits to emanate from an intervention such as the RLPGPP should be factored in making a case for voting funds into similar interventions. One limitation of this study has to do with the financial inclusion variable. It was impossible to have different measures of financial inclusion due to data limitations and therefore, further robustness analyses using other measures of financial inclusion could not be done. However, this does not in any way invalidate the findings and conclusions arrived at. Future studies may observe other unintended and unmeasured impacts of clean energy transition programs to aid in the full impact assessment of these programs.

CRediT authorship contribution statement

Kwame Adjei-Mantey: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Eric Evans Osei Opoku:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Kwame Adjei-Mantey reports financial support was provided by Sumitomo Foundation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

Balancing properties or covariates
NNM

	Standardized differences		Variance ratio	
Variables	Unmatched	Matched	Unmatched	Matched
Access to information	0.248	0	0.610	1
Agricultural worker	0.050	0	1.051	1
Education	0.099	0.015	0.885	1.025
Location	-0.082	0	1.114	1
Age of hh head	0.297	0.010	0.838	1.008

PSM

	Standardized differences		Variance ratio	
Variables	Unmatched	Matched	Unmatched	Matched
Access to information	0.248	-0.040	0.610	1.113
Agricultural worker	0.050	-0.005	1.051	0.995
Education	0.099	0.011	0.885	0.970
Location	-0.082	-0.040	1.113	1.051
Age of hh head	0.297	0.015	0.838	0.997

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