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Barnabe ABBA YADOU

abbayadou@gmail.com

University of Maroua

Louise Angèle Baida

University of Maroua

Philemon Bonaventure NTANG

University of Maroua

Valery ABBA ABAM-NDE

University of Maroua

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The employment sector and energy poverty in sub-Saharan Africa : a two-edged sword?

Barnabe ABBA YADOU (corresponding author)
Faculty of Economics and Management
University of Maroua, Cameroon
E-mail : abbayadou@gmail.com

Louise Angèle Baida
Faculty of Economics and Management
University of Maroua, Cameroon
E-mail: handafr@yahoo.fr

Philemon Bonaventure NTANG
Faculty of Economics and Management
University of Maroua, Cameroon
E-mail : ntang4u@yahoo.fr

Valery ABBA ABAM-NDE
Faculty of Economics and Management
University of Maroua, Cameroon
E-mail: abamnde@gmail.com

Abstract
The energy transition is one of the major challenges of the Sustainable Development Goals in developing countries in general, and in Sub-Saharan African countries (SSA) in particular, for social well-being. It is therefore useful for SSA countries to identify the determinants of energy poverty in order to address it. In this context, this paper examines the effect of the employment sector on energy poverty in Sub-Saharan Africa. This study is based on a sample of 40 SSA countries over a period from 2000 to 2018. The Ordinary Least Square (OLS) and IV-2SLS methodologies were used. The results show that employment in the agricultural sector increases energy poverty, while employment in the industrial sector reduces it. Furthermore, our results remain robust with the addition of control variables and the subdivision of our sample into rural and urban areas. Several economic policy recommendations are discussed.

Keywords: Energy Poverty, Agriculture employment, Industrial employment, Sub-saharan Africa, OLS, IV-2SLS

JEL classification: I31 (General welfare) Q43(energy and macro) C23 (panel data) O13 P28 K32

1- Introduction

To achieve sustainable development, countries have set themselves a number of economic and social objectives. These include access to clean energy to ensure environmental sustainability. Indeed, Goal 7 of the Sustainable Development Goals (SDGs) targets universal access to clean cooking fuel in order to tackle the negative impact of climate change, as adopted by COP26.The recent Intergovernmental Panel on Climate Change (IPCC) shows that 25% of black carbon emissions come from cooking and residential heating. It is therefore necessary for African countries to turn to less polluting and environmentally friendly fuels in order to achieve Goal 7 of the SDGs.

In 2020, for example, 69% of the world's population had access to clean and technologies for cooking fuel, while 2.4 billion had no access at all (IEA, 2022). In recent decades, access to clean energy has increased by 12%. If the current trends continue, a quarter of the world's people, mostly in low- and middle-income countries, will lack access to clean cooking fuels in 2030. Indeed, there is a disparity between regions when it comes to access to clean cooking fuels. For example, in 2022, more than 850 million people in Africa will depend on wood and charcoal for cooking, of

whom around 700 million will be in Sub-Saharan Africa. Sub-Saharan Africa[1] remains the only region in which the number of people without access to clean fuels and technologies for cooking is rising.

Indeed, in developing countries the risk of mortality of household members is attributed to indoor air pollution due to inefficient cooking practices using solid fuels (Patrick et al., 2017). It is estimated that 41% of households worldwide rely on solid fuels for cooking (Bonjour et al., 2013) and the number of premature deaths linked to indoor air pollution continues to increase over 500 000 by 2030 (IEA, 2020). To meet this challenge, it would be wise to promote the use of clean cooking energy in developing countries, and in SSA in particular.

In order to tackle the problem of energy poverty, several determinants have been studied at both microeconomic and macroeconomic levels. These works on the determinants of household energy consumption has highlighted several determinants ranging from income to social and demographic factors. The "energy ladder hypothesis" places income as a determinant that explains the effect of the energy transition from traditional (biomass) to modern energy such as domestic gas, oil or electricity (Leach, 1992; Barnes et al., 2005). Other determinants range from social and demographic factors such as education, household size, age of the head of household, type of shelter and its ownership status, location of the house and distance from the forest (Gupta and Kohlin, 2006; Heltberg, 2005; Rehfuess et al., 2010). Other factors such as local cooking habits and frequency of cooking (Ouedraogo, 2006), ethnicity (Heltberg, 2005), local traditions and institutions (Hiemstra-van der Horst and Hovorka, 2008) are other factors affecting energy demand. In addition, gender and the position of women in the household is considered a key factor in the energy choice decision (Heltberg, 2004; Rehfuels et al., 2010).

The other potential source of determinants in energy choice depends on market availability and access to domestic gas and electricity (Davis, 1998; Karezi and Majoro, 2002; Kebede et al., 2002). However, economic factors are a key constraint in the energy transition from traditional (biomass) to clean, modern energy (Gazi, 2020). Furthermore, Edward and Langpap (2005) show that the most critical constraint in the adoption of LPG is insufficient income. Similarly, Khandker et al. (2012) find that clean energy adoption is prevalent among the urban-poor households despite the

[1] In 2020, 86 percent of people living in urban areas and just 48 percent of the rural population had access to clean fuels and technologies. In Sub-Saharan Africa, more than 93 percent of the rural population lacks access to clean cooking fuels and technologies, compared with 71 percent of the population living in urban areas.

availibility of and access to modern energy such as LPG and electricity being higher in urban areas. These studies highlight the importance of income in energy consumption and the transition to modern energy but do not specify which income is more significant (Gazi, 2020). A significant limitation of these studies is the inattention of the sources of income that could enhance this transition process especially from off-farm work (Martey et al., 2022). However, to our knowledge, apart from the studies by Martey et al (2022) and Zheng (2023), which focus on Ghana and China respectively, no study has addressed the case of SSA. We thus contribute to the literature on the determinants of energy poverty in Africa by considering the employment sector as one of the determinants.

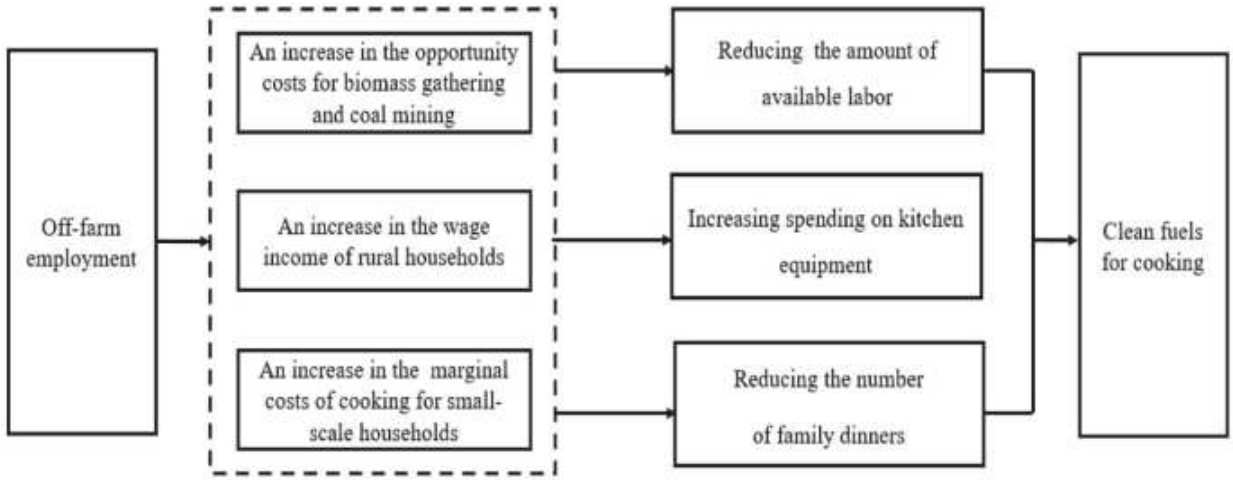
The rest of the paper is structured as follows. The second section presents a brief review of the literature (2), the next section presents the data and methodological strategy (3). The fourth section presents the empirical results, followed by the conclusion and policy recommendations.

2- Theoretical underpinnings and review of literature

2.1- Theoretical underpinnings

Theoretically, the work of Zheng (2023) shows us the channel through which non-agricultural work improves the energy transition at three points as presented in Figure 1.

Figure 1: Analytical framework for the influence of off-farm employment on cooking fuel choices



Source: Zheng (2023)

Firstly, off-farm employment will lead to a reduction in the labor force for biomass gathering and coal. Indeed, off-farm employment can potentially raise the opportunity cost of biomass gathering

and coal mining, making it economically less expensive for rural households to use non-clean fuel. Secondly, the off-farm employment will increase the wage income and consequently increase expenditure on kitchen equipment. Formally speaking, the acquisition of different kitchen equipment creates an extension in the choice of clean cooking fuels. As a result, when rural household earn income from off-farm employement, they are likely to buy kitchen cooking equipment (Demurger and wang, 2016), thereby creating conditions for clean fuel use.

Thirdly, off-farm employment will reduce the number family diners and indirectly increase the opportunity cost of using non-clean fuels. In fact, non-agricultural industrial companies are located in urban areas more than in rural areas, off-farm employement means spatial separation of family members (Wang et al., 2017), wich greatly reduces the number of family diners for all members. In this case, smaller households are better off using gas and electricity than biomass and coal. This is because the latter will take more time and have higher marginal costs to cook meal (Ma et al., 2019; Martel et al., 2022).

2.2-Empirical Literature

The issue of energy poverty has been the subject of much debate, with many different determinants. These determinants can be both socio-demographic and geographical. Indeed, several authors have shown that the energy transition from un-clean energy to clean energy depends primarily on income (Leach, 1992 ; Barnes et al., 2005). In addition to income, household size, education, age of the head of household, geographical location, distance from the forest (Gupta and Kohlin, 2006 ; Heltberg, 2005; Rehfuess et al., 2010), eating habits (Ouedraogo, 2006), ethnicity (Heltberg, 2005), local traditions and institutions (Hiemstra-van der Horst and Hovorka, 2008) are other factors affecting energy demand. In addition, gender and the position of women in the household is considered a key factor in the energy choice decision (Heltberg, 2004; Rehfuels et al., 2010). The other potential source of determinants in energy choice depends on market availability and access to domestic gas and electricity (Davis, 1998; Karezi and Majoro, 2002; Kebede et al., 2002) and trade liberalization (Muntasir, 2020).

Of all the above, income is a key determinant (Leach, 1992), but nothing is said about the source of income. Indeed, the source of income can be volatile or less consistent for the acquisition of kitchen equipment adapted to modern energies. With this in mind, some studies have taken into account income sources such as remittances as an alternative source of income (Abba Yadou et

al., 2023 ; Djeunankan et al., 2023; Barkat et al., 2023). In addition, the work of zheng (2023) takes into account non-agricultural employment. The work of zheng (2023) on China shows that off-farm employement exerts a positif and significant impact on the probability of adopting clean fuels for cooking with specific reductions in biomass and coal and increase in electricity and gas. However, this effect is permanently realized by the reduction in the number of available jobs, the number of family meals and the increase in kitchen equipment. But this relationship between off-farm employment and the energy transition varies considerably by region, village and household group. Furthermore, the work of Martey et al (2022) examines the effect off-farm employment has on cooking energy choice and time poverty using the seven round of the Ghana Living Standard Survey (GLSS) data. The results show that increase in off-farm employment is associated with a decrease in the use of dirty fuel but positively associated with clean energy and time poverty. Some consider that off-farm employment is the manifestation of the rural-urban transformation in developing countries and plays a crucial role in rural areas in the sustainability of energy transformation (Zheng, 2023). For Zhou et al. (2023), the transfer of the labor force, the level of household income improves and the structure of energy consumption changes. Based on survey data on 8198 farmers in 27 provinces from China's labor dynamic of 2016, Zhou et al. (2023) show that labor off-farm employment contributes 39% to the use the cooking clean energy. Thus, the labor off-farm employment promoted the use of cooking clean energy and this action is carried out by three mechanisms which are among others per capita annual cash income, social relationship network and family population structure. In conclusion, the work of Cyrek and Cyrek (2022) shows that agricultural employment is a factor increasing household energy poverty. All these different studies show that the employment sector has an effect on the energy transition. However, the empirical literature has not taken into account SSA countries where the energy transition is weak, and where research into the various determinants is crucial to tackling environmental degradation (Ntang et al., 2023).

3- Data and empirical strategy

3.1- Empirical strategy

This paper examines the empirical effect of sectoral employment on energy poverty in SSA countries. This study therefore reveals the importance of further research into the role of economic structural change on the energy transition in SSA, whose countries are listed in Appendix 5. Thus, our model is specified as follows:

$$ACFT_{it} = f(employ_{it}, X_{it}) \qquad (1)$$

With ACFT representing access to clean fuel and technologies for cooking, employ designating the employment sector (agricultural and industrial) and X representing the control variables cited above. More specifically, equation (2) presents the effect of agricultural employment (eagri) on energy poverty. Equation (3), on the other hand, takes into account the effect of industrial employment on the use of clean energy.

$$ACFT_{it} = f(eagri_{it}, X_{it}) \qquad (2)$$

$$ACFT_{it} = f(eind_{it}, X_{it}) \qquad (3)$$

These different equations can be rewritten as follows:

$$ACFT_{it} = \beta_0 + \beta_1 eagri_{it} + \beta_2 X_{it} + \varepsilon_{it} \qquad (4)$$

$$ACFT_{it} = \beta_0 + \beta_1 eind_{it} + \beta_2 X_{it} + \varepsilon_{it} \qquad (5)$$

These various control variables are selected on the basis of existing literature on the determinants of energy poverty. These variables include remittances (remit), GDP per capita (gdppc), financial development (private), natural resources (totalrents) and urbanization (urb). Descriptions of the different variables in the model are presented in Appendix 3, and Appendix 4 contains the correlation matrix.

In this study, we first use an Ordinary Least Square (OLS) as a preliminary method, and secondly we use an IV-2SLS model to account for the likely endogeneity between our variables. Indeed, although OLS are interesting, they do not provide sufficiently robust results because they do not address the problem of probable endogeneity in our model (Yadou et al., 2024). The endogeneity problem can arise either from simultaneity or omitted variables, or from measurement errors in the model. It is with this in mind that we use IV-2SLS to account for likely endogeneity in our model to make our results more robust. Furthermore, as specified by James and singh (1978), 2SLS are ideal for estimating structural equations.

3.2- Data

The aim of this paper is to analyze the effect of employment sector on energy poverty in SSA measured by access to clean cooking fuels and technology using a panel of 40 SSA countries over the period 2000 to 2018. The choice of sample is motivated primarily by the growth of energy poverty in SSA. Indeed, Sub-Saharan Africa remains the only region in which the number of

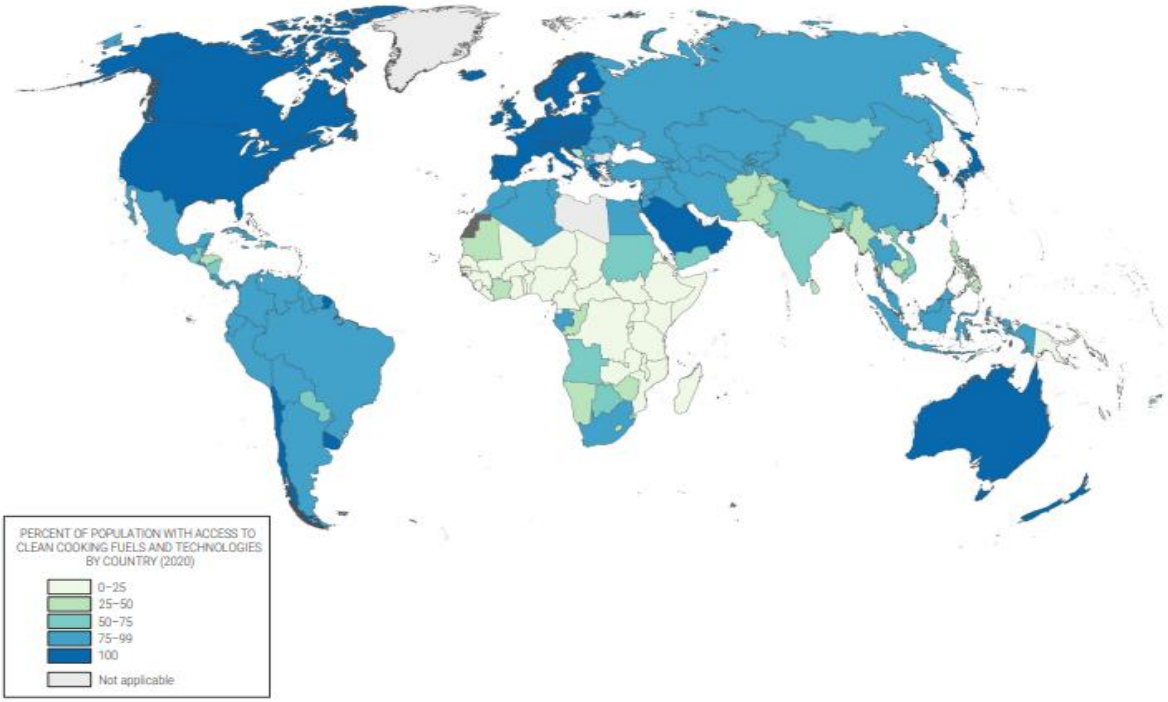
people without access is rising. The access deficit in Sub-Saharan Africa nearly doubled between 1990 and 2020 ; it rose by more than 50 percent since 2000 to 923 million (898-946) in 2020. Secondly, the share of employment in the agricultural sector is certainly evolving, but at a slightly decreasing level compared to the share of employment in the industrial sector. And finally, the period is determined by data availability and data on access to clean energy starts in the 2000s.

3.2.1- Dependent variable: Clean fuels and technology for cooking

Access on clean fuels and technology for cooking[2] has been used by several researchers on the issue of energy poverty, following the example of the work of Martey et al.,2022 ; Zheng,2023 ; Djeunankan et al.,2023 ; Abba et al., 2023). This is the logic behind the use of access to clean cookings fuels like as the dependent variable. In fact, the figure 1 shows us the proportion of the population with access to clean cooking fuels and technologies worldwide. Africa in general, and SSA in particular, has a low proportion compared with other regions. In fact, over 850 million people in Africa depend on wood and charcoal for cooking. In 2013, the leaders of the Economic Community of West African States (ECOWAS) adopted universal access to efficient and sustainable cooking energy as one of their priorities by 2030. However, the gap in access to clean energy is growing in some regions. This deficit was estimated at around 3 billion in 2000 in SSA, with growth from 580 million in 2000 to 860 million in 2016. This is how this deficit in the SSA region in proportion rose from 19% in 2000 to 29% in 2016 (IEA, 2018). This growing deficit in SSA leads us to question the determinants of access to clean energy for cooking. For most households in Africa and Sub-Saharan Africa (SSA), energy is primarily used for cooking and lighting. Interestingly, these two main energy uses have been enshrined in the Sustainable Development Goals (SDGs). Specifically, Goal seven of the SDG aims at ensuring access to affordable, reliable, sustainable and modern energy for all. Continuous calls have been made from all quarters for developing countries, particularly SSA countries, to increase access to clean cooking fuels. Clean cooking fuels have been found to save lives, improve livelihoods, empower women, reduce indoor air pollution and protect the environment (Marchand et al., 2019; Crentsil et al., 2019; Olang et al., 2018). As such, the type of cooking fuel used by the household has implications for health, economic welfare and by extension, economic development.

[2] Access to clean fuels and technologies for cooking is the proportion of total population primarily using clean cooking fuels and technologies for cooking. Under WHO guidelines, kerosene is excluded from clean cooking fuels.

Figure 1: Percentage of population with access to clean cooking fuels and technologies, by country, 2020



Source : WHO (2022)

In this study we use access to clean cooking fuels and technology as our variable for energy poverty in SSA countries. Figure 1 shows the distribution of access to clean fuels and technology for cooking around the world. This distribution is unequal in the different regions. Africa in general (see appendix 2) and sub-Saharan Africa (see appendix 3) show little change compared with the rest of the world. In addition to the variable access to clean fuels and technologies for cooking, we take into account the distribution of this variable by rural and urban area, to see if the effect is different despite the disparity between rural and urban access to clean energy for cooking.

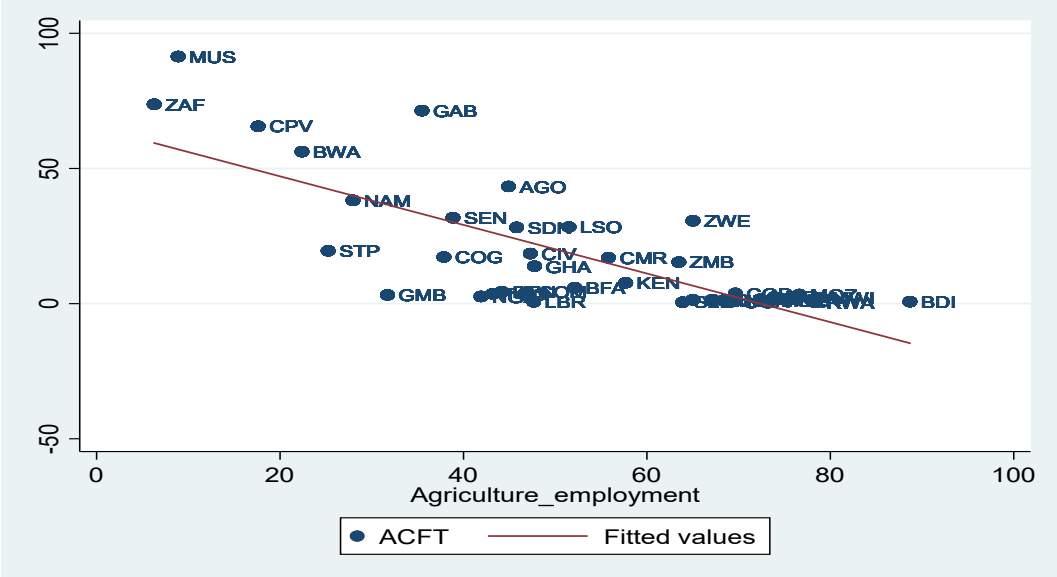
3.2.2- Independents variables: employment in agriculture and industry

Several determinants of the energy transition have been developed, including social and demographic factors, such as education, household size, age of the head of household, type of shelter and its ownership status, location of the house and distance from the forest (Gupta and Kohlin, 2006; Heltberg, 2005; Rehfuess et al., 2010). Other factors such as local cooking habits and frequency of cooking (Ouedraogo, 2006), ethnicity (Heltberg, 2005), local traditions and institutions (Hiemstra-van der Horst and Hovorka, 2008), gender (Heltberg, 2004; Rehfuels et al.,

2010). The other potential source of determinants in energy choice depends on market availability and access to domestic gas and electricity (Davis, 1998; Karezi and Majoro, 2002; Kebede et al., 2002). However, the critical or major determinant of the energy transition is income (Mottaleb et al., 2017; He et al., 2018; Ma et al., 2019; Twumasi et al., 2020). Based on the energy ladder hypothesis, household income plays a key role in the energy transition from dirty or solid energy to clean energy. But this theory does not address the source of income that will enable the energy transition process, especially from off-farm work (Martey et al., 2022; Zheng, 2023).

In this study, we use two variables as sources of income in the countries in our sample. Firstly, we use employment in the agricultural sector, as Zheng's (2023) work stipulates that work in the agricultural sector provides an income that is volatile compared with other off-farm jobs. It is in this vein that we secondly use employment in the industrial sector as a determinant in the process of energy transition from unclean energy (solid) fuels to clean fuels. Moreover, in our sample, the share of employment in the agricultural sector is higher than in the industrial sector (see Appendix 1). Figure 2 shows the relationship between employment in the agricultural sector and energy poverty or access to clean cooking fuels and technology. We observe a negative relationship between our two sample variables. This is consistent with the intuition that sources of income in the agricultural sector are volatile and therefore do not allow for an energy transition.

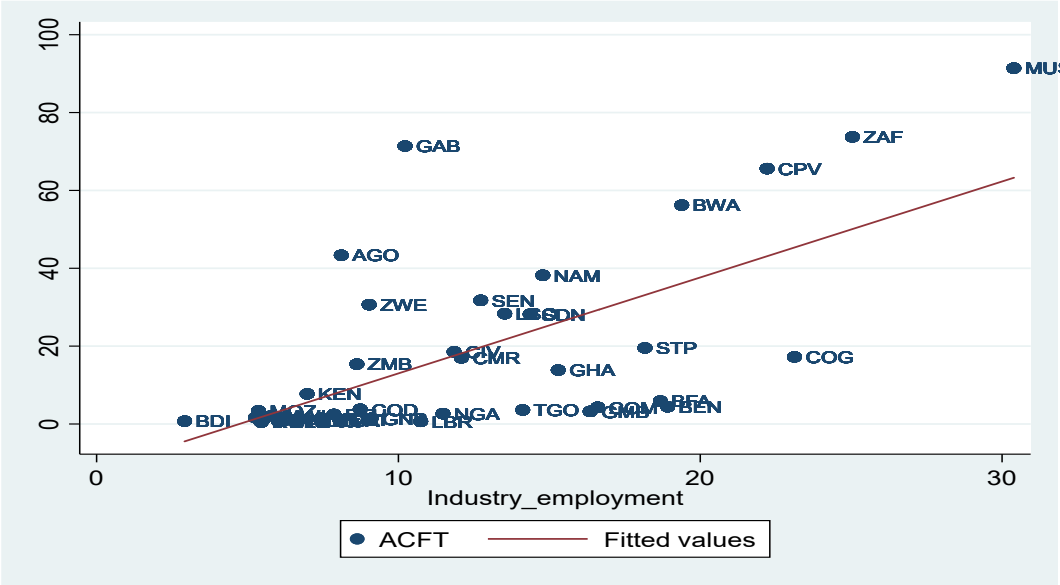
Figure 2: Correlation between energy poverty and agriculture employment in SSA



Note: ACFT represent the access to clean fuels and technologies for cooking
Source : Authors' construction

Figure 3, on the other hand, shows a positive effect between employment in the industrial sector. It shows that there is a positive correlation between industrial employment and clean energy. For as Zheng (2023) shows, off-farm employment exerts a positive and significant impact on the probability of adopting clean fuels for cooking.

Figure 3: Correlation between energy poverty and industry employment in SSA



Note: ACFT represent the access to clean fuels and technologies for cooking
Source : Authors' construction

3.2.3-Control variables

The control variables used in this study come from the economic literature on the determinants of energy poverty. These variables are the level of development captured by GDP per capita, remittances, credit available to the private sector, internet access, natural resources and urbanization.

In fact, income is a major determinant in the energy transition, and access to credit boosts household income levels (Twumasi et al., 2020; Khan et al., 2023). In addition, access to credit enables households to create an extra source of income through investment in a microenterprise (Bateman, 2012). In this way, access to credit helps poor households break out of the vicious circle of poverty. This is because it increases capital accumulation, thereby boosting household income. In addition, migrant remittances are considered an alternative source of income for households

(Abba et al., 2021) and enable the transition from traditional to modern energy use (Djeunankan et al., 2023; Abba et al., 2023). The level of development captured by GDP per capita is also used and total natural resource rents as a percentage of GDP (Magnani and Vaona, 2016; Djeunankan et al., 2023). Total natural resource rents represent the sum of oils rents, natural gas rents, coal rents and forest rents (World Bank, 2022). Theoretically, natural resources are seen as an additional source of income for resource-rich countries, enabling them to finance development and access to electricity (Nkoa et al., 2023). The comparison of energy access between urban and rural areas is consistent in that energy poverty is more pronounced in rural areas than in urban areas. Barriers limiting the energy transition in rural areas include the remoteness and dispersion of the population compared with urban areas, which do not have this difficulty (Aung et al., 2022). For some authors, the difference in energy poverty can be explained by the level of urbanization (Roberts et al., 2015; Rodriguez-Alvarez, 2021). Thus, advanced urbanization leads households to use modern energies, compared with rural areas, where traditional energies (biomass, wood and charcoal for example) are readily available at low cost, making it difficult for households in rural areas to make the energy transition. Access to technology enables households to learn about the health and environmental benefits of using clean cooking fuels (Abba et al., 2023; Wang et al., 2023).

Table 1 presents the descriptive statistics for our different variables. On average, 19.74% of the countries in our sample have access to clean fuel and technologies for cooking. However, agricultural employment represents on average 51.53% and industrial employment 12.19% of total employment. This shows that there is a strong dominance of agricultural employment in our sample. Table 1 : Descriptive statistic

Variables	Obs	Mean	Std. Dev.	Min	Max
acft	779	19.74403	25.77091	.15	93.8
eind	760	12.19764	6.431386	2.26	39.25
eagri	760	51.53489	20.779	4.6	91.76
gdppc	761	2071.301	2686.122	194.8731	14417.06
remit	753	3.775715	6.22239	.0001832	53.82618
private	778	21.36376	25.37908	10.1337	160.1248
totalrents	778	10.38875	10.34561	.0011713	58.65016
urb	779	40.47268	17.21626	8.246	89.37

Notes: Obs represented Observations and Std.Dev is standard deviation.
Source: Authors'

4- Empirical results

This section presents the empirical results obtained. First, we look at baseline results and robustness, taking into account additional variables and subdivision according to geographical position.

4.1- Baseline results

Table 2 presents the results of our estimations of the relationship between agricultural and industrial employment on the use of clean cooking energy in Sub-Saharan Africa. We use in turn an Ordinary Least Square (OLS) and an IV-2SLS.

Table 2: OLS and IV-2SLS estimation results

Dependent variable ACFT				
	OLS	OLS	IV-2SLS	IV-2SLS
eagri	-0.0849**		-0.160***	
	(0.0360)		(0.0451)	
eind		0.372***		0.391***
		(0.0729)		(0.107)
remit	0.395***	0.388***	0.371***	0.403***
	(0.0602)	(0.0569)	(0.0615)	(0.0598)
totalrents	-0.200***	-0.203***	-0.165***	-0.199***
	(0.0418)	(0.0388)	(0.0350)	(0.0371)
private	0.171***	0.158***	0.158***	0.161***
	(0.0205)	(0.0193)	(0.0237)	(0.0236)
urb	0.0915**	0.0982***	0.0328	0.0899***
	(0.0378)	(0.0294)	(0.0451)	(0.0320)
gdppc	0.00748***	0.00750***	0.00737***	0.00752***
	(0.000252)	(0.000243)	(0.000242)	(0.000235)
Constant	2.110	-6.828***	8.309*	-7.139***
	(3.262)	(1.102)	(4.310)	(0.924)
Observations	713	713	695	695
Countries	40	40	40	40
R-squared	0.854	0.858	0.855	0.860
Adj R-squared	0.853	0.857		
Fisher test	688.0***	711.2***		
Kleibergen-Paap rk LM P val			0.0000	0.0000
Kleibergen-Paap rk Wald F stat			1723	265.1
Hansen P val			0.2590	0.218
Robust standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1		

Source: Authors'

First of all, we find that agricultural employment reduces the use of clean energy. This can be explained by the fact that employees in the agricultural sector are more inclined to collect and use firewood for cooking. Furthermore, the share of agricultural employment in the context of our study area is greater than employment in the manufacturing sector. This can be explained by the preponderance of agricultural employment in SSA which represent about 60% of employment (ILO, 2024) but also by the ease with which agricultural employees can gather firewood for cooking at lower cost (Zheng, 2023). This result corroborates that of Zheng (2023) and Cyrek and Cyrek (2022).

However, industrial employment increases the use of clean energy in SSA. In fact, off-farm employment, which refers to industrial jobs, is more stable in terms of income, and industrial employment also reduces the time needed to fetch firewood for cooking. What's more, industrial employment provides the means to purchase more modern kitchen equipment. Furthermore, off-farm employment implies an additional income source and these households keep lower precautionary savings because of more stable expected gains and lower liquidity constraints, which provides incentives for investing in durable goods, including energy facilities (Chang et al., 2024) This result is fully in line with the work of Zhou et al (2023) and Zheng (2023).

Remittances increase the use of clean fuels and technologies for cooking in SSA countries. Indeed, remittances, seen as an alternative household income, enable people to escape from precariousness and have the appropriate means to cope with energy poverty. This result is perfectly in line with the work of Djeunankan et al (2023), Abba et al (2023) and Barkat et al (2023).

Financial development increases access to clean fuels and technologies for cooking by increasing the financial means to purchase cooking equipment and raising household income levels. The results are identical to those of Khan et al (2023).

Urbanization has a positive and significant effect on the use of clean fuels and technologies for cooking. Indeed, urbanization increases access to modern energies by improving the availability of clean energies. Empirical studies show that in urban areas, energy poverty decreases in terms of quantities consumed and access to modern fuels, but increases in terms of share of energy expenditure (Mahumane and Mulder, 2022). Moreover, promoting urbanization contributes significantly to mitigating energy poverty (Qi et al., 2024).

The level of development captured by GDP per capita has a positive effect on clean fuels and technologies for cooking, which corroborates several studies such as Djeunankan et al. (2023).

Natural resources, on the other hand, have a negative effect on clean fuels and technologies for cooking. In fact, natural resources will have to increase the use of clean fuels for cooking via the use of domestic gas. However, the work of Nkoa et al (2023) shows that natural resources increase energy poverty.

4.2-Robustness check

To test the robustness of our baseline estimates, we begin by increasing the control variables and subdividing our sample into rural and urban areas. Table 3 presents our robustness with the addition of control variables such as : life expectancy, investment captured by gross fixed capital formation (GFCF) and regulatory quality

Additional variables

Table 3: Additional variables

	Dependent variable ACFT					
	1	2	3	4	5	6
eagri	-0.133***	-0.143***	-0.126***			
	(0.0466)	(0.0461)	(0.0425)			
eind				0.323***	0.351***	0.317***
				(0.111)	(0.109)	(0.102)
remit	0.397***	0.368***	0.407***	0.425***	0.397***	0.430***
	(0.0566)	(0.0532)	(0.0583)	(0.0531)	(0.0492)	(0.0546)
totalrents	-0.177***	-0.267***	-0.227***	-0.203***	-0.300***	-0.257***
	(0.0372)	(0.0463)	(0.0461)	(0.0383)	(0.0491)	(0.0483)
private	0.164***	0.180***	0.167***	0.167***	0.183***	0.170***
	(0.0228)	(0.0222)	(0.0196)	(0.0226)	(0.0218)	(0.0193)
urb	0.0193	-0.0108	-0.00816	0.0651*	0.0368	0.0328
	(0.0458)	(0.0477)	(0.0449)	(0.0333)	(0.0353)	(0.0342)
gdppc	0.00738***	0.00783***	0.00771***	0.00752***	0.00800***	0.00786***
	(0.000258)	(0.000290)	(0.000287)	(0.000253)	(0.000294)	(0.000288)
	Additional variables					
invest	0.203***	0.231***	0.146***	0.199***	0.228***	0.146***
	(0.0496)	(0.0517)	(0.0507)	(0.0507)	(0.0532)	(0.0520)
Regulatory		-3.997***	-3.636***		-4.173***	-3.812***
		(1.147)	(1.135)		(1.167)	(1.151)
life			0.367***			0.355***

			(0.0674)			(0.0646)
Constant	2.946	1.645	-18.62***	-9.770***	-12.13***	-30.15***
	(4.585)	(4.463)	(4.977)	(1.382)	(1.461)	(3.573)
Observations	677	677	677	677	677	677
R-squared	0.862	0.865	0.872	0.866	0.870	0.876
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	1614	1556	1736	253.1	261.8	303.6
Hansen P Val	0.3847	0.825	0.131	0.331	0.750	0.178
Countries	39	39	39	39	39	39
Robust standard errors in parentheses			*** p<0.01, ** p<0.05, * p<0.1			

Notes: 39 countries due to lack of data on the invest variable for Sao Tome and Principe
Source : Authors'

Table 3 shows that our previous results are identical with the addition of the three control variables mentioned above. In addition, investment and life expectancy have a positive and significant effect on clean fuels and technologies for cooking. But the quality of regulation has a negative effect on clean cooking fuels and therefore does not enable the energy transition.

Geographical position

For some authors, differences in energy poverty can be explained by taking into account the level of urbanization (Roberts et al., 2015; Rodriguez-Alvarez, 2021) and therefore a difference between rural and urban areas.

Table 4: IV-2SLS results with rural and urban division

Dependent variable ACFT				
	rural	urban	rural	urban
eagri	-0.302***	-0.228***		
	(0.0531)	(0.0742)		
eind			0.746***	0.570***
			(0.117)	(0.186)
remit	0.108**	0.906***	0.166***	0.948***
	(0.0546)	(0.115)	(0.0454)	(0.110)
Totalrents	-0.0496	-0.553***	-0.122***	-0.607***
	(0.0371)	(0.102)	(0.0383)	(0.104)
private	0.146***	0.147***	0.155***	0.153***
	(0.0209)	(0.0377)	(0.0203)	(0.0374)
urb	-0.415***	-0.0787	-0.314***	-0.00323
	(0.0581)	(0.0778)	(0.0392)	(0.0628)
gdppc	0.00509***	0.0101***	0.00546***	0.0104***
	(0.000340)	(0.000548)	(0.000344)	(0.000545)
invest	-0.115***	0.457***	-0.115***	0.457***
	(0.0393)	(0.0904)	(0.0392)	(0.0934)
regulatory	-1.907**	-8.077***	-2.304**	-8.387***
	(0.952)	(2.581)	(0.978)	(2.581)
life	0.562***	-0.0207	0.536***	-0.0414
	(0.0818)	(0.125)	(0.0721)	(0.126)
Constant	-2.889	11.16	-30.73***	-9.844
	(5.267)	(10.03)	(3.623)	(6.502)
Observations	677	677	677	677
R-squared	0.769	0.738	0.798	0.737
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	1736	1736	303.6	303.6
Hansen P Val	0.9679	0.5516	0.6648	0.6383
Countries	39	39	39	39

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source : Authors'

Taking into account the geographical division into urban and rural areas, our results remain identical and significant. However, it emerges that whatever the geographical location (rural or urban) of households, the result remains identical. Consequently, agricultural employment remains

a factor in increasing subjective household energy poverty, while industrial employment is a determinant of the energy transition in SSA countries. More empirical evidence supports that rural households engaged in off-farm employment are more able to expand their energy expenditure and are more likely to consume more efficient but expensive fuels, such as gas or electricity (Chang et al., 2024).

5- Conclusion

The main objective of this study is to examine the effect of employment sector on energy transition in SSA. This study fills the gap in the empirical literature on the determinants of the energy transition in Africa and SSA in particular. The study covers a sample of 40 SSA countries over the period 2000-2018. Several results were obtained after several estimation methods. The results show that employment in the industrial sector increases access to clean cooking fuels, while employment in the agricultural sector has a negative effect. Taking into account the disparity in the use of modern energies between urban and rural areas, the results remain identical. This study reveal the need to deepen the research about the role of structural change within economies on the problem of energy poverty.

So, the energy transition can be supported by a public investment opportunity that encourages off-farm work. Consideration should be given to developing the human capital of households, which will help secure these off-farm jobs. In addition, the modernization of agriculture should increase income levels and thus stability. Thus, a transformation of traditional economies is necessary to face the problems of energy affordability at housels level. From all this, it will be appropriate to promote clean fuels by considering the socio-demographic factors and the location of the target audience.

In order to achieve Goal 7 of the SDGs, it will be appropriate for governments to focus on employment opportunities and use ICTs as a tool for promoting clean energy. Indeed, ICTs would help to raise awareness among households of the need to use modern energies, by showing them the disadvantages of traditional energies (biomass, charcoal...) on health and climate change.

For future research, we'll be broadening our panel to include developing countries, and focusing on the income level of each country. We'll be looking at low income, low and middle income, upper middle income and high income.

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Declaration of competing interest

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Data availability

Data will be made available on request.

Declaration of competing interest

There is no conflict interest

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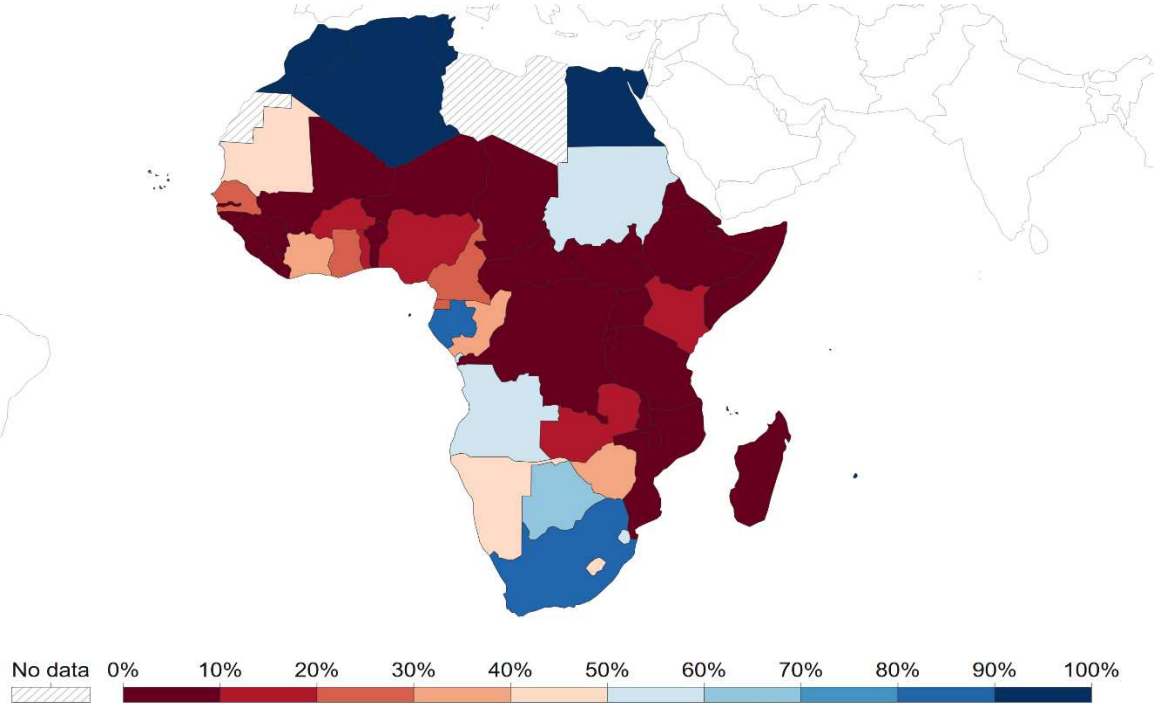
Appendix

Appendix 1: Evolution of proportion in agriculture and industry employment



Source: Authors construction

Appendix 2: Share of the population with access to clean fuels for cooking in Africa, 2020



Source: WHO, Global Health Observatory (2022)

Appendix 3: Description of variables

Variables	Description	Sources
acft	Access to clean fuels and technologies for cooking (% of population)	World Bank
eind	Employment in industry (% of total employment) (modeled ILO estimate)	World Bank
eagri	Employment in agriculture (% of total employment) (modeled ILO estimate)	World Bank
gdppc	GDP per capita (constant 2010 US$)	World Bank
remit	Personal remittances, received (% of GDP)	World Bank
private	Domestic credit to private sector (% of GDP)	World Bank
totalrents	Total natural resources rent (% of GDP)	World Bank
urb	Urban population (% of total population)	World Bank

Source: Authors'

Appendix 4: Correlation matrix

	acft	eagri	gdppc	remit	private	internet	totalrents	urb
acft	1.0000							
eagri	-0.7241	1.0000						
gdppc	0.8948	-0.6884	1.0000					
remit	-0.0379	-0.1115	-0.1781	1.0000				
private	0.6326	-0.6067	0.5115	-0.0818	1.0000			
internet	0.6036	-0.5326	0.5958	-0.0155	0.4227	1.0000		
totalrents	-0.1437	0.1913	-0.0659	-0.1399	-0.1802	-0.2597	1.0000	
urb	0.5328	-0.7236	0.5885	-0.0725	0.2888	0.3936	0.1041	1.0000

Source: Authors'

Appendix 5: List of countries sample

Angola	Cote d'ivoire	Madagascar	Senegal
Benin	Ethiopia	Malawi	Seychelles
Botswana	Gabon	Mali	Sierra Leone
Burkina Faso	Gambia	Mauritius	South Africa
Burundi	Ghana	Mozambique	Sudan
Cabo verde	Guinea	Namibia	Tanzania
Cameroon	Guinea-Bissau	Niger	Togo
Comoros	Kenya	Nigeria	Uganda
Congo Dem Rep	Lesotho	Rwanda	Zambia
Congo Rep	Liberia	Sao Tome and Principe	Zimbabwe

Source: Authors'