The Impact of Conflict on energy poverty: Evidence from Sub-Saharan Africa

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Abstract

This study uses the actual number of fatalities and influx of refugees as proxies for conflict to empirically investigate the impact of violent events on energy poverty in SSA over 30 years from 1990 to 2019. We use different proxies for energy poverty, including electricity consumption and electricity production in kWh and electricity access rate in percentage, thus covering both the demand and supply side of the spectrum. The data on the different electrification indices were obtained from the World Bank and the United Nations Statistics Division, while the conflict casualties were from the Armed Conflict Location Event Data. To ensure the robustness of our analysis, we applied different econometric techniques comprising fixed effects, Generalised Method of Moments (GMM) and quantile regression estimations to investigate the relationship between conflict fatalities and electricity poverty. All the different panel data models consistently show conflict fatalities to have a detrimental effect on electricity consumption, production, and access rates. The fixed effects quantile regression analysis also reveals a disparate impact of conflict fatalities on electricity consumption and production depending on a given country's energy poverty level. There is a progressive increase in the coefficients as energy poverty levels reduce, indicating that countries making appreciable progress in addressing electricity poverty are more at risk of faltering if conflict breaks out. However, replacing fatalities with the number of refugees in a host country as the proxy for conflict results in higher electricity access rates.

Keywords: Energy Poverty, Political Conflict, Sub-Sharan Africa, Quantitative analysis, electricity access, refugees

1. Introduction

The United Nations estimates that over 750 million people lacked access to modern electricity services in 2019, with Sub-Saharan Africa (SSA) accounting for three-quarters of the number (United Nations, 2020). In some seriously affected countries, such as South Sudan and Chad, citizens without electricity access as of 2019 were as high as 93% and 91%, respectively (World Bank, 2021a). Data from the World Bank's world development indicators for 2019 show sub-Saharan Africa's average electricity access rate of 47% to be the lowest globally. The whole of sub–Saharan Africa's per capita electricity consumption of 732.39 Terawatt-hours (TWh) is startlingly five times less than Europe's per capita consumption of 3837.89 Terawatt-hours (TWh). The stark shortage of electricity access in SSA can significantly impede the region's economic development.

Similarly, another major issue hindering the development of SSA is the prevalence of violent conflict in the region, especially in the last decade, as shown in Figure 1. Various insecurities have afflicted the African continent, including inter-state wars, civil wars, guerrilla wars, violent coup d'états, ethnic wars, religious crises, piracy, and terrorism. Furthermore, Africa accounts for about half of the World Bank's list of countries facing fragility and conflict concerns (World Bank, 2021b). Surprisingly, despite the simultaneous pervasiveness of violent conflict and energy poverty in SSA, as evident in Figures 1 and 2, there is insufficient empirical insight on the conflict-electrification nexus.

[Figure.1 is here]

Therefore, this study fills this gap by investigating the relationship between violent conflict and energy poverty. We empirically examine the conflict-energy poverty nexus by using fatalities as a proxy for conflict and electricity demand, production and access rates as different proxies for energy poverty. Furthermore, given that nearly one-third of the global refugee population resides in Africa (UNHCR, 2022), the study also uses refugees[1] as another proxy for conflict. Thus, the study tests whether the influx of refugees will worsen the electricity access gap given the already inadequate electricity infrastructure in the host SSA

[1] People fleeing their countries of residence to escape violent conflict or persecution

countries. In summary, this study answers two key questions; a) Does an increase in fatalities result in lower electricity demand and production in SSA? b) Does increasing the number of refugees in a country lower the electricity access rate?

The study contributes to the existing literature in three folds. First, unlike previous studies that focus on the effects of perceptions of instability or the risk of violence on electricity poverty, rather than actual conflict, this research focuses on the impact of actual fatalities on electricity poverty. Ahlborg et al. (2015, p. 132) have suggested that future studies also examine *"actual outbreaks of conflict besides perceptions of the risk for such outbreaks"*. Nevertheless, the literature has been thin on the armed conflict and electricity poverty nexus, hence the need for this research. To the best of our knowledge, no previous study investigated the specific influence of violent conflict measured by the level of fatalities on electricity poverty in SSA. Second, the study fills the gap in the empirical studies on political instability and electrification by comprehensively including all three leading indices that determine electricity poverty: electricity consumption, production, and access. Third, apart from fatalities, the study is also novel in examining the effects of refugees on electricity access. To the best of our knowledge, no earlier research examined the effect of the influx of refugees on electricity poverty in SSA.

The rest of the paper is organised as follows. Section 2 reviews the related literature, while section 3 presents the methodology and model specifications. The description of the data and variables follows in section 4, while section 5 analyses the data. Section 6 presents the empirical results and discussion. Finally, section 7 summarises the key conclusions and policy recommendations.

2. Review of existing literature

Some empirical studies on the conflict-electrification nexus (Araya et al., 2013; Ahlborg et al., 2015; Dagnachew et al., 2017; Bøe et al., 2018; Patankar et al., 2019) use a broad definition of energy poverty and conflict. Most of the papers view energy poverty based on the lack of access to modern energy services measured by electricity access on the one hand and affordability of households to adequate cooking and heating on the other. However, there is divergence in the definition of energy poverty depending on whether electricity access is more pressing in a region than the affordability of households to adequate cooking and heating services. While studies focusing on the developing world define energy poverty as a lack of access to electricity (Ahlborg et al., 2015; Morris, 2017; Patankar et al., 2019), others that focus on the developed world define it as households' inability to afford adequate energy for warmth, lighting, cooking and use of appliances (Sokołowski et al., 2020).

Likewise, there is a lack of consensus on the definition of conflicts as it incorporates both violent and non-violent types of conflicts. For instance, Halkia et al. (2020) describe conflict or country risk to include several political, security, social, economic and geographical factors. These risk factors may lead to non-violent and possibly violent conflicts. The level of democracy in a given country, including the strength of opposition politicians and their ability to upturn particular policies, is an example of a political risk factor that negatively impacts infrastructure investments (Ahlborg et al., 2015). Furthermore, Halkia et al. (2020) explain the social factor dimension of conflict to comprise corruption, transnational ethnic affiliations and homicide rate, while geographical factors refer to population size and demographic composition within a country. Defining conflict or country risk broadly without delving into its specific components can downplay the impact of armed conflicts considering its direct disruptive effect on individuals, families and societies. For instance, a country with a high level of social issues such as corruption could have a high-risk rating even if it is free of violent conflict. It is thus essential to analyse the influence of violent conflict on investment in the electricity sector separately.

The few empirical studies that specifically examined the impact of armed conflict on energy production were contradictory. Sequeira and Santos (2018) found a negative correlation between country risk, particularly guerilla warfare, and electricity generation, though the negative relationship is most notable for oil & gas producing countries. While Araya et al. (2013) confirm the negative influence of country risk on electricity infrastructure investments, it contrasts with a 2009 – 2013 survey by the Multilateral Investment Guarantee Agency (MIGA) of the World Bank. The survey found political and regulatory risk rather than terrorism and war to be the main reason for investment apathy in developing countries (MIGA, 2013). The findings from the survey further support the empirical investigation by Toft et al. (2010), which found no correlation between terrorist groups' orientation and their propensity to attack energy infrastructure, except for conflict-affected states.

Nevertheless, there are several reasons for the targeting of electricity infrastructure by terrorists. According to Sullivan (2014), the first reason is their desire for publicity and attention by causing maximum fatalities and economic devastation. Secondly, electricity infrastructure, particularly transmission towers, is an easy target as they pass through sparsely populated areas. Even though attacks against transmission towers are low impact and easily rectifiable in the developed world, the issue is more challenging for developing countries due to insufficient technical and financial capacity to effect necessary repairs. Furthermore, the ability to rectify damaged infrastructure depends on the severity of the security situation and the extent of the damage, given the cost implication and shortage of skilled workforce in conflict-affected countries.

Existing literature appears to ascribe the relatively higher cost of electrification in SSA to the region's higher country-risk rating and the consequent risk premium demanded by investors (Labordena et al., 2017). However, in-depth analysis may ascribe part of the higher operational cost to the increased cost of security arising from the need to respond to conflict (Korkovelos et al., 2020). Therefore, policies that minimise conflict can enhance accessibility and affordability and increase per capita electricity consumption in the region. Another problem militating against international private sector capital deployment is the risk arising from currency exchange fluctuations, which is even more critical in countries undergoing severe conflict. Therefore, it will be insightful to study the role of hedging instruments and their effectiveness in mitigating exchange rate risk under conflict situations in SSA.

The electricity access challenges in SSA, especially under fragility and violent conflict situations, have been described as a 'conflict trap' (Morris, 2017). The 'conflict trap' is a vicious cycle where fragility and conflict reduce household incomes, leading to suppressed energy prices and lower capital mobilisation for energy investments. As a result, a lower return on investment leads to fewer investments and an infrastructure deficit that fuels conflict. The conclusions of Mohamed et al. (2019) on the existence of bidirectional causality between terrorism and renewable energy consumption further support the presence of a conflict trap. Nevertheless, since the study was limited to France — a country relatively free from fragility and conflict concerns — the results may not be generalisable to conflict-affected situations. Therefore, empirical research is necessary to test the 'conflict trap' hypothesis in a more appropriate setting, such as SSA, where conflict and energy poverty are prevalent. Such a study will provide valuable insight and proffer policy advice necessary to break the cycle and attain the United Nations' sustainable development goal of universal access to clean energy.

3. Methodology and the model

This study uses panel data of all 48 SSA countries over 30 years (1990-2019). Panel data regression also called pooled, or longitudinal data modelling, enables the statistical analysis of several subjects or entities over time. It combines the features of time series and cross-section analyses and thus provides more information, more degrees of freedom, less collinearity between regressors and more robustness (Gujarati and Porter, 2009). In addition, the technique considers the heterogeneity among sample entities.

This empirical work starts with estimating Fixed effects and random effect models to control the issue of heterogeneity. Then, applies the GMM approach to overcome the problem of endogeneity.

Even though the fixed and random effect regressions models are efficient estimators, they both depend on the normality assumption, which requires normal data distribution. Unfortunately, it is rare to guarantee normal data distribution. Fortunately, applying quantile regression estimates pioneered by Koenker and Bassett Jr (1978) will address this problem since the technique generates different effects along the output variable’s quantiles or distributions. Thus, it provides a more comprehensive understanding of the relationship between the regressors and the dependent variable at various points of its distribution (Konstantopoulos et al., 2019). Also, the technique which helps control heterogeneity and endogeneity problems in panel data modelling produces robust estimates even with heavily tailed distributions and the presence of outliers (Li et al., 2021). Given SSA’s heterogeneous population, conflict and income levels, the quantile regression technique will be helpful in comprehensively explaining the relationship between conflict and electrification. Moreover, the Breushe-Pagan test for heteroskedasticity rejected the null hypothesis and confirmed our data to be heteroscedastic, further justifying the need for quantile regression.

Consequently, this study further tests the hypotheses in this paper using the fixed effect quantile regression technique (FEQR) which was developed by Canay (2011) It is the appropriate technique for our question for two main reasons. First, it uses a fixed effect and therefore captures the unobserved heterogeneities among the provinces and the sectors. Second, it uses a two-stage regression, which mitigates endogeneity. The quantile regression technique was introduced in the seminal paper by Koenker and Bassett (1978). The conditional quantile model presented by Canay (2011) can be summarized as follows:

$$Y_{it} = X_{it}^{'}\beta(\tau) + \alpha_{i\tau} + \varepsilon_{it\tau}, \tag{1}$$

where

$$\varepsilon_{it\tau} = X_{it}^{'}\big(\beta(U_{it}) - \beta(\tau)\big) \text{ and} \tag{2}$$

$$\varepsilon_{it\tau} = X_{it}^{'}\big(\beta(U_{it}) - \beta(\tau)\big). \tag{3}$$

Then,

$$Y_{it} = X_{it}^{'}\beta(U_{it}) + \alpha_{i}, \tag{4}$$

where Y_{it} is an observable explained variable, $X_{it}^{'}$is a vector of explanatory variables for country *i* at time *t*; *t* = 1 …, T; *i*= 1, …, n, the vector $X_{it}^{'}$is supposed to contain a constant term, (U_{it}, α_i) are unobservable, and $U_{it} \sim U[0,1]$. β is an unknown parameter; the function $\tau \mapsto X^{'}\beta(\tau)$ is assumed to be strictly increasing in $\tau \in (0.1)$ and the parameter of interest is presumed to be β (τ).

The model is formulated as follows;

$$Lec_{it} = \beta_1 Lec_{i,t-1} + \beta_2 Lec_{i,t-2} + \beta_3 Lf_{it} + \beta_4 X_{it} + \varepsilon_{it} \tag{5}$$

$$Lep_{it} = \alpha_1 Lep_{i,t-1} + \alpha_2 Lep_{i,t-2} + \alpha_3 Lf_{it} + \alpha_4 X_{it} + \varepsilon_{it} \tag{6}$$

In the two models above, *Lec* and *Lep* are the dependent variables representing logarithmic values of electricity consumption and electricity production, respectively. On the other hand $(Lec_{i,t-1},\ Lec_{i,t-2})$ and $(Lep_{i,t-1},\ Lep_{i,t-2})$ represent the lagged values of electricity consumption and electricity production of country *i* at time *t-1 and t-2*. Lf_{it} is the logarithmic value of conflict fatalities while X_{it} denotes the vector of the other explanatory variables.

4. Sample and Data

The study uses Stata 17.0 statistical software to run the various models. The dependent variable is the rate of electrification in each country. While Bøe et al. (2018) studied the impact of government stability on investment in the oil and gas industry, Sequeira and Santos (2018) used electricity production for each country as the dependent variable. Even though Sequeira and Santos (2018) investigation was on the electricity sector, focusing on electricity production alone fails to consider the severity of the lack or inadequacy of electricity supply in the world's most energy-deprived and conflict-prone region. Therefore, it will be more insightful to focus on the demand side as well by examining the relationship between conflict and electricity consumption or access. Accordingly, this paper investigates the impact of conflict on three different indices – electricity consumption, electricity production and electricity access rates.

Data on the level of fatalities arising from conflict events in each SSA country for each year was sourced from the Armed Conflict Location Event Database (ACLED). The ACLED (2019) defines violent conflict events to include battles, explosions, violence against civilians, riots and protests resulting in reported fatalities. The disputing sides in a conflict may be different countries or a given country and non-state actors or simply disputes between opposing non-state actors. Additionally, this research examines the relationship between the number of refugees in a host country and the level of electrification. The data source on the number of refugees for each SSA country was the UNHCR through the United Nations Statistics Division (UNSD).

Each SSA country's gross electricity production data was sourced from the United Nations Statistics Division (UNSD). The UNSD (2021) defines gross electricity production as the total electrical energy produced by all power generating plants as measured at the main generators' output terminals. The data on electricity access and electricity consumption per capita were obtained from the World Bank's world development indicators. While electricity access data is in percentages, electricity consumption per capita is in kilowatt-hours (kWh). The World Bank's world development indicators and the world governance indicators were the sources of the other control variables. Apart from electricity production and electricity consumption, we consider a third dependent variable, the electricity access rate, which measures the percentage of a country's population having access to electricity. In addition, data on battle-related deaths was obtained from world development indicators and used as a different proxy for conflict under a separate model to confirm the robustness of the first model.

Several studies have confirmed the linkage between GDP and infrastructure investments (Ahlborg et al., 2015; Moszoro et al., 2015; Sequeira and Santos, 2018; Mohamed et al., 2019; Halkia et al., 2020). The size of an economy may indicate the existence of high returns to investors and showcase its attractiveness. Therefore, GDP at current US dollars is one of the control variables considered in this paper, which will provide insights into the nature of the relationship between a country's income level and its level of electrification. Similarly, the level of trade openness can affect the decision of investors to invest in SSA electrification programmes. An increase in trade liberalisation will enhance investment, thus leading to higher access to electricity (Araya et al., 2013; Ahlborg et al., 2015; Sequeira and Santos, 2018). Gregory and Sovacool (2019) underscored the need to consider exchange rates in examining infrastructure investments in SSA. Also, Busse and Hefeker (2007) argue that exchange rate controls, especially in developing countries, may be linked to trade restrictions resulting in lower inflows of foreign direct investments (FDI). Accordingly, the exchange rate forms part of the control variables in this study.

Oil rents as a percentage of GDP is another control variable considered in line with the literature (Ahlborg et al., 2015; Okafor, 2017; Halkia et al., 2020). Even though studies have found a positive relationship between natural resource endowments and development, it can be a catalyst for armed conflict and instability, resulting in investment apathy. Therefore, given the abundance of natural resources, including oil and gas deposits in some SSA countries, it is apt to include oil rents as a control variable. The critical question here is whether investments will continue to flow into conflict-prone countries because of the high return potential in resource-rich nations. For instance, studies show oil exploration and production companies pursuing high-risk, high-reward projects (Bøe et al., 2018).

Corruption is one of the standard indices that measure the quality of a country's institutions. The expectation is that the higher the level of corruption in a country, the lower the level of private capital attracted due to investors' wariness to uncertainties arising from corrupt practices. For instance, some studies such as Araya et al. (2013), Morris (2017), Bøe et al. (2018), Gregory and Sovacool (2019) found a negative correlation between corruption and infrastructure investments. Similarly, the regulatory rating, property rights, the rule of law and governance ratings affect investors' perception of risk within a country and their decision to invest. Including regulatory rating as a control variable aligns with Gregory and Sovacool's (2019) suggestion on the negative impact of uncommercial electricity tariff regulation on private investment capital. The inclusion of corruption and regulatory ratings is also evident in the literature (Ahlborg et al., 2015; Moszoro et al., 2015; Bøe et al., 2018). Consequently, corruption and regulatory ratings also form part of the model in this paper. The world bank's regulatory quality rating estimates a government's capacity to execute regulations that enhance private participation in the economy, with -2.5 being the lowest rating and +2.5 the highest. Similarly, the world bank's control of corruption indicator estimates the perceived level of corruption in a given country, and it ranges from -2.5 (lowest rating) to +2.5 (highest rating).

Finally, in line with Gregory and Sovacool's (2019) suggestions for the inclusion of factors that ensure efficiently operating technological systems, the electricity grid's level of transmission and distribution losses are included as a proxy. The expectation is that fragile grids with high transmission and distribution losses will constrain optimal energy evacuation, resulting in lower returns on investment and thus investor apathy. A summary of all the variables is in Table 1.

[Table.1 is here]

The descriptive statistics in Table2 shows electricity production ranging from a minimum of just 15 TWh to 263,447 TWh, indicating significant heterogeneity among the countries in the sample. Similarly, huge disparities exist among countries regarding electricity consumption and electricity access. The minimum electricity access is less than 1%, while the maximum is 100%, with a standard deviation of 25.88. The fatalities also differ significantly, with the minimum being nil and the maximum being 72,811 casualties. Similarly, huge disparities exist in income levels measured by GDP per capita, trade openness and exchange rates. The summary data shows the average value of most variables to be positive. The standard deviation of the corruption rating has the lowest variation, followed by the regulatory rating.

[Table.2 is here]

The correlation matrix in Table 3 shows that apart from a few cases, the correlation between most of the variables is below 50%, indicating the likely absence of severe multicollinearity among regressors.

[Table.3 is here]

5. Empirical Results

This section discusses the empirical findings on the effect of conflict fatalities on SSA's electricity consumption and production. The paper employs several panel data econometric methods starting with fixed and random effects models. The study then applies the GMM estimation and quantile regression techniques to investigate the relationship between the regressors and the dependent variable.

5.1. Core results

5.1.1. Conflict fatalities-electricity consumptions nexus (demand side)

Table 4 shows the regression results of the fixed effects and the random-effects model with the log of electricity consumption per capita as the dependent variable. The signs of the estimated parameters of the two models are the same even though they differ in the degree of significance. Nevertheless, the two models' results show that the number of fatalities arising from conflict negatively impacts the level of electricity demand; a 1% increase in fatalities leads to about a 0.011% - 0.015% decrease in electricity consumption. This negative effect could be due to damages to the electricity network and the dearth of investment capital and expertise necessary for repairing damaged infrastructure. In the literature, this result aligns with the study of Araya et al. (2013), who find an inverse relationship between country risk and foreign investment in infrastructure. Likewise, it agrees with the study of Sequeira and Santos (2018) that conflict negatively influences electricity production. Therefore, policymakers, particularly in conflict-prone countries, have to note that as fatalities increase, the electricity consumption of citizens reduces.

[Table.4 is here]

Table 4 also shows that GDP per capita positively and significantly impacts electricity access, which is in tandem with the literature (Araya et al., 2013; Ahlborg et al., 2015; Moszoro et al., 2015; Sequeira and Santos, 2018). The estimates of the two models are almost equivalent by rounding off. Statistically, a one per cent rise in the GDP per capita brings about a 0.35% - 0.36% increase in access to electricity on average. This result is intuitive and aligns with the literature. Further, this result provides an empirical explanation on the relatively high electricity access rate in the countries that experience high levels of violent conflicts, such as Nigeria and Angola, as earlier depicted in Figure 5. It is thus crucial for conflicted affected countries to institute policies that will ensure sustainable growth of the economy.

An increasing degree of economic liberalisation could create an opportunity for national development. Both models confirm a positive association between trade per GDP rate and electricity consumption which aligns with previous studies (Talat and Zeshan, 2013; Moszoro et al., 2015). With rounding to three decimal places, a unit increase in the trade per GDP rate brings about a 0.003% increase in electricity access under both the FE and RE models.

Also, in line with the literature on the resource curse hypothesis, we find evidence of a negative correlation between oil rents and electricity consumption under both the fixed effects and random effects models. On average, a unit rise in the oil rents brings about a 0.007% - 0.008% unit decrease in electricity consumption per kWh. A key finding from the random effects model at the 10% significance level is that an inverse impact of exchange rate on electricity consumption. This small negative impact could be due to uncertainties around the repatriation of earnings by foreign investors. As the exchange rate increases, investors' ability to repatriate profits will likely be impaired, thus limiting foreign investment.

Expectedly, the fixed effects model at a 5% significance level shows a negative impact of electricity losses on electricity consumption. This result reveals investors' concerns about the effect of losses on the bottom line. Sometimes, electricity regulators adjust tariffs to reflect the estimated impact of electricity losses; however, this practice appears ineffective since investors remain wary of customer resistance to tariff increases. Furthermore, many electricity regulators in SSA face capacity and independence constraints, thus exacerbating uncertainties. Finally, there is no evidence from the two models that regulatory and corruption ratings significantly affect electricity consumption.

Even though the findings of the fixed effects and random effects models are similar, a Hausman specification test was applied to determine the most suitable model. As a result, the fixed effects model was preferable over the random effects model, given the very low p-value of 0.0002. So far, there is no discussion on the issue of endogeneity. Although the FE model controls for the problem of heterogeneity between the panels (countries), it does not account for the issue of omitted variables and the two-way causality between the variables, which might lead to misleading results. Therefore, we will apply the GMM approach to overcome this problem.

Results from the GMM estimation in Table 4 further confirm that a 1% significance level and approximately the same level of elasticity that conflict fatalities are detrimental to electricity consumption. Specifically, a 1% increase in fatalities results in a 0.01% decrease in electricity consumption. The drop in electricity consumption resulting from conflict could be partly due to the displacement of people and the resultant decline in economic activities. On the other hand, it could also be attributable to damages to the electricity grid and the dearth of new infrastructure due to investor apathy. Whichever is the case, if conflict festers, it could lead to a vicious circle of underdevelopment. Therefore, policymakers must address the underlying causes of conflict when planning electrification programmes.

Similarly, the GMM estimation results at a 1% significance level but at a lower coefficient confirm the findings of the fixed effects and random effects models on the positive impact of GDP per capita on electricity consumption. Likewise, the GMM estimation also corroborates at a 1% significance level that an increase in currency exchange rates results in lower electricity consumption which agrees with earlier studies (Talat and Zeshan, 2013; Shumetie and Watabaji, 2019). The fall in electricity consumption may be attributable to the shortage of industries and consumers' inability to afford appliances that are usually foreign-made. Therefore, it is incumbent on policymakers to adequately manage exchange rate volatility and enable policies that promote local manufacturing and backward integration.

The FE and GMM results depend on the fundamental OLS assumption, which is the normality. This study applies the Canay (2011) two-step FEQR analysis for further robustness. The results of the FE panel quantile regression are presented in Table 5.

[Table.5 is here]

The FE quantile regression estimates in Table 5 shows the impact of conflict fatalities to be insignificant at the lower quantiles. On the other hand, from the median quantiles up to the 90th quantile, fatalities from conflict appear to hinder electricity consumption even at the 1% significance level, indicating that countries making substantial progress in addressing electricity poverty are more at risk of failing in their electrification programmes in the event of a conflict. It is also evident that there is a sizable rise in the coefficients in higher quantiles. Specifically, the coefficient of -0.0193 in the 80th quantile is at least twice the coefficients of the first four quantiles and the results of the FE and GMM models in Table 4.

There is a consistently positive association between GDP per capita and electricity consumption at the 1% significant level for all quantiles. However, the coefficient slope is reducing for countries in the higher quantiles.

A noteworthy finding is that the challenge of increasing exchange rates is more pronounced in the lower quantiles than the higher quantiles, possibly due to investors' perception of low-income and conflict-prone countries to be high-risk, low-return. Such a scenario makes it even more difficult for countries with low electricity consumption to exit the 'poverty trap'. Policymakers thus have to consider appropriate modular and scalable technologies such as microgrids and mini-grids using cheaper renewable energy sources.

5.1.2. Conflict fatalities-electricity production nexus (supply side)

The level of electricity production is an essential measure of a country's ability to meet the energy needs of its citizens. Table 6 presents the outcome of the FE, RE and GMM estimations, showing an inverse correlation between conflict fatalities and electricity production. This result corresponds with the findings under the conflict-electricity consumption nexus but with higher coefficients indicating heightened investor concerns regarding conflict uncertainties.

The results align with existing literature (Ahlborg et al., 2015; Moszoro et al., 2015; Sequeira and Santos, 2018; Mohamed et al., 2019; Halkia et al., 2020) in confirming the positive impact of GDP per capita on electricity production. Notably, the coefficient of 0.521% is much higher in comparison to the results of the FE estimation under the conflict-electricity consumption nexus.

A noticeable difference between the results of the FE estimations under the supply-side and the demand-side models is that there is a statistically significant negative impact of exchange rate increases on electricity production but not on electricity consumption. The different sensitivities of production and consumption could be attributable to foreign investors' averseness to currency conversion risks which is vital since large-scale electricity infrastructure investments often require foreign capital. Similarly, the production side is sensitive to increases in electricity losses, whereas there is no statistically significant association between electricity losses and consumption. These findings confirm Gregory and Sovacool's (2019) identification of exchange rate convertibility and efficiently functioning electricity grid among structural factors influencing new electricity infrastructure investments in SSA. Therefore, countries need to institute policies that ensure stable currency exchange systems and grid stability.

Like the demand-side analysis, the Hausman test with a p-value of almost zero rejects the null hypothesis that the RE model is more suitable to the FE model.

[Table.6 is here]

A striking similarity in the signs and the slopes of the coefficients is noticeable between the GMM estimation results in Table 6 and the earlier one in Table 4. Additionally, the results show the logs of fatalities and GDP per capita to have a negative and positive impact on electricity production, respectively.

Surprisingly, however, improvements in trade openness and corruption rating appear detrimental to electricity production at 90% and 95% confidence intervals. The inverse correlation between trade openness and electricity production contrasts with Moszoro et al. (2015). There are mixed positions in the literature regarding the impact of corruption on development. While Mengistu and School (2013) and Shumetie and Watabaji (2019) argue that corruption could be an enhancing or 'greasing' factor, Talat and Zeshan (2013) and Moszoro et al. (2015) assert it to have a detrimental or 'sanding' effect on development. The results in Table 6 aligns with the former group since a one-unit improvement in the corruption rating results in a 0.118 unit decrease in electricity production.

Looking at the fixed effects quantile regression estimates, the impact of conflict on electricity production in Table 7 confirms the outcomes of the earlier models. As conflict casualties increase, electricity production decreases significantly at the median to higher quantiles, where a progressive increase in the size of the coefficients is visible. For instance, the negative coefficient of 0.024% in the 95th quantile is more than twice that of the 20th quantile. This outcome signifies that electricity producers are more sensitive to conflict in countries with higher electricity production, which is intuitive given the more considerable investment risk at stake. The disparity of the impact in the distribution requires different policy responses among SSA countries. For instance, it is more suitable for countries with higher electricity production to institute privatisation and electricity market reforms to attract private investment, while smaller countries focus more on small-scale distributed electricity programmes.

The corruption perception rating findings differ from the GMM estimation results in Table 6. Corruption appears to have a 'sanding' effect as improvements in the corruption rating are associated with increased electricity production. The effects of the remaining variables are in line with the findings from the previous models.

[Table.7 is here]

5.1.3. Number of refugees-electricity access nexus

This section tests the hypothesis that the influx of refugees into host countries negatively impacts electricity access. The basis for this assumption lies in the fact that the influx of refugees, many of whom lack access to electricity services, could worsen the level of electricity access in a given SSA country. Therefore, the number of refugees in host countries replaces conflict fatalities as the primary explanatory variable to test this hypothesis.

The FE and RE models in Table 8 rejects the hypothesis of a negative correlation between refugees and electricity access. This result may be due to host countries not necessarily being in conflict and thus not adversely affected by investor apathy. The RE and FE models show that a 1% increase in refugees is associated with a 0.039% - 0.0488% increase in electricity access. The positive correlation may be due to the additional need to provide electricity services to refugees. Therefore, development agencies such as the UNHCR, World Bank, the UN and others have to intensify investment into countries harbouring large numbers of refugees.

The statistically significant results regarding the positive impact of GDP per capita and trade openness align with the literature and the models presented in previous sections of this paper. However, the oil rents variable is inversely correlated with electricity access, thus supporting the resource curse hypothesis in the literature.

The Hausman statistic lends credence to the FE models as the null of the RE model is rejected at the p-value of 0.0312.

[Table.8 is here]

Results of the FEQR model in Table 9 show a positive association between the number of refugees in host countries and electricity access. However, the results are only statistically significant in the 60th and 70th quantiles at the 10% significance level. On the contrary, GDP per capita and trade openness are consistently statistically significant in all quantiles with a positive impact on electricity access, as has been the case under all models.

The model also shows oil rents, regulatory rating and electricity losses to negatively impact electricity access in all quantiles, although the coefficients of the latter variable are near zero. On the other hand, the results for improvement in corruption rating show a positive correlation with electricity access, thus contrasting with the earlier findings under the GMM estimation in Table 6. The contrasting result could be due to the disparity in governance rating between the refugees' conflict-affected country of origin and the host country which may or may not have significant corruption.

[Table.9 is here]

5.2 Robustness check

After examining the effects of conflict on electricity consumption and production, this section concludes the analyses by testing the robustness of the results in the previous sections using electricity access as the dependent variable. Furthermore, section 6.2.2 uses a different data source for the main predictor variable. The World Bank data on battle-related deaths replaces the ACLED fatalities data as the primary explanatory variable to check the robustness of earlier models. The fixed and random effects estimations and the quantile regression technique will form the basis of the robustness check.

5.2.1 Conflict fatalities and electricity access nexus

Table 10 confirms the robustness of the results in the previous models. Conflict fatalities consistently impact electricity access negatively, as evident in all the earlier models under different outcome variables. For example, a 1% increase in conflict fatalities is associated with a 0.0128% decrease in electricity access under the FE model's 10% significance level. Similarly, the results regarding GDP per capita is consistent with the outcomes of all the previous models. The results indicate a 1% rise in GDP per capita, leading to a 0.431% to 0.437% increase in electricity access at the 1% significance level. Likewise, improvement in trade openness and corruption rating variables positively impact electricity access.

Surprisingly, insignificant under the previous models, the regulatory rating variable has an inverse relationship with electricity access at the 5% significance level under the FE and RE estimations in Table 10. A one-unit increase in the regulatory rating is associated with a 0.156 unit decrease in electricity access. This result is counter-intuitive since the expectation is that robust regulatory systems reduce uncertainties and give investors some comfort. This negative association may be attributable to the bureaucratic bottlenecks associated with nascent regulatory systems in SSA that deters private investment in infrastructure.

The Hausman test shows the RE model to be preferable over the FE model.

[Table.10 is here]

The results of the FEQR estimates in Table 11 generally agree with the previous models regarding the signs, coefficients, and significance levels. However, the FEQR estimates show the negative impact of conflict on electricity access to be more significant in the lower quantiles than the higher quantiles, which contrasts with the findings under the FEQR results in Table 9. The implication is that conflict disproportionately impacts countries with lower electricity access, confirming the poverty trap hypothesis discussed in the introductory chapter.

In line with most of the literature and our previous models, GDP per capita and trade openness have a consistently positive impact on electricity access for all quantiles. Similarly, improvement in the corruption rating in all quantiles has a statistically significant and positive impact on electricity access, which aligns with most of the existing literature and our earlier estimations in Tables 7, 9 and 10. On the other hand, the regulatory rating variable has a statistically significant and inverse association with electricity access in all quantiles, thus confirming our earlier estimations in Tables 7, 9 and 10. However, the lower quantiles have a higher impact as the coefficients in the first two quantiles are thrice that of the last two quantiles.

[Table.11 is here]

5.2.2. Battle-related deaths-electricity production nexus

Replacing the ACLED conflict fatalities data with the battle-related deaths data from the World Bank's world development indicators in the regression yields similar results with previous findings. The results of the FE and RE models in Table 12 show that, while battle-related deaths negatively influence electricity production, GDP per capita has a positive impact on electricity generation, which is consistent with our earlier models. The Hausman test with a p-value of 0.0126 confirms the FE model to be more suitable.

The quantile regression estimates in Table 13 further shows the effect of conflict to be more significant at the lower quantiles, indicating the need for a different policy response from countries with lower levels of electricity production and access. However, consistent with the findings in our previous models, the positive impact of GDP per capita on electrification is significant at the 99% confidence interval across all quantiles.

[Table.12 is here]

[Table.13 is here]

6. Conclusions and policy implications

The study examined the conflict–energy poverty nexus in SSA from 1990 to 2019 using an array of econometric techniques with different datasets and predictors. The outcome of the FE, RE, GMM and FEQR estimations are near identical for most of the variables. The analysis revealed consistent results signifying the detrimental impact of conflict fatalities on electricity consumption, production and access rates. Similarly, exchange rates and electricity losses were found to impact electricity poverty negatively. In contrast, all the estimations consistently show GDP per capita to have a statistically significant and positive impact on electricity consumption, production and access rates. However, there are mixed outcomes on the impact of regulatory and corruption ratings on electricity poverty in SSA. Most of the findings on the association between improvement in the corruption rating and the rate of electrification show the former having a positive impact on the latter. Contrastingly, the findings show an inverse relationship between regulatory rating and electrification though only a few results are within the 90% confidence interval.

The findings have important implications for SSA since our two main variables, conflict and electrification, are among the most pressing issues disproportionately affecting the region. First, SSA countries must minimise conflict; otherwise, attaining the UN's universal energy access goal will continue to derail. Second, even within the SSA, countries with extreme electricity deprivation are impacted differently by conflict, thus requiring a different approach to close the electricity access gap. Third, SSA countries need to ensure currency exchange stability and sustainable economic growth to attract private capital. Fourth, SSA countries, particularly those with higher income levels, can reduce electricity poverty by ensuring favourable regulatory institutions, minimising corruption and enabling electricity market reforms. Finally, given the negative impact of electricity losses on the rate of electrification, electricity regulators must ensure that tariffs are sufficient to cover electricity losses to minimise uncertainties and attract private capital.

Another key outcome is the positive correlation between the influx of refugees into a country and its level of electrification. This result may be attributable to the humanitarian support of the UNHCR and other non-governmental organisations in assisting refugees in host countries. The relative stability in host countries compared to active conflict environments in the refugees' countries of origin could also explain the positive refugee-electrification nexus. However, the likelihood of conflict spilling over neighbouring countries is ever-present (Halkia et al., 2020). Therefore, host countries must be concerned with the spread of the conflict. They must institute policies to ensure rapid infrastructure expansion using conflict resilient technologies. As was evident from the results of the FEQR models, countries with low electricity production and access rates should explore small-scale modular systems such as solar photovoltaics and distributed electricity systems.

SSA countries should enhance cooperation through existing regional power pools to avoid the disparate investment apathy facing lower-income or conflict-prone nations. Such collaboration is vital in eliminating electricity poverty and ensuring the timely attainment of the UN's universal energy access goal.

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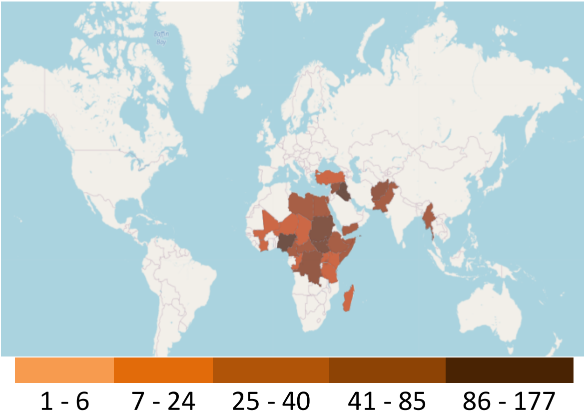
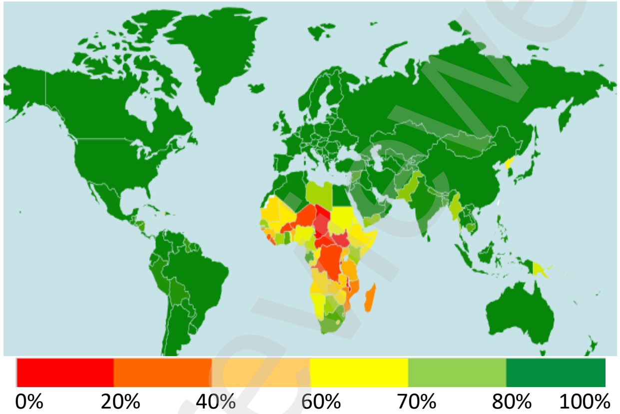
Figures

Figure 1: Conflict events with more than 100 fatalities between 2009 – 2019



Source: ACLED

Figure 2: Access to Electricity (% of the population) in 2019



Source: World Bank

Tables

Table 1: Summary of variables used

Variable	Description	Source
Electricity consumption (kWh pc.)	Dependent variable	World Bank WDI
Electricity production (TWh)	Dependent variable	UNSD
Electricity access (% of population)	Dependent variable	World Bank WDI
Refugees in the host country	Dependent variable	UNHCR – UNSD
Conflict fatalities	Independent variable	ACLED
Battle-related deaths	Independent variable	World Bank WDI
GDP per capita (current $)	Independent variable	World Bank WDI
Trade openness (% of GDP)	Independent variable	World Bank WDI
Oil rents (% of GDP)	Independent variable	World Bank WDI
Exchange rate	Independent variable	World Bank WDI
Electricity losses (TWh)	Independent variable	UNSD
Regulatory rating	Independent variable	World Bank WGI
Corruption rating	Independent variable	World Bank WGI

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Electricity consumption (kWh pc.)	590	5.394	1.297	3.078	8.487	World Bank
Electricity production (TWh)	1395	7577.348	33234.8	15	263447	UN
Electricity access (% of population)	1111	35.345	25.872	0.534	100	World Bank
Conflict fatalities	963	692.745	3547.877	0	72811	ACLED
GDP per capita (current $)	1407	1718.188	2708.008	102.598	22942.61	World Bank
Trade openness (% of GDP)	1265	66.817	33.674	0.785	225.023	World Bank
Oil rents (% of GDP)	1351	3.684	9.964	0	62.697	World Bank
Exchange rate	1092	586.633	1680.209	0	19068.42	World Bank
Electricity losses (TWh)	1351	837.964	2764.098	0	24468	UN
Regulatory rating	1044	-0.717	0.643	-2.645	1.127	World Bank
Corruption rating	1045	-0.641	0.644	-1.905	1.23	World Bank
Refugees in the host country	1079	91090.1	172061.8	1	1724365	UNHCR

Source: Author’s calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 3: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Electricity consumption	1											
(2) Electricity production	0.60	1										
(3) Electricity access	0.60	0.50	1									
(4) Conflict fatalities	-0.18	-0.03	-0.08	1								
(5) GDP per capita	0.70	0.45	0.70	-0.11	1							
(6) Trade openness	0.33	-0.16	0.14	-0.24	0.34	1						
(7) Oil rents	-0.03	-0.10	0.24	0.01	0.39	0.44	1					
(8) Exchange rate	-0.48	-0.24	-0.23	-0.02	-0.20	-0.23	-0.01	1				
(9) Electricity losses	0.58	0.98	0.51	0.00	0.45	-0.17	-0.09	-0.25	1			
(10) Regulatory rating	0.51	0.42	0.31	-0.26	0.41	0.06	-0.27	-0.11	0.40	1		
(11) Corruption rating	0.54	0.34	0.27	-0.31	0.37	0.16	-0.37	-0.29	0.31	0.71	1	
(12) Refugees in host country	-0.23	-0.07	-0.34	0.15	-0.23	-0.33	-0.16	0.26	-0.07	0.00	-0.20	1

Source: Author’s calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 4: FE/RE regression and GMM estimates (fatalities-electricity consumption nexus)

Log of Electricity consumption VARIABLES	(1) FE Electricity consumption	(2) RE Electricity consumption	(3) GMM Electricity consumption
Lagged 1-year - Log of Electricity consumption			0.622*** (0.12400)
Lagged 2 years - Log of Electricity consumption			0.227** (0.10700)
Log of Conflict fatalities	-0.0108* (0.00623)	-0.0145** (0.00623)	-0.0100** (0.00505)
Log of GDP per capita	0.352*** (0.06120)	0.361*** (0.06030)	0.0602* (0.03200)
Trade openness	0.00293* (0.00148)	0.00327** (0.00155)	-0.000102 (0.000589)
Oil rents	-0.00653*** (0.00178)	-0.00784*** (0.00175)	-0.000509 (0.001580)
Exchange rate	-0.0000625 (0.000097)	-0.000181* (0.000094)	-0.000126*** (0.000)
Electricity losses	-0.0000252** (0.000011)	-0.00000686 (0.000009)	-0.00000258 (0.000)
Regulatory rating	-0.0257 (0.101)	-0.00807 (0.098)	0.0594 (0.041)
Corruption rating	-0.064 (0.113)	0.00671 (0.129)	0.00651 (0.06020)
Constant	2.829*** (0.393)	2.877*** (0.525)	0.558*** (0.17500)
Observations	227	227	227
R-squared	0.537		
Hausman test (P-value)	0.0002		
Number of countries[2]	23	23	23

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

[2] The number of countries dropped from 48 SSA countries to 23 due to many missing values of one of the dependent variables. The missing values of the electricity consumption per capita variable are evident from its significantly lower number of observations in Table 2.

Table 5: Quantile regression estimates (fatalities-electricity consumption nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log Conflict fatalities	-0.0008 (0.0060)	-0.0086 (0.0053)	-0.0090* (0.0050)	-0.0107*** (0.0035)	-0.0154*** (0.0035)	-0.0180*** (0.0037)	-0.0163*** (0.0039)	-0.0193*** (0.0038)	-0.0158*** (0.0059)	-0.0026 (0.0054)
Log GDP per capita	0.3688*** (0.0209)	0.3562*** (0.0181)	0.3511*** (0.0166)	0.3460*** (0.0148)	0.3404*** (0.0134)	0.3307*** (0.0155)	0.3236*** (0.0139)	0.3252*** (0.0158)	0.2893*** (0.0142)	0.2946*** (0.0214)
Trade openness	-0.0000 (0.0000)	-0.0001* (0.0000)	-0.0000 (0.0000)	-0.0001** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)
Oil rents	0.0028*** (0.0005)	0.0035*** (0.0005)	0.0029*** (0.0005)	0.0027*** (0.0003)	0.0024*** (0.0003)	0.0018*** (0.0004)	0.0019*** (0.0004)	0.0019*** (0.0005)	0.0018** (0.0009)	0.0042*** (0.0011)
Exchange rate	-0.0076*** (0.0010)	-0.0095*** (0.0012)	-0.0085*** (0.0014)	-0.0068*** (0.0014)	-0.0064*** (0.0013)	-0.0048*** (0.0014)	-0.0045** (0.0020)	-0.0035 (0.0025)	0.0020 (0.0025)	0.0010 (0.0038)
Electricity losses	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
Regulatory rating	-0.0591** (0.0276)	-0.0351 (0.0270)	-0.0334 (0.0238)	-0.0279 (0.0193)	-0.0091 (0.0198)	-0.0052 (0.0198)	0.0106 (0.0139)	0.0230 (0.0254)	0.0022 (0.0399)	0.0898*** (0.0322)
Corruption rating	-0.0436 (0.0265)	-0.0766** (0.0321)	-0.0533* (0.0279)	-0.0591*** (0.0186)	-0.0630*** (0.0220)	-0.0626*** (0.0238)	-0.0648*** (0.0200)	-0.0722* (0.0382)	0.0312 (0.0362)	-0.0524** (0.0252)
Constant	2.5277*** (0.1639)	2.6613*** (0.1503)	2.7790*** (0.1357)	2.8598*** (0.1161)	2.9685*** (0.1080)	3.1155*** (0.1173)	3.1836*** (0.1070)	3.2198*** (0.1158)	3.5559*** (0.1029)	3.3569*** (0.1165)
Observations	227	227	227	227	227	227	227	227	227	227

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 6: FE/RE regression and GMM estimates (fatalities-electricity production nexus)

Log of Electricity production	(1)	(2)	(3)
VARIABLES	FE Electricity production	RE Electricity production	GMM Electricity production
Lagged 1-year - Log of Electricity production			0.631*** (0.03480)
Lagged 2 years - Log of Electricity production			0.256*** (0.03180)
Log of Conflict fatalities	-0.0149** (0.00673)	-0.0132** (0.00671)	-0.00964** (0.00475)
Log of GDP per capita	0.521*** (0.05710)	0.516*** (0.05700)	0.0703*** (0.01800)
Trade openness	-0.0000971* (0.00005)	-0.0000965* (0.00005)	-0.000039* (0.000021)
Oil rents	0.000376 (0.00142)	0.000122 (0.00143)	0.00035 (0.000654)
Exchange rate	-0.00957*** (0.002400)	-0.00967*** (0.002460)	-0.000449 (0.002)
Electricity losses	-0.0000084 (0.000016)	0.0000027 (0.000018)	0.0000025 (0.000)
Regulatory rating	-0.046 (0.078)	-0.0329 (0.077)	0.00615 (0.046)
Corruption rating	0.0983 (0.122)	0.0901 (0.121)	-0.118** (0.0480)
Constant	4.088*** (0.319)	3.885*** (0.490)	0.378** (0.1590)
Observations	380	380	378
R-squared	0.585		
Hausman test (P-value)	0.0002		
Number of countries[3]	38	38	37

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

[3] The number of countries dropped from 48 SSA countries to 38 due to many missing values of one of the independent variables. The missing values of the conflict fatalities variable are evident from its 963 observations, which is the second lowest as shown in the descriptive statistics in Table 2.

Table 7: Quantile regression estimates (fatalities-electricity production nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log of conflict fatalities	-0.0066 (0.0071)	-0.0097* (0.0052)	-0.0128*** (0.0042)	-0.0151*** (0.0047)	-0.0149*** (0.0054)	-0.0166*** (0.0049)	-0.0184*** (0.0045)	-0.0172*** (0.0057)	-0.0245*** (0.0079)	-0.0240*** (0.0053)
Log of GDP per capita	0.5000*** (0.0206)	0.5157*** (0.0169)	0.5074*** (0.0089)	0.5064*** (0.0135)	0.5033*** (0.0163)	0.5049*** (0.0152)	0.5061*** (0.0144)	0.4997*** (0.0181)	0.4968*** (0.0291)	0.4983*** (0.0198)
Exchange rate	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)
Trade	0.0019*** (0.0003)	0.0008* (0.0004)	0.0007** (0.0003)	0.0004 (0.0004)	0.0007 (0.0004)	0.0000 (0.0003)	0.0003 (0.0004)	-0.0001 (0.0004)	-0.0005 (0.0008)	-0.0003 (0.0008)
Oil rents	-0.0132*** (0.0022)	-0.0115*** (0.0012)	-0.0112*** (0.0008)	-0.0114*** (0.0010)	-0.0112*** (0.0015)	-0.0091*** (0.0014)	-0.0096*** (0.0014)	-0.0081*** (0.0023)	-0.0003 (0.0065)	0.0045 (0.0073)
Electricity losses	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000* (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
Regulatory rating	-0.0250 (0.0315)	-0.0697** (0.0286)	-0.0622*** (0.0222)	-0.0471** (0.0204)	-0.0368 (0.0262)	-0.0385* (0.0223)	-0.0345* (0.0177)	-0.0065 (0.0261)	-0.0342 (0.0373)	-0.0332*** (0.0123)
Corruption rating	0.0501 (0.0331)	0.0835*** (0.0296)	0.0953*** (0.0287)	0.0934*** (0.0258)	0.0845*** (0.0313)	0.0883*** (0.0233)	0.0751*** (0.0241)	0.0841** (0.0416)	0.1742*** (0.0615)	0.2201*** (0.0199)
Constant	3.8943*** (0.1579)	3.9348*** (0.1210)	4.0644*** (0.0685)	4.1504*** (0.0942)	4.1944*** (0.1160)	4.2754*** (0.1099)	4.2777*** (0.1084)	4.3993*** (0.1388)	4.5832*** (0.1983)	4.6521*** (0.1329)
Observations	380	380	380	380	380	380	380	380	380	380

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1 significance level
Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 7: Quantile regression estimates (fatalities-electricity production nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log of conflict fatalities	-0.0066 (0.0071)	-0.0097* (0.0052)	-0.0128*** (0.0042)	-0.0151*** (0.0047)	-0.0149*** (0.0054)	-0.0166*** (0.0049)	-0.0184*** (0.0045)	-0.0172*** (0.0057)	-0.0245*** (0.0079)	-0.0240*** (0.0053)
Log of GDP per capita	0.5000*** (0.0206)	0.5157*** (0.0169)	0.5074*** (0.0089)	0.5064*** (0.0135)	0.5033*** (0.0163)	0.5049*** (0.0152)	0.5061*** (0.0144)	0.4997*** (0.0181)	0.4968*** (0.0291)	0.4983*** (0.0198)
Exchange rate	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)	-0.0001*** (0.0000)
Trade	0.0019*** (0.0003)	0.0008* (0.0004)	0.0007** (0.0003)	0.0004 (0.0004)	0.0007 (0.0004)	0.0000 (0.0003)	0.0003 (0.0004)	-0.0001 (0.0004)	-0.0005 (0.0008)	-0.0003 (0.0008)
Oil rents	-0.0132*** (0.0022)	-0.0115*** (0.0012)	-0.0112*** (0.0008)	-0.0114*** (0.0010)	-0.0112*** (0.0015)	-0.0091*** (0.0014)	-0.0096*** (0.0014)	-0.0081*** (0.0023)	-0.0003 (0.0065)	0.0045 (0.0073)
Electricity losses	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000* (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
Regulatory rating	-0.0250 (0.0315)	-0.0697** (0.0286)	-0.0622*** (0.0222)	-0.0471** (0.0204)	-0.0368 (0.0262)	-0.0385* (0.0223)	-0.0345* (0.0177)	-0.0065 (0.0261)	-0.0342 (0.0373)	-0.0332*** (0.0123)
Corruption rating	0.0501 (0.0331)	0.0835*** (0.0296)	0.0953*** (0.0287)	0.0934*** (0.0258)	0.0845*** (0.0313)	0.0883*** (0.0233)	0.0751*** (0.0241)	0.0841** (0.0416)	0.1742*** (0.0615)	0.2201*** (0.0199)
Constant	3.8943*** (0.1579)	3.9348*** (0.1210)	4.0644*** (0.0685)	4.1504*** (0.0942)	4.1944*** (0.1160)	4.2754*** (0.1099)	4.2777*** (0.1084)	4.3993*** (0.1388)	4.5832*** (0.1983)	4.6521*** (0.1329)
Observations	380	380	380	380	380	380	380	380	380	380

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1 significance level
Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 8: FE/RE regression estimates (refugees-electricity access nexus)

Log of Electricity access	(1)	(2)
VARIABLES	FE Electricity access	RE Electricity access
Log of Conflict refugees	0.0488*	0.0391*
	(0.02420)	(0.02040)
Log of GDP per capita	0.479***	0.490***
	(0.06010)	(0.05930)
Trade openness	0.0000877	0.0000567
	(0.00005)	(0.00004)
Oil rents	0.00291*	0.00295*
	(0.00169)	(0.00161)
Exchange rate	-0.00706***	-0.00737***
	(0.002450)	(0.002680)
Electricity losses	-0.000015	-0.0000055
	(0.000016)	(0.000014)
Regulatory rating	-0.0922	-0.103
	(0.106)	(0.107)
Corruption rating	0.063	0.0711
	(0.1090)	(0.1010)
Constant	-0.7680	-0.7140
	(0.4810)	(0.4990)
Observations	463	463
R-squared	0.495	
Hausman test (P-value)	0.0312	
Number of countries	38	38

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 9: Quantile regression estimates (refugees-electricity access nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log of conflict refugees	0.0113 (0.0174)	0.0124 (0.0091)	0.0015 (0.0082)	-0.0017 (0.0069)	0.0024 (0.0034)	0.0041* (0.0024)	0.0069* (0.0038)	0.0078 (0.0080)	0.0106 (0.0073)	0.0115 (0.0097)
Log of GDP per capita	0.5176*** (0.0405)	0.4569*** (0.0204)	0.4427*** (0.0181)	0.4328*** (0.0167)	0.4143*** (0.0105)	0.4010*** (0.0066)	0.3959*** (0.0102)	0.3692*** (0.0198)	0.3238*** (0.0217)	0.3915*** (0.0341)
Exchange rate	0.0001 (0.0000)	0.0000*** (0.0000)	0.0000*** (0.0000)	0.0000*** (0.0000)	0.0000*** (0.0000)	0.0000*** (0.0000)	0.0000*** (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Trade	0.0041*** (0.0012)	0.0042*** (0.0006)	0.0039*** (0.0004)	0.0038*** (0.0005)	0.0043*** (0.0003)	0.0044*** (0.0002)	0.0042*** (0.0004)	0.0044*** (0.0007)	0.0043*** (0.0005)	0.0034*** (0.0007)
Oil rents	-0.0066** (0.0033)	-0.0051*** (0.0012)	-0.0052*** (0.0011)	-0.0053*** (0.0013)	-0.0047*** (0.0009)	-0.0042*** (0.0006)	-0.0041*** (0.0010)	-0.0031** (0.0014)	-0.0026** (0.0012)	-0.0048** (0.0019)
Electricity losses	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000*** (0.0000)
Regulatory rating	-0.3215*** (0.0937)	-0.2556*** (0.0222)	-0.1936*** (0.0205)	-0.1711*** (0.0159)	-0.1504*** (0.0126)	-0.1331*** (0.0124)	-0.1290*** (0.0173)	-0.1052*** (0.0301)	-0.0648** (0.0254)	-0.0886*** (0.0337)
Corruption rating	0.2262*** (0.0724)	0.2285*** (0.0304)	0.1900*** (0.0294)	0.1729*** (0.0248)	0.1819*** (0.0197)	0.1814*** (0.0176)	0.1793*** (0.0190)	0.1635*** (0.0388)	0.1790*** (0.0411)	0.1744*** (0.0450)
Constant	-0.9732*** (0.3525)	-0.4486** (0.2025)	-0.1375 (0.1662)	0.0188 (0.1485)	0.1177 (0.0806)	0.2267*** (0.0580)	0.2715*** (0.0867)	0.4724*** (0.1797)	0.8786*** (0.1719)	0.5234** (0.2568)
Observations	355	355	355	355	355	355	355	355	355	355

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1 significance level
Source: Author's calculations based on UN, World Bank and ACLED data using Stata

Table 10: FE/RE regression estimates (fatalities-electricity access nexus)

Log of Electricity access	(1)	(2)
VARIABLES	FE Electricity access	RE Electricity access
Log of Conflict fatalities	-0.0128*	-0.0119
	(0.00736)	(0.00726)
Log of GDP per capita	0.431***	0.437***
	(0.02820)	(0.02730)
Trade openness	0.0000259	0.0000148
	(0.00003)	(0.00003)
Oil rents	0.00375***	0.00343***
	(0.00092)	(0.00088)
Exchange rate	-0.00445	-0.00489
	(0.003190)	(0.003020)
Electricity losses	-0.0000168	-0.00000482
	(0.000014)	(0.000012)
Regulatory rating	-0.156**	-0.140**
	(0.065)	(0.062)
Corruption rating	0.158**	0.149**
	(0.0683)	(0.0656)
Constant	0.0650	0.0401
	(0.1890)	(0.2060)
Observations	367	367
R-squared	0.496	
Hausman test (P-value)		0.243
Number of countries	38	38

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 11: Quantile regression estimates (fatalities-electricity access nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log of conflict fatalities	-0.0231**	-0.0191***	-0.0219***	-0.0190***	-0.0119***	-0.0065	-0.0030	-0.0012	-0.0088	-0.0080
	(0.0102)	(0.0072)	(0.0053)	(0.0037)	(0.0035)	(0.0040)	(0.0051)	(0.0059)	(0.0063)	(0.0084)
Log of GDP per capita	0.4665***	0.4406***	0.4233***	0.4114***	0.4138***	0.4087***	0.3986***	0.3858***	0.3865***	0.3841***
	(0.0200)	(0.0225)	(0.0140)	(0.0120)	(0.0074)	(0.0122)	(0.0150)	(0.0185)	(0.0211)	(0.0256)
Exchange rate	0.0000	0.0000***	0.0000**	0.0000***	0.0000***	0.0000**	0.0000**	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Trade	0.0037***	0.0036***	0.0032***	0.0038***	0.0037***	0.0039***	0.0040***	0.0040***	0.0031***	0.0027***
	(0.0009)	(0.0006)	(0.0005)	(0.0004)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0007)
Oil rents	-0.0046***	-0.0040**	-0.0036***	-0.0045***	-0.0045***	-0.0044***	-0.0042***	-0.0041***	-0.0035***	-0.0036**
	(0.0017)	(0.0016)	(0.0009)	(0.0008)	(0.0006)	(0.0007)	(0.0011)	(0.0015)	(0.0011)	(0.0018)
Electricity losses	-0.0000**	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Regulatory rating	-0.2767***	-0.2248***	-0.1819***	-0.1565***	-0.1430***	-0.1313***	-0.1192***	-0.0853***	-0.0542*	-0.0786**
	(0.0606)	(0.0230)	(0.0313)	(0.0074)	(0.0075)	(0.0120)	(0.0156)	(0.0212)	(0.0309)	(0.0362)
Corruption rating	0.1928***	0.1815***	0.1542***	0.1295***	0.1434***	0.1413***	0.1530***	0.1157***	0.1358***	0.1629***
	(0.0505)	(0.0332)	(0.0281)	(0.0180)	(0.0150)	(0.0213)	(0.0240)	(0.0265)	(0.0423)	(0.0492)
Constant	-0.4006***	-0.1125	0.0990	0.1742**	0.1882***	0.2317***	0.3306***	0.4686***	0.6754***	0.7356***
	(0.1461)	(0.1633)	(0.1019)	(0.0831)	(0.0463)	(0.0840)	(0.1047)	(0.1330)	(0.1518)	(0.1747)
Observations	367	367	367	367	367	367	367	367	367	367

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1 significance level
Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 12: FE/RE regression estimates (battle deaths-electricity production nexus)

Log of Electricity production VARIABLES	(1) FE electricity production	(2) RE electricity production
Log of Battle-related deaths	-0.0275*** (0.00929)	-0.0252*** (0.00918)
Log of GDP per capita	0.430*** (0.06960)	0.439*** (0.06450)
Trade openness	0.000819 (0.00120)	0.000835 (0.00124)
Oil rents	-0.00557** (0.00247)	-0.00633*** (0.00230)
Exchange rate	0.0000297 (0.000153)	-0.0000193 (0.000157)
Electricity losses	0.000249*** (0.000037)	0.000373*** (0.000067)
Regulatory rating	-0.0763 (0.138)	-0.0277 (0.118)
Corruption rating	0.208 (0.1650)	0.152 (0.164)
Constant	4.373*** (0.5350)	4.287*** (0.672)
Observations	105	105
R-squared	0.662	
Hausman test (p-value)	0.0126	
Number of countries	23	23

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1 significance level

Source: Author's calculations based on UN, World Bank and ACLED data using Stata 17.0

Table 13: Quantile regression estimates (battle deaths-electricity access nexus)

VARIABLES	(1) 0.10	(2) 0.20	(3) 0.30	(4) 0.40	(5) 0.5	(6) 0.60	(7) 0.70	(8) 0.80	(9) 0.90	(10) 0.95
Log of battle deaths	-0.0781***	-0.0595**	-0.0520**	-0.0330	-0.0073	-0.0034	0.0096	-0.0058	-0.0246	-0.0354***
	(0.0214)	(0.0278)	(0.0201)	(0.0222)	(0.0178)	(0.0141)	(0.0133)	(0.0235)	(0.0222)	(0.0035)
Log of GDP per capita	0.2344***	0.2025**	0.2228***	0.2998***	0.2651***	0.3056***	0.3624***	0.3747***	0.4132***	0.3838***
	(0.0626)	(0.0965)	(0.0773)	(0.0761)	(0.0656)	(0.0498)	(0.0445)	(0.0704)	(0.0794)	(0.0352)
Trade	0.0003	0.0035	0.0024	0.0021	0.0017	0.0017	0.0024***	0.0026***	0.0011	0.0018***
	(0.0029)	(0.0022)	(0.0018)	(0.0014)	(0.0015)	(0.0011)	(0.0009)	(0.0008)	(0.0017)	(0.0003)
Oil rents	-0.0033	-0.0110*	-0.0064	-0.0053	-0.0056	-0.0076***	-0.0121***	-0.0091***	-0.0059*	-0.0111***
	(0.0087)	(0.0061)	(0.0052)	(0.0040)	(0.0037)	(0.0024)	(0.0022)	(0.0031)	(0.0035)	(0.0021)
Exchange rate	0.0002**	0.0002	0.0002	0.0001	0.0001	0.0000	0.0000	0.0002	0.0002*	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Electricity losses	0.0000	0.0001*	0.0002	0.0001	0.0002***	0.0002***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Regulatory rating	-0.3710***	-0.3824***	-0.3587***	-0.4066***	-0.2686***	-0.2919***	-0.2557***	-0.2440*	-0.5187***	-0.4099***
	(0.0974)	(0.1371)	(0.0970)	(0.0945)	(0.0948)	(0.0788)	(0.0606)	(0.1258)	(0.0977)	(0.0722)
Corruption rating	0.1110	0.1080	0.0541	0.0755	-0.0192	0.0065	-0.0427	0.0089	0.3381*	0.2444***
	(0.1418)	(0.0657)	(0.0972)	(0.0973)	(0.0575)	(0.0481)	(0.0708)	(0.1506)	(0.1747)	(0.0641)
Constant	5.6110***	5.5996***	5.5215***	5.0709***	5.3155***	5.0994***	4.7454***	4.7367***	4.8548***	5.1844***
	(0.4637)	(0.7133)	(0.5080)	(0.5294)	(0.4466)	(0.3663)	(0.3050)	(0.4894)	(0.4993)	(0.2640)
Observations	97	97	97	97	97	97	97	97	97	97

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1 significance level
Source: Author's calculation based on UN, World Bank and ACLED data using Stata 17.0