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Economic and Social Impact Evaluation of the Rural Electrification Projects in Nigeria – Evidence from Dakkiti and Mbela-Lagaje Communities

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ABSTRACT

This study evaluates the socioeconomic impact of the rural electrification projects in Dakkiti and Mbela-Lagaje rural communities in northeastern Nigeria. The aim of the study is to assess the effect of rural electrification projects on household income and household productivity engagements'. The study used the primary method approach to gather data using structured questionnaires. A 'simple random' method was used as the sampling method of choice and the method of spinning a bottle after each sampling unit was was also employed. The study adopts the difference-in-difference approach, while the "two-stage least square and difference-in-difference modelling approach was used for the inferential analysis. The results reveal that there is no significant improvement in household income due to the interventions of the electrification projects in the study area. However, the study culture of residents connected to electricity had a significant increase of 11 per cent and a 5.3 per cent improvement in occupational diversity. This study recommends that the Rural Electrification Agency of Nigeria increase the generating capacity of the existing solar mini-grid station in Dakkiti and Mbela-Lagaje rural communities,and extend the solar mini-grid project to the unserved communities of Jauro-Manu and Wadayi.

Keywords: Rural Electrification, Impact, Socio-economic, Household, Income, Electricity.

I. BACKGROUND

Electricity is a commodity. It is botha consumption item and a capital good. Asa short-term concept, the flow of service provides utility to households, helping improvelabour productivity. Electricity comes in another form as a long-run concept, an input in the production and reproduction processes facilitating machines and equipment with a lifespan spread across several cycles. Access to electricity and its socio-economic impact in rural areas is no more a debate in the field of energy and development economics but rather a position strongly held by scholars. But to what extent have access energy in rural areas impacted the growth of economies around the world is the scientific question that policymakers at all levels want to know. Literature has shown that there has been an increasing interest by local and international organizations to measure the effects of rural electrification on economic development through impact evaluation, especially in less-developed countries.

Energy, particularly in form of electricity has been considered a socio-economic driver in various facets of human endeavors such as health, education, household, and agriculture etc. Many less-developed countries have in recent years paid attention to increasing electricity access to rural communities by setting up policies and programs germane to achieving the objectives of Sustainable Development Goals (SDG). In recognition of this, the Nigerian government re-jigged its focus towards the provision ofenergy access to rural areas; andin 2009 developed the Rural

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Electrification Policy (REP) with the set objectives of (i) raising the standard of living through the water supply, lightening, and security; (ii) promote industrial, commercial, socio-economic activities; (iii) reducing rural-urban migration; (iv) promote agriculture and use of electric appliance; and reducing indoor pollution and other related environmentally friendly alternatives to kerosene, candle and fossil powered generators. These objectives were designed and made to be implemented through the Rural Electrification Agency (REA), which was established in 2006 with a mandate to promote rural electrification across; co-ordinate rural electrification programs; administer the Rural Electrification Fund (REF) to promote, support and provide rural electrification through public and private sector participation. In addition, he REA's broad objective is to achieve universal access to affordable and sustainable electricity, thus improving the quality of life and economic opportunities for unserved and underserved communities.

As of 2007, Nigeria ranked 7th among the twelve most concentrated countries without electricity with about 85 million people, 42% of its total population as of 2013 living without electricity [1].These shows that, governments at both local and international levels have over time paid full attention to the demand and supply chain of the energy sector and the desired outcome. Furthermore, a major factor that has delayed the provision of adequate energy supply across the world has been the huge financial capital required to fund power generation projects [1].According to [2], about 580 million people in Sub-Saharan Africa lack access to electricity in 2019 which accounts for three-quarters of the global total. Also, government attention to economic crises and utilities that deliver access face severe financial strains and borrowing cost has risen in countries where access deficit exists. The IEA estimates that a rise in poverty level worldwide in 2020 may have made basic electricity service unaffordable for more than 100 million people who already had electricity connection, which results in pushing households to rely on inefficient sources of energy.It is against this background that the REA in partnership with the International Organizationsimplemented rural electrification projects in selected rural areas across all the regions in the country. Therefore, this study seeks to evaluate the impact of rural electrification projects on the economic and social life of the people living in Dakkiti and MbelaLagajerural communities of Gombe and Adamawa States respectively.

II. METHODOLOGY

Model specification

The close relationship between electrification projects and rural development has long been recognized by scholars [3,4]. In fact, in both theory and practice, it is taken that rural electrification with the use of renewable energies or hybrid energy systems improves the individual quality of life, facilitates community services such as health and education (the consumption,use,) and enables business entities to carry out professional activities (the productive use) for rural populations [5,6,7].Against this backdrop, it is possible to hypothesize that the rural electrification project (z_1), could be assumed to have a direct relationshipwith our economic and social outcomes (Y) of rural communities namely: income/earning (Y_1), employment (Y_2), education (Y_3) and social capital (Y_4).

It is however important to state that the four outcomes mentioned above are also influenced by household characteristics especially the average level of education of household members (z_1) treatment (z_2), gender of head of household, (z_3), and household wealth (z_4).The project outcome for i^{th} member of the j^{th} community (Y_{ij}) can be formally expressed as a linear combination of the observed predictor variables, z_{i1}, z_{i2}, $z_{i3,}$ and z_{i4}, with the constant β_0 term and a random error term ε_i added on:

$$Y = \left[\beta_0 + \beta_1 z_{i1} + \beta_2 z_{i2} + \beta_3 z_{i3} + \beta_4 z_{i4}\right] + \varepsilon_i$$
$$= \sum_{i=1}^{n}\sum_{j=1}^{4} Y_{ij} = \left[\beta_0 + \sum_{j=1}^{4}\beta_i z_{ij}\right] + \varepsilon_i \quad (1)$$

The model's constant term β_0 can be interpreted as the mean for the outcomes of the electrification project when the value of all the predictor variables is zero, presupposing that we should expect some level of socio-economic living standard to obtain in a non-intervention scenario. The intercept and regression coefficients β, …andβ_4 are unknown parameters and can be estimated. As for the response variables, there is more than one - meaning that we must use a multivariate multiple linear regression model for estimation. To do that, there will be the need to write a regression model for each response on the i^{th} observation, where i= 1, …, n:

$$Y_{i1} = [\beta_{01} + \beta_{11}z_{i1} + \beta_{21}z_{i2} + \beta_{31}z_{i3} + \beta_{41}z_{i4}] + \varepsilon_{i1}$$
$$Y_{i2} = [\beta_{02} + \beta_{12}z_{i1} + \beta_{22}z_{i2} + \beta_{32}z_{i3} + \beta_{42}z_{i4}] + \varepsilon_{i2}$$
$$Y_{i3} = [\beta_{03} + \beta_{13}z_{i1} + \beta_{23}z_{i2} + \beta_{33}z_{i3} + \beta_{43}z_{i4}] + \varepsilon_{i3}$$
$$Y_{i4} = [\beta_{01} + \beta_{14}z_{i1} + \beta_{24}z_{i2} + \beta_{34}z_{i3} + \beta_{44}z_{i4}] + \varepsilon_{i4}$$

(2)

To simplify the interpretation of equation (2), we can construct each matrix component of our multivariate multiple regression model:

$$Y = \begin{bmatrix} Y_{11} & Y_{12} & \dots & Y_{1m} \\ Y_{21} & Y_{22} & \dots & Y_{2m} \\ . & . & \dots & . \\ Y_{n1} & Y_{n2} & \dots & Y_{nm} \end{bmatrix} = \begin{bmatrix} Y_{(1)} & Y_{(2)} & \dots & Y_{(m)} \end{bmatrix}$$

$$\text{where } Y_{(j)} = \begin{bmatrix} Y_{1j} \\ Y_{2j} \\ . \\ Y_{nj} \end{bmatrix}, m = 4, n = 4, r = 4, j = 4$$

(3)

$$z = \begin{bmatrix} 1 & z_{11} & z_{12} & \dots & z_{1r} \\ 1 & z_{21} & z_{22} & \dots & z_{2r} \\ . & . & . & \dots & . \\ 1 & z_{n1} & z_{n2} & \dots & z_{nr} \end{bmatrix}$$

(4)

$$\beta = \begin{bmatrix} \beta_{01} & \beta_{02} & \dots & \beta_{0m} \\ \beta_{11} & \beta_{12} & \dots & \beta_{1m} \\ . & . & \dots & . \\ \beta_{r1} & \beta_{r2} & \dots & \beta_{rm} \end{bmatrix} = \begin{bmatrix} \beta_{(1)} & \beta_{(2)} & \dots & \beta_{(m)} \end{bmatrix}$$

$$\text{where } \beta_{(j)} = \begin{bmatrix} \beta_{0j} \\ \beta_{1j} \\ . \\ \beta_{rj} \end{bmatrix}$$

(5)

$$\varepsilon = \begin{bmatrix} \varepsilon_{11} & \varepsilon_{12} & \dots & \varepsilon_{1m} \\ \varepsilon_{21} & \varepsilon_{22} & \dots & \varepsilon_{2m} \\ . & . & \dots & . \\ \varepsilon_{n1} & \beta_{\varepsilon n2} & \dots & \varepsilon_{nm} \end{bmatrix} = \begin{bmatrix} \varepsilon_{(1)} & \varepsilon_{(2)} & \dots & \varepsilon_{(m)} \end{bmatrix}$$

$$\text{where } \varepsilon_{(j)} = \begin{bmatrix} \varepsilon_{1j} \\ \varepsilon_{2j} \\ . \\ \varepsilon_{nj} \end{bmatrix}$$

(6)

The $Y_{(j)}$ vectors are column vectors that contain the values of the socio-economic outcome variable for each of the n observations. Similarly, each $\varepsilon_{(j)}$ vector contains the random error terms obtained for each of the n observations when considering each of the socio-economic outcome variables. Each $\beta_{(j)}$ vector is comprised of the unknown regression coefficients for the regression model obtained for the specific socio-economic outcome variable. We can therefore rewrite equation (2) in a more compact form as:

$$Y_{(j)} = z\beta_{(j)} + \varepsilon_{(j)}, \quad j = 1,2, \dots m$$

(7)

Combining each of the single socio-economic outcome models, the following matrix version can be constructed:

$$\begin{bmatrix} Y_{11} & Y_{12} & \dots & Y_{1m} \\ Y_{21} & Y_{22} & \dots & Y_{2m} \\ . & . & \dots & . \\ Y_{n1} & Y_{n2} & \dots & Y_{nm} \end{bmatrix} = \begin{bmatrix} 1 & z_{11} & z_{12} & \dots & z_{1r} \\ 1 & z_{21} & z_{22} & \dots & z_{2r} \\ . & . & . & \dots & . \\ 1 & z_{n1} & z_{n2} & \dots & z_{nr} \end{bmatrix} \begin{bmatrix} \beta_{01} & \beta_{02} & \dots & \beta_{0m} \\ \beta_{11} & \beta_{12} & \dots & \beta_{1m} \\ . & . & \dots & . \\ \beta_{r1} & \beta_{r2} & \dots & \beta_{rm} \end{bmatrix} + \begin{bmatrix} \varepsilon_{11} & \varepsilon_{12} & \dots & \varepsilon_{1m} \\ \varepsilon_{21} & \varepsilon_{22} & \dots & \varepsilon_{2m} \\ . & . & \dots & . \\ \varepsilon_{n1} & \beta_{\varepsilon n2} & \dots & \varepsilon_{nm} \end{bmatrix}$$

(8)

Equations (7) and (8) are taken to have the properties: $E(\varepsilon) = 0$, $E(Y) = z\beta$, $\operatorname{cov}(\varepsilon) = \delta^2 I$ for each of the socio-economic outcome variables.

As $\beta_{(j)}$ cannot be estimated directly, we make recourse to trial data. If we, therefore, consider the vector $b_{(j)} = \begin{bmatrix} b_{oj} \\ b_{1j} \\ . \\ b_{rj} \end{bmatrix}$, which contains trial values for $\beta_{(j)}$. We could thus obtain the trial model:

$$\begin{bmatrix} Y_{ij} \\ Y_{2j} \\ . \\ Y_{nj} \end{bmatrix} = \begin{bmatrix} 1 & z_{11} & z_{12} & \dots & z_{1r} \\ 1 & z_{21} & z_{22} & \dots & z_{2r} \\ . & . & . & \dots & . \\ 1 & z_{n1} & z_{n2} & \dots & z_{nr} \end{bmatrix} \begin{bmatrix} b_{0j} \\ b_{1j} \\ . \\ b_{rj} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1j} \\ \varepsilon_{2j} \\ . \\ \varepsilon_{nj} \end{bmatrix}$$

(9)

We then can write a regression model for the socio-economic outcome variable on the i^{th} observation using the trial values, $b_{(j)}$: $[b_{0j} + b_{1j}z_{i1} + b_{2j}z_{i2} + \dots + b_{rj}z_{ir}] + \varepsilon_{ij}$ where i = 1, …,n and j = 1, …, m. The focus will then be on the difference between the observed values, Y_{ij}, and the predicted mean of Y_{ij} given by $b_{0j} + b_{1j}z_{i1} + b_{2j}z_{i2} + \dots + b_{rj}z_{ir}$. Minimizing this difference will result in the error term taking on the smallest possible value. Ultimately, the $b_{(j)}$ vector that minimizes the sum of the squares of these differences will be selected and referred to as the estimated parameter vector:

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$$\hat{\beta}_{(j)} = \begin{bmatrix} \hat{\beta}_{0j} \\ \hat{\beta}_{1j} \\ \cdot \\ \hat{\beta}_{rj} \end{bmatrix}$$

(10)

Using the least squares method, we obtain:

$$\hat{\beta}_{(j)} = (Z'Z)^{-1} Z'Y_{(j)}$$

(11)

We then collect all of the univariate $\hat{\beta}_{(j)}$ estimates and form the estimated parameter matrix:

$$\hat{\beta} = \left[\hat{\beta}_{(1)} \ \cdot \hat{\beta}_{(2)} \ \ldots \ \cdot \hat{\beta}_{(m)}\right]$$

(12)

Yielding:

$$\hat{\beta} = (Z'Z)^{-1} Z'\left[Y_{(1)} \ . \ Y_{(2)} \ \ldots \ Y_{(m)}\right] = (Z'Z)^{-1} Z'Y$$

(13)

But our goal is to evaluate the impact of rural electrification referred to here as the treatment (z_1) on socio-economic outcomes (Y_j) over i^{th} population of households. Suppose that we have two groups of households in the population indexed by treatment status, T = 0, 1, where 0 indicates households who have been served by the project, referred to as the control group, and 1 indicates households who have been served by the project, referred to as the treatment group.

Let us make the additional assumption that we observe households in two time periods, t = 0, 1 where 0 stands for some time before the treatment group was served, that is pre-treatment; and 1 indicates a time period after the treatment group has been served by the project, that is post-treatment. Let us also say every observation is indexed by the letter i = 1, …, n; the household will typically have two observations each, one-pre-treatment and one post-treatment.

For simplicity of exposition, let $\bar{Y}_0^T$ and $\bar{Y}_1^T$ be the sample averages of the outcomes for the treatment group before and after treatment respectively, and let $\bar{Y}_0^C$ and $\bar{Y}_1^C$ be the corresponding sample averages of the outcomes for the control group. Subscripts correspond to the time period and superscripts to the treatment status. The outcomes of Y can be modeled by the following equation:

$$Y_{ij} = \alpha + \beta T_{ij} + \gamma t_{ij} + \delta(T_{ij} \bullet t_{ij}) + \varepsilon_{ij} \quad (14)$$

where the coefficients given by the Greek symbols α, β, γ, and δ are all unknown parameters and are a random unobserved error term thatcontains all determinants of Y_{ij} given that:α = constant term; β = treatment group-specific effect (to account for average permanent differencesbetween treatment and control; γ = time trend common to control and treatment groups; δ = true effect of treatment.

The purpose of the programme evaluation is to find a good estimate δ ,given the data collected through observation. For statistical validity of equation (14), three assumptions would have to be met, namely correct specification of the model, the zero average error term ($E(\varepsilon_{ij}) = 0$), and the parallel-trend assumption - $\text{cov}(\varepsilon_{ij}, t_{ij}) = 0$;

Six steps were followed in analyzing the empirical data. The first was measuring data in interval and ratio forms with responses expressed in nominal and ordinal scales converted to either interval or ratio scale data. The second step was estimatingY_{ij} and obtaining the values The third step was to use the values to generate predicted values of $\hat{Y}_{ij}$, calculatethe averages -$\bar{Y}_0^T$, andrepresented the fourth step. The last two steps involved performing a test for the parallel-trend assumption to determine if the use of the difference-in-difference methodology for the study were to be justified, and estimating equation (14) to determine α, β, γ, and the true treatment effect, δ.

Study area, population and sample size determination

The area of the study consisted of Mbela-Lagaje, located at Mayo-Belwa Local Government Area in Adamawa State, and Dakkiti, located at Akko Local Government Area, in Gombe. The two locations are situated in the northeast region of Nigeria. The two communities share similar characteristics, both are rural and residential in nature and the major occupation of the communities are farming and cattle rearing. Mbela-Lagaje has very low commercial activities compared to Dakkiti. The two communities served as the treatment communities/group. Jauro -Manu which is a distant150meters from Mbela-Lagaje served as the control community/group for Mbela-Lagaje, while Wadayi which is a distant 1kilometre to Dakkiti served as the control community/group for Wadayi. A baseline survey carried out by the [8] estimated the human population of Mbela-Lagaje at 535 with 107 households; and, Dakkiti has an estimated [household population of 510.

The questionnaireadministered contain impact indicators for respondents in the threesegmented socio-economic groups namely: Household; Social and Productive. For questionnaires administered for household earnings, impact indicators were analyzed under four broad categories namely: demography and socio-economic characteristics; dwelling condition; energy condition; and economic condition. Under social participation, the broad categories are socio-demography; dwelling condition; energy condition; and economic condition lastly, the indicators under productive engagement include dwelling condition; energy condition; and economic condition.

Data for the sampling frame used in this study was obtained from [8]. The[9] formula was used to determine the sample size for the study (see table 1), a simple random method was used as the sampling method of choice and the [10] method of spinning a bottle after each sampling unit was identified was also employed. A total of 171 households were then selected for the administration of the research instrument, the questionnaire (Table 2).The [11] difference in difference model was used to anylse the time and impact effect of the study.

Table 1: Sample Size Determination for Household

Community	The population of Household Experiment/ Control	Desired Sample Size
Dakkiti	250 (Treatment)	69
MbelaLagaje	80 (Treatment)	25
Wadayi	191(Control)	55
Jauro Manu	70(Control)	22
Total	**591**	**171**

Source: Authors compilation

Table 2: Distribution of Questionnaires to Commercial and Public Users

Community	Household	Commercial Users	Public Users	Total
Dakkiti	37	30	2	39
MbelaLagaje	16	5	4	25
Wadayi	49	4	2	55
Jauro Manu	19	2	1	22
Total	**121**	**41**	**9**	**171**

Source: Authors compilation

Analysis of Empirical Results

Before estimation of equation 3.14, we tested for identification (rank and order conditions). According to the rule of the first-order condition of identification of a model of M simultaneous equation, for an equation to be identified, the number of predetermined variables excluded from the equation must not be less than the number of endogenous variables included in the equation less 1, that is, if $K - k = m - 1$, the equation is just identified; if $K - k > m - 1$, the equation is overidentified [12] given that:

M = number of endogenous variables in the model
m = number of endogenous variables in a given equation
K = number of predetermined variables in the model including the intercept
K = number of predetermined variables in a given equation.
From equation (3.9), the following were derived:
K = 5; K = 4; M = 4; m = 1.

Therefore, in each of the four equations derivable from equation 3.2, the identification conditions are as follows:

Equation 1: $5 - 4 \geq 1 - 1$
$1 \geq 0$ (equation overidentified)
Equation 2: $5 - 4 \geq 1 - 1$
$1 \geq 0$ (equation overidentified)
Equation 3: $5 - 4 \geq 1 - 1$
$1 \geq 0$ (equation overidentified)
Equation 4: $5 - 4 \geq 1 - 1$
$1 \geq 0$ (equation overidentified)

As for the sufficient condition, we applied the Rank test. [12] suggest that in a model containing M equations in M endogenous variables, an equation is identified if and only if at least one nonzero determinant of order (M – 1) (M – 1) can be constructed from the coefficient of the variables (both endogenous and predetermined) excluded from that particular equation but included in the other equation of the model as follows:
(M – 1) (M – 1)
(4 – 1) (M – 1)
Rank condition:
Y_{01} -□$_{01}$ - □ Z

$$\begin{vmatrix} -\beta_{01} & 1 & 0 & 0 & 0 & -\beta_{11} & -\beta_{21} & -\beta_{31} & -\beta_{41} \\ -\beta_{02} & 0 & 1 & 0 & 0 & -\beta_{12} & -\beta_{22} & -\beta_{32} & -\beta_{42} \\ -\beta_{03} & 0 & 0 & 1 & 0 & -\beta_{13} & -\beta_{23} & -\beta_{33} & -\beta_{43} \\ -\beta_{04} & 0 & 0 & 0 & 1 & -\beta_{14} & -\beta_{24} & -\beta_{34} & -\beta_{44} \end{vmatrix}$$

Table 3: Results of the order and rank conditions

Equation No.	No. of Predetermined Variables Excluded, (K – k)	No. of Endogenous Variables Included, Less One, (m – 1)	Identified?
1	1	0	Overidentified
2	1	0	Overidentified
3	1	0	Overidentified
4	1	0	Overidentified

Source: Authors compilation

Accordingly, the four equations satisfied both the necessary (Order) and sufficient (Rank) conditions. Further, it is easy to see that all four equations are overidentified. To this effect, it was then considered most appropriate to use the Two-StageLeast Square (2SLS) method to estimate the final equations as shown in tables 4 and 5. Under 2SSLS, the second set of equations from the first stage was estimated and the results are shown in tables 4 and 5.

Table 4: Estimation results for the Control group (First stage of 2SLS)

REGRESSAND	**REGRESSORS**						
Pre-Intervention Period							
	Constant	**Intervention (z1)**	**Occupation diversity (z2)**	**Gender (z3)**	**Household wealth (z4)**	**R^2**	**D-W**
Income/earnings (Y1)	56,919.94 (0.0000) *	-	-1,043.754 (0.3172) *	- 3,121.57 (0.8364) *	16,552.00 (0.0198) *	0.119087	2.050805
Employment (Y2)	0.159291 (0.0997) *	-	0.007274 (0.3491) *	- 0.223461 (0.0504) *	-0.007955 (0.8780) *	0.095360	2.137214
Study culture (Y3)	0.200000 (0.0000) *	-	5.72E-19 (0.8550) *	-2.20E-16 (0.0000) *	-8.27E-17 (0.0002) *	-	0.599325
Community/social activity (Y4)	0.085828 (0.2345) *	-	-0.005604 (0.3362) *	0.191428 (0.0261) *	-0.011677 (0.7638) *	0.141389	0.692323

Post-Intervention Period							
Income/earnings (Y1)	14,701.93 (0.0001)*	-	-236.02 (0.3993)*	-234.9537 (0.9507)*	4,208.527 (0.0154)*	0.116265	2.020989
Employment (Y2)	0.459126 (0.0003)*	-	0.000532 (0.9556)*	-0.377852 (0.0048)*	-0.077406 (0.1857)*	0.116025	1.809337
Study culture (Y3)	0.219999 (0.3528)*	-	0.017632 (0.3511)*	0.032647 (0.8987)*	0.158698 (0.1692)*	0.057906	2.134500
Community/social activity (Y4)	0.096048 (0.1938)*	-	-0.006041 (0.3049)*	0.151917 (0.0604)*	-0.016293 (0.6480)	0.111966	0.682921

Source: Computed from field survey, 2022

Table 5: Estimation results for Treatment group (First stage of 2SLS)

REGRESSAND	**REGRESSORS**						
Pre-Intervention Period							
	Constant	**Intervention (z1)**	**Occupation diversity (z2)**	**Gender (z3)**	**Household wealth (z4)**	**R^2**	**D-W stat**
Income/earnings (Y1)	16,241.81 (0.0000)*	-	745.5620 (0.0317)*	-887.5023 (0.8129)*	-765.5700 (0.6317)*	0.051841	1.665152
Employment (Y2)	0.147429 (0.0367)*	-	0.003567 (0.6937)*	0.089201 (0.3688)*	0.031870 (0.4503)*	0.015024	2.014962
Study culture (Y3)	1.336781 (0.0000)*	-	-0.043539 (0.1787)*	0.138054 (0.6953)*	0.401727 (0.0086)*	0.092724	1.950630
Community/social activity (Y4)	0.355253 (0.0001)	-	0.013016 (0.2472)*	0.360265 (0.0040)*	0.021149 (0.68540*	0.999698	1.671370
Post-Intervention Period							
Income/earnings (Y1)	2,965.188 (0.0650)*	1,551.488 (0.3074)*	213.5484 (0.0261)*	-610.4248 (0.5121)*	-239.7209 (0.5198)*	0.068354	1.681387
Employment (Y2)	0.288618 (0.1057)*	-0.062387 (0.7115)*	-0.002242 (0.8315)*	0.160599 (0.1230)*	-0.042140 (0.3099)*	0.038692	1.494721
Study culture (Y3)	3.387321 (0.0000)*	-0.936928 (0.1606)*	-0.092561 (0.0278)*	-0.010686 (0.9791)*	0.229623 (0.1611)*	0.096340	1.881867
Community/social activity (Y4)	0.511262 (0.0062)*	0.030586 (0.8606)*	0.015963 (0.1448)*	0.193279 (0.0729)*	-0.007611 (0.8587)*	0.060075	1.908192

Source: Computed from field survey, 2022

For this study, the interpretation of the second set of equations is more relevant than the first. The summary of the second-stage estimation of equations for the control group is shown in table 4. As indicated in the model specification, the decision rule for coefficients as far as the signs are concerned were expected to be either zero or positive.

However, a look at table 5 reveals that the post-treatment group income/earnings equation, as well as those attached to occupation diversity, gender, and household wealth variables under the employment equation, carry the opposite sign, thereby suggesting that the solar electrification project might not have influenced beneficiaries' relationship with income/earnings and employment as would be expected. As for the study culture indicator as well as community/social activity equations, all the coefficients were correctly signed. Despite these mixed results, it is interesting to observe that all the coefficients in the equations were statistically significant at the 5percent level. The R-squared statistics of the control group equations ranged between 0.9987 and 0.9998, indicating a very good fit.

Table 6: Estimation results for the Control group (Second stage of 2SLS)

REGRESSAND	REGRESSOR						
Pre-Intervention Period							
	Constant	**Intervention (z1)**	**Occupation diversity (z2)**	**Gender (z3)**	**Household wealth (z4)**	**R^2**	**D-W**
Income/earnings (Y1)	0.0000 (1.0000)*	-	0.0000 (1.0000)*	0.0000 (1.0000)*	0.0000 (1.0000)*	-	-
Employment (Y2)	56,919.96 (0.0000)*	-	-1,045.755 (0.0000)*	-3,121.556 (0.0000)*	16,551.99 (0.0000)*	0.9999	1.715862
Study culture (Y3)	0.159518 (0.0000)*	-	0.007341 (0.0000)*	-0.224500 (0.0000)*	-0.008416 (0.0000)*	0.999453	1.565754
Community/social activity (Y4)	0.20000 (0.0000)*	-	5.72E-19 (0.8550)*	-2.20E-16 (0.0000)*	-8.27E-17 (0.0002)*	-	-
Post-Intervention Period							
Income/earnings (Y1)	14,701.93 (0.0000)*	-	236.0178 (0.0000)*	-234.9498 (0.0000)*	4,208.525 (0.0000)*	0.998670	1.639867
Employment (Y2)	0.457894 (0.0000)*	-	0.000647 (0.0000)*	-0.377506 (0.0000)*	-0.077954 (0.0000)*	0.999707	2.255167
Study culture (Y3)	0.219855 (0.0000)*	-	0.017626 (0.0000)*	0.033095 (0.0000)*	0.158351 (0.0000)*	0.999792	2.166542
Community/social activity (Y4)	0.095688 (0.0000)*	-	0.017626 (0.0000)*	0.033095 (0.0000)*	0.158351 (0.0000)*	0.999792	2.011501

Source: Computed from field survey, 2022

The estimation results of the second stage of the 2SLS procedure for the treatment group are summarized in table 6. The second segment of the table which is more relevant to the impact analysis in this study shows that the actual sign carried by some of the coefficients in each of the four equations turned out to be negative instead of positive. For the income/earnings equation, gender and household wealth coefficients carried negative signs. Three out of four (intervention, occupation diversity, and household wealth) have negative signs.

Table 7: Estimation results for Treatment group (Second stage of 2SLS)

REGRESSAND	REGRESSORS						
Pre-Intervention Period							
	Constant	**Intervention (z1)**	**Occupation diversity (z2)**	**Gender (z3)**	**Household wealth (z4)**	**R^2**	**D-W stat**
Income/earnings (Y1)	16,421.81 (0.0000)*	-	745.5620 (0.0317)*	-887.5023 (0.8129)*	-765.5700 (0.6317)*	0.051841	1.665152
Employment (Y2)	0.147,429 (0.0367)*	-	0.003567 (0.6937)*	0.089201 (0.3688)*	0.031870 (0.4503)*	0.015024	2.014962
Study culture	1.336781	-	-0.043539	0.138054	0.401727	0.092724	1.950630

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(Y3)	(0.0000)*		(0.1787)*	(0.6953)*	(0.0086)*		
Community/social activity (Y4)	0.355253 (0.0001)*	-	0.013016 (0.2472)*	0.360265 (0.0040)*	0.021149 (0.6854)*	0.101841	1.748837
Post-Intervention Period							
Income/earnings (Y1)	2,965.187 (0.0000)*	1,551.489 (0.0000)*	213.5483 (0.0000)*	-610.4206 (0.0000)*	-239.7206 (0.0000)*	0.99999	2.020378
Employment (Y2)	0.287291 (0.0000)*	-0.062200 (0.0000)*	-0.002086 (0.0000)*	0.161546 (0.0000)*	-0.41808 (0.0000)*	0.999028	2.184296
Study culture (Y3)	3.389615 (0.0000)*	-0.939249 (0.0000)*	-0.092605 (0.0000)*	-0.009950 (0.0000)*	-0.229782 (0.0000)*	0.999970	2.105889
Community/social activity (Y4)	0.511396 (0.0000)*	0.029727 (0.0000)*	0.015954 (0.0000)*	0.192867 (0.0000)*	-0.007745 (0.0000)*	0.999349	1.925513

Source: Computed from field survey, 2022

The importance of processes and dynamism of change have not only been studied for a long but recognized in economics. First, the dependence of a variable on another is rarely instantaneous, which is why the short- and long-run components are often distinguished. Second, the impact of a stimulus on the dependent variable either "evaporates" or "explodes" with time is no longer questionable. Three, policy changes are transmitted to their final states through interim and distributed lag "multiplier" and "accelerated" processes. Last, the "actual" and "time" effects often combine to produce the final impact of a policy intervention on project beneficiaries. In the light of all this, the project and time effects of rural electrification in the study area were first determined separately; then combined to arrive at the overall ("true") impact on the socio-economic lives of the project communities. Here, the difference-in-difference (DID) methodology and procedure were employed.

Table 8: Estimation results for outcomes ('true impact') of intervention (Using DID Procedure)

REGRESSAND	**REGRESSOR**					
	Constant	**Treatment status (T)**	**Time period (t)**	**The combined effect of participation and time (T.t)**	**R^2**	**D-W**
'True impact' on income/earnings	-32,021.97 (0.0000)*	53,035.09 (0.0000)*	48,779.11 (0.0000)*	-64,008.00 (0.0000)*	0.438604	1.976477
'True impact' on occupation diversity	0.144783 (0.0000)*	0.0818854 (0.5097)*	0.153789 (0.0000)*	0.053579 (0.1829)*	0.109440	1.901630
'True impact' on study culture	0.252029 (0.0000)*	1.309789 (0.0000)*	0.421737 (0.0000)*	-0.110808 (0.0000)*	0.645125	1.590871
'True impact' on participation in community/social activity	-0.000290 (0.9896)*	0.505037 (0.0000)*	0.142887 (0.0000)*	0.054783 (0.0178)*	0.691574	1.447171

Source: Computed from field survey, 2022

Table 8. summarizes the results of the DID estimation, the results for the overall outcomes of the study are summarized in columns 3 and 4 of the table which showsthe actual and time impact of the project on the socio-economic life of the target communities measured by improvements in four indicators namely income/earnings, occupation diversity, study culture, and

community/social activity of the people. It is easy to see that all the coefficients are correctly signed and statistically significant at a 5 percent level except for the treatment effect on occupation diversity. As for the goodness of fit statistic, while income/earnings equation is moderately fit, 65 percent and 69 percent of changes in the study culture and community/social activity equations were explained by individual components of the project and their combined impact, respectively.

Column 5 of table 8 indicates the overall and combined (long-run) impact of the intervention on the socio-economic life of the project communities measured by the four indicators. As for the impact on income/earnings, though the coefficient is statistically significant at 5percent level, the negative sign it carries suggests that the actual impact may be lower than expected. The coefficient explaining the combined effect of participation and time is not only insignificant statistically (at 5 and 10 percent levels) but negligible in magnitude (less than 1 percent change). The combined effect of participation and time on community/social activity is statistically significant at 5 percent; however, the size of the change is somewhat small (less than 1 percent). Similarly, the combined impact of project participation and time on household study culture has been positive judging by the statistical significance of the coefficient. However, the size of the change is somewhat negligible (about 1 percent).

III. DISCUSSION OF FINDINGS

The ultimate objective of the REA is not only to provide rural households with affordable modern energy at a cheap price over inferior alternatives in the long run but to improve the benefiting communities' quality of life and jump-start growth on a range of socioeconomic fronts. For instance, as a replacement for kerosene-based lighting sources, electric lighting is expected to substantially reduce indoor air pollution and carbon emissions. In addition, it gives school-going children more time in the evening to study aside from its benefits to income-generation activities through business operations keeping longer open hours for active and productive uses. Another of its expected benefit is building on social cohesion through social interaction and social capital by giving members of the community toaffordable energy foster their relationships and cultural exchange, entertainment, facilitating long and comfortable social gatherings and ceremonies.

This study alsotests the validity of findings of studies done in the past regarding the benefits of rural electrification programs in developing countries. A great and still growing number of literatures on the effect of rural electrification have emerged and pointed to the claims that rural electrification greatly contributes to the welfare growth of rural households [4,13,14,15] What follows below is a discussion of the findings of this study in testing the validity of this assertion. We shall segment the discussion into four parts, each concentrating on one out of three socio-economic indicators of the effect of the rural electrification project namely, income/earnings representing household welfare, employment/production representing the productive impact, study culture and community/social activity representing impact on community cohesion.

The estimation results of the impact of the rural electrification project on income/earnings reveals that before the project, the annual increase in income/earning may have been negative, but the intervention has led to positive changes in income/earning over time. However, the unobserved negative effect of the past situation may have outweighed the observed changes of the treatment period and over time, leaving an overall dismal performance of the intervention thereby casting doubt on the assertion that electrification projects generally have the potential to impact positively on income household welfare via long-term improvement in earnings in developing countries. Thus, this particular outcome of the study appears to be in contrast with similar studies in other developing countries. For instance, a study conducted in India by [16]shows that household incomeswere higher for electricity users. [17] found that entrepreneurs who invested in small use productive use containers powered by solar panels benefitted from extra monthly sources of income in South Africa. Similarly,[18]concluded that in 42 Vietnamese communities, household electrification is responsible for a growth of 21 percent and 29 percent in total and non-food income, respectively.

Results of this study show that the rural electrification intervention has a 5.3 percent improvement in occupational diversity. Occupational diversity here means the emergence of new electricity-reliant businesses which serves as an indicator of an increase in local production and revenues, and improvement in people's productivity. [19] reported that an extra kWh of electricity led to multiple ancillary agro-allied businesses and generated an incremental surplus of agricultural production for Indian farmers. [20] reported that in villages in northern Benin, the number of allied cottage enterprises and profits of connected firms was considerably higher by 73.8 percent than those of non-connected firms and this is especially true for electricity-reliant firms. [21] reportedthat households managing small cottage industries in rural India were able to increase their daily income using electric lighting to extend their productive hours after nightfall. Lastly, [22] reported that in Zambia, lighting in the evening could improve teachers' income, enabling them to earn some extra income by teaching in the evening.

The results of this study reveals that in households with electricity, household members especially boys and girls spend more time studying than those in households without electricity, which suggesta better educational outcome in the future for connected households. The 11 percent overall improvement in studying culture in this particular study compares favorably with the results of similar studies conducted in developing countries. For instance, [23] reported that in rural areas of Assam, India, a 1-point increase in the percentage of households electrified resulted in 0.17-point improvement in the percentage of literate people older than 6 years. The authors also suggested that domestic electricity consumption per capita has a positive correlation with educational attainment, indicating that those households with very low initial levels of electricity consumption can achieve high educational benefits from increasing their consumption of electricity. Further, the literacy rate of Assam state is estimated to rise from 63.3 percent to 74.4 percentif all the rural areas were to be electrified. Similarly, [24] concluded that an increase in electricity access is correlated with an improved literacy rate in the Economic Community of West African States (ECOWAS), though countries with low national electrification rates such as Cote d' Ivore and Mali have better literacy rates than Ghana that scores higher in both urban and rural electrification rate. It was also discovered that rural Nicaraguan men and women are more than twice as likely to have completed primary education if they live in households with access to electricity [25]. [26] in a study of South African rural communities reported that electrified rural areas in the country have higher fractions of adults with high school degrees compared to non-electrified communities. [18] with the use of an econometric model analysed 42 Vietnamese communities and finds that household electricity connection is correlated with a 9 percent higher school enrolment for girls and 6.3 percent for boys.

According to [16] in India, the impact of electrification on labor supply is positive, that is household access to electricity increases employment by more than 17 percent for women and only 1.5 percent for men. Electricity lighting also allows household members to extend hours of operation for home-based businesses and engage in other income-generating activities after completing domestic chores such as sewing or making handicrafts [16].In terms of changes in people's daily habits and activity scheduling, social interaction, and community participation in networking, this study found a 5.5 percent improvement in the project communities as a result of electricity connection. This finding compares well with those from similar studies elsewhere. For instance, [27] report that the provision of access to electricity in Tsilitwa village, South Africa, allowed household members to wake up earlier, about a half-hour before sunrise, and go to bed about 2 – 3 hours later. More available free time seems to increase the time dedicated to reading and cultural activities [28,29, 30].[31] observed that the 'innovation diffusion of electricity access in rural Bangladesh brought mostly recreational and leisure benefits. [32,33] reported the same dynamics for rural Bangladesh and Rwanda households respectively. Lighting and the related perceived improved security as well as evening market operation seem to increase outdoor and/or indoor evening meetings and chats, and connectivity among [34].

IV. CONCLUSION

This study is a modest effort at exploring the impact of rural electrification projects on household earnings, productive engagement, and social participation in Dakkiti and Mbela-lagaje rural communities. It employs the difference-in-difference approach as a method of evaluating the socio-economic impact of rural electrification projects.The key dependent variables used are household earnings/income, productive engagement, and social participation on the independent variable. Theempirical findings of the studyautomate as a baseline survey of the two rural communities of Wabiyi and Jauro Manu who served as the control group. Furthermore, this study providesempirical insight on key energy policiesand objectives of the REA which is the implementation agency of the government of Nigeria. This study has again closed the gap between the theoretical postulation behind the benefits and practical outcomes of rural electrification intervention in developing countries, using Nigeria as a case in point.

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