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Welfare Impacts of Rural Electrification in Bangladesh: Propensity Score Matching and Binary Logistic Regression Approach

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Abstract

This research focuses on assessing the program's effectiveness in the economic, health, educational, household, and entertainment sectors. Through primary data collection from 380 households across seven districts, the study analyzes the benefits and challenges associated with rural electrification. Propensity Score Matching is employed to address confounding factors and assess the impact on income, expenditure, and education. The Binary Logistic Regression model explores contributing factors such as age, education, housing, total income, and expenditure in determining the likelihood of rural electrification. The findings indicate a significant positive impact of rural electrification on income, expenditure, and education. Households with electricity show higher odds of positive outcomes in these areas compared to non-electrified households. Education levels, total income, and expenditure patterns emerge as influential factors in the electrification process. While recognizing the positive impacts, the study also highlights challenges such as the unequal distribution of benefits, issues with billing systems, and concerns about the duration of electricity supply. The research suggests that continuous attention to cost-effective supply, equitable distribution, and balancing financial sustainability with reaching the poor is crucial for the success of rural electrification programs. In conclusion, the study contributes to the ongoing discourse on the effectiveness of rural electrification programs, emphasizing the need for comprehensive evaluations that consider various socio-economic factors. The insights gained from this research can inform future policy decisions and program improvements to maximize the welfare impacts of rural electrification in developing countries.

Keywords: Rural Electrification in Bangladesh, Propensity Score Matching, Binary Logistic Regression

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1.0 Introduction

"Rural Electrification" (RE) is not just about light; it entails enlightenment, and at the same time, it is one of the most powerful vehicles for reducing between urban and rural areas (Barnes, 2007). It is universally accepted that electrification enhances the quality of life at the household level and stimulates the economy at a broader level. The immediate

benefit of electrification comes through improved lighting, which promotes extended hours of study and, in turn, contributes to better educational achievements. Lighting can also benefit other household activities, such as sewing by women, social gatherings after dark, and so on (Barnes et al., 2012). Electric gadgets such as radios and televisions improve rural households' access to information and provide entertainment to family members (Dinkelman, T., 2011). In addition, household's economic activities both inside and outside the home benefit a lot from electricity. For example, crop productivity can be increased by the application of electric irrigation pumps, businesses can be operated longer hours in the evening, electric tools and machinery can impart efficiency and productivity to Industrial enterprises, and so on.

The Bangladesh Rural Electrification (RE) Program was founded with a Presidential Ordinance on 29th October 1977 that established the Rural Electrification Board (REB). It was responsible for electrifying rural Bangladesh. Since its inception, the purpose of the program has been to use electricity as a means of creating opportunities for improving agricultural production and enhancing socio-economic development in rural areas, whereby there would be improvements in the standard of living and quality of life for the rural people (World Bank, 2008).

The magnitude of changes and the impact of the RE Program is vast and diversified, and information documenting these have become more acute in recent years. But, questions are being raised about the efficiency of RE. Does RE have enough contribution to improving and developing the condition of the rural areas or not? Is there any significant difference between the RE and NON-RE households? Are the students in RE households doing better in the educational sector than NON-RE households? In short, the questions are about the effect of RE on the lives of the RE users compared to the NON-Res.

To find the answers to these questions, we conducted the following study by dividing the individuals into RE and NON-RE groups and reaching a conclusion. The study revealed an overall impact of RE on the lives of the rural people in Bangladesh.

Through the study, it came to our knowledge that rural electrification has a vast impact on the lifestyles of rural people. It almost improves all the sides of an individual. But with such appreciation, it also earned some complaints as the non-availability of electricity connection, or the billing system which is not appropriate for poor people again one of the most common problems is the duration of electricity supply which hardly meets the needs of the people.

2.0 Objectives of the Study

The study's prime objective is to assess the welfare of rural electrification in terms of economic, health, women empowerment, etc., irrespective of non-rural electrification. In brief, the objectives of the study can be summarized as follows:

1. To attain an understanding of the benefits of electricity to rural people.
2. To attain an understanding of the sufferings of the rural people who do not have electricity.

3.0 Rationale of the Study

It has long been claimed that rural electrification greatly improves the quality of life. Lighting alone brings benefits such as increased study time and improved study environment for school children, extended hours for small businesses, and greater security.

But electrification brings more than light. Its second most common use is for television, which brings both entertainment and information. The people who live in rural areas appreciate these benefits and are willing to pay for them at more than sufficient levels to cover the costs. However, the evaluation of these and other benefits (for example, in terms of public goods), as well as of their distribution, has been sparse.

Hence, in principle, RE investments can have good rates of return and be financially sustainable. But caveats are in order. The first caveat is that attention needs to be paid to ensuring the least cost supply, including limiting system losses. Second, continued attention needs to be paid to achieving the right balance between financial sustainability and reaching the poor.

The study investigates whether the goals of RE with which it started the journey are met or not. In which sectors it needs to work harder? Whether the aids given by the World Bank are properly used or not? Are the rich households getting more profits from RE than poor ones? Also, it concentrates on the duration of the electricity supply, billing system, corruption, connection to electricity, etc. These can be discussed as follows:

While assessing who benefits most from RE, it is widely recognized that the larger share of benefits from RE is captured by the non-poor. Different analyses showed that this continues to be the case, although the gap closes as coverage expands. Two factors underpin this anti-poor pattern in electrification: which communities get connected and which households can afford the connection once the grid is available. In many countries, communities connected to the grid are identified on a "least cost" basis, which favors larger communities nearer to the existing grid, roads, and towns. So, studies are being done to ensure the proper distribution of electricity at a minimum cost base.

Again, there are villages where some are left out of connection either because they are unable to pay the monthly bills or because of the delay made by the authority concerned. So, these should also be analyzed.

Here, we also assessed the purpose for which electricity is used most and its impact on economic growth. Also, if the electricity is used to watch television or listen to the radio, it makes them aware of health sectors or current affairs activities. The dominant use of electricity in rural households is lighting. All households use it for this purpose, and many use little electricity for anything else. The next most common use is TV. Lighting and TV account for at least 80 percent of rural electricity consumption, and the bulk of the benefits are delivered by electrification. Electricity is rarely used for cooking in rural areas. Fans and irons are also used for a minority of consumption.

A big contribution of RE is in the economic growth. So, in the study, a comparison has been made between the RE and NON-RE households, measuring the yearly income, expenditure, farm land, non-farm land, and the price of the lands, etc. Again, the yearly yield has also been compared. RE does not drive industrial development, but it can provide an impetus to home businesses, even though few households use electricity for productive purposes.

As we all know, "Education is the backbone of a nation." So, we also compared the relative study time, schooling year accomplished by the females and males, etc., between RE and NON-RE households. Health conditions between the two groups have also been compared. Their knowledge about different diseases, precautions, family planning knowledge, vaccination, etc., have been compared. Lastly, in the entertainment sector, the availability of entertainment equipment, their needs, and their points of view about using them have also been assessed.

Hence, the study is conducted with the aim of developing a new methodology for measuring the benefits of RE and its impact on rural life. For this purpose, the study-analyzed data from a range of sources, including World Bank papers, different journals, etc. The analysis unpacks the causal chain from the provision of electricity to the various benefits it is claimed to bring and quantifies these benefits where possible to address the balance of costs and benefits. The data were used to test the impact of RE on several variables, such as the quantity of lighting used, opening hours of clinics, female health knowledge, and income from home businesses, etc.

4.0 Review of Literature

It is so believed that electricity supply and economic growth have a causal relationship between them. The more the supply of electricity, the better the economic growth. The initial relationship between energy consumption and

economic growth was explored by Kraft and Kraft(1978)[1]in the US. The majority of the study showed a mixed causality between them.

A study conducted by The World Bank in 2009 by Shahidur R. Khandakar, Douglas F. Barnes, and Hussain A. Samad[2] revealed some findings about the welfare impacts of rural electrification on Bangladesh. It showed that "the gain in total income due to electrification can be as much as 30 percent. Electricity also leads to insignificant improvement in both completed schooling years and study time for children in rural households. And, not only does household electrification result in income improvement, but this impact is sustained for as long as eight years, after which the benefit level off."

From that study, it is also known that "rich households benefit more than the poor ones from electrification. Electrification impacts per capita expenditure for rich households (12.4 percent) four times more than that for poor households (3.1 percent). Having electricity improves farm income a lot for rich households (almost 50 percent)Without any significant impact on farm income of poor households."

In Bangladesh, the REB, for the most part, has been very successful in expanding electricity in rural areas all over the country through local electric cooperative distribution companies (Waddle 2007)[3].

There is a strong relationship between electricity and poverty eradication. The availability of electricity helps in agriculture, education, household, and health sectors, eventually improving the rural people's economic condition.

The link between energy and poverty was clearly laid out in a number of the World Bank's reports (World Bank 1996). By 2008, the World Bank could claim that the economic case for investment in rural electrification was proven and that the benefits to rural households were above the average long-run supply costs, indicating that cost recovery tariff levels were achievable (World Bank 2008).

In general, one of the dilemmas of rural enterprise in developing countries is that electric machinery potentially replaces labor that is comparatively cheap, and the poorly educated fail to recognize the potential uses and benefits of motive power. In this situation, the inclusion of complementary services, including training, becomes an important element for creating change. This is reaffirmed in the study by Peters et al. (2009)[4,] who examine the impact of developing rural electricity with complementary services as opposed to just financing hardware and civil works. Complementary services in their study refer to advocacy for taking up and using electricity. These services comprise sensitization campaigns

to raise awareness amongst households, enterprises, and social institutions of both the advantages and disadvantages of electricity.

According to Kirubi et al. 2008; Brew-Hammond, 2009; Mustonen2010[5], With respect to commercial electricity users, complementary services can be broadened to cover business development services, consumer and micro-finance services, and other infrastructure, telecommunications and transport.

Kirubi et al. (2008)[6] conducted fieldwork in Kenya and reported that electricity enabled the use of electric power tools and equipment, which resulted in an increase in the productivity of enterprises studied. These ranged from retail shops, grain mills, petrol garages, and welding and carpentry businesses.

It is, however, difficult to draw firm conclusions from the empirical studies and project evaluation reports that have attempted to assess the impact that rural electrification has had on income-generating activities. Wamukonya and Davis's (2001)[7] study in Namibia reported that electrification did not have a significant impact on the growth of income-generating activities in rural areas.

From a study of "Socio-economic Baseline Study of the Rural Electrification Development Project (REDP) (2009)[8]" it can be concluded that the literacy rate in RE households (already electrified and to be electrified by 2010) is 10% higher than the NON-RE (not electrified and not to be by 2010) households. However, in RE, the number of employed members was lower than that of the NON-RE group. A huge difference is seen in yearly income and expenditure as RE households seem to be in a better position than NON-RE. But, there is no significant difference in women's empowerment and migration.

Empirical evidence shows that corruption inhibits efficient electric power supply in many countries. According to Lampietti (2004)[9], Losses of 10–15 percent, as observed in Hungary and Poland, are consistent with fully commercialized electricity utilities. Continuing corruption and theft and the use of outdated distribution equipment keep losses above the desired levels in other countries.

Bangladesh is reported to be one of the world's most corrupt countries. According to the 2005 *World Development Report* (World Bank 2004a), 58 percent of Bangladeshi businessmen surveyed say that corruption is a major constraint in their operations. The corruption problem has also been published in dailies.

5.0 Research Methodology

For the above research, the primary data of 380 households was collected using a questionnaire. Data were collected from 7 districts: Chandpur, Shariatpur, Narshingdi, Kurigram, Noakhali, Barisal, Chapainababganj. The personal

interview method of data collection was applied to obtain information from households under RE and non-RE. The study collected opinions about rural electrification concerning economic, health, education, household, entertainment, agriculture, and women empowerment. A convenient sampling method was applied, and the sample size was determined using the following formula:

$n = \frac{pqz^2}{d^2} = (1.96^2 * .5 * .5)/0.05^2 = 380.16 \sim 380$

Assuming P = 0.5 (that is assuming 50% of households are benefitted from electrification) and d= 5% = 0.05.

After entering the data into the computer and making the necessary corrections, all statistical analyses were done using well-known statistical software SPSS, STATA, and R. The Propensity Score Matching and Binary Logistic regression Model were fitted to analyze the data in this study.

6.0 Findings of the Study

6.1 Findings from Propensity Score Matching

Propensity score matching (PSM) is the most commonly used matching technique, and it goes further than directly matching observable characteristics. The PSM technique was calculated for both treated (with electricity) and untreated (without electricity) samples, and the probability of treatment or electrification as a household function was calculated using a logic or probit model. This probability of adopting electricity, calculated for households both with and without electricity, is called the propensity score.

A simple comparison of households with and without electricity just gives a snapshot of the outcomes without any consideration as to what causes them. These households may fundamentally differ in initial characteristics and their ability to access electricity. The calculated benefits may be due to the difference in households' characteristics rather than in having electricity. We address this problem in part by using a matching technique. At the heart of any matching technique lies the identification of a counterfactual, which identifies households with similar characteristics but with intervention.

The propensity technique first involves matching households with and without electricity based on observed pre-intervention attributes. After this matching is done, it is possible to observe the difference in average outcome values between the two groups. Households that cannot be matched are discarded from this comparison process. We want to analyze the effect of Rural Electrification on households (Farm and non-farm). Here, both variables are coded as binary variables. We need to first calculate the propensity score. Our

study found that age, schooling years, yearly crop production, and yearly total income are confounding factors for households having electricity. The result of the model used to create the propensity score is given below:

Table 1: Results of the model used to create the Propensity Score

Variables in the Equation							
		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	AGE1	0.052	0.013	2.135	1	0.113	1.005
	EDU1	0.027	0.088	0.096	1	0.757	1.028
	CROP	0.945	0.376	4.674	1	0.102	2.865
	HH1_TOTAL	0.928	0.328	4.004	1	0.136	2.880
	Constant	-0.609	0.805	1.572	1	0.019	0.544
a. Variable(s) entered on step 1: AGE1, EDU1, CROP , HH1_TOTAL.							

The model shows that age, education, yearly crop production, and yearly total income may significantly affect households having electricity. So, to get a better result, we need to control this confounding factor. We can do this by matching propensity scores. To conduct matching, we need to classify the case and control group by this propensity score. Here, our control group is households out of rural electrification. There is no automatic way to do this by using SPSS. Instead of matching, we will adjust the propensity score, which will have a significant impact on us.

Now, we discuss how a propensity score adjustment can be done. Here, we need to know the effect of electricity on household's total expenditure. To do this, we need to run a logistic regression model. In this logistic regression model, we consider "household type as farm and non-farm" ("1" –Household type Farm & "0" –Household type Non-Farm) as a dependent variable and household total income and predicted probability (PRE_1) as covariates.

Table 2: Results of the regression model to adjust the Propensity Score

		B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
Step 1[a]	HH1_EXPEN	.501	.348	2.471	1	0.013	1.507
	PRE_1	2.562	1.510	3.624	1	0.054	12.221
	Constant	-1.362	1.656	0.677	1	0.000	.156

a. variable(s) entered on step 1: HH1_EXPEN, PRE_1

This result shows that, after controlling age, schooling years, yearly crop production, and yearly total income. So the adjusted effect of yearly expenditure for the households under rural electricity is 1.507 in terms of odds ratio, which is

highly significant. Now, we want to know what happens if we use Logic instead of predicted probabilities. Logic is defined as: Logic = $\ln\left[\frac{PRE_1}{1-PRE_1}\right]$

The result of this regression model is given below:

Table 3: Results of the logit regression model to adjust the Propensity Score

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	HH1_EXPEN	0.719	0.287	2.549	1	0.010	1.652
	Logit	0.923	00.710	1.929	1	0.125	2.319
	Constant	-1.752	0.321	30.316	1	0.000	.125
a. Variable(s) entered on step 1: HH1_EXPEN, logit.							

From the table, we see that by using logic instead of predicted probability, the odds ratio becomes 1.652, which is also very similar to the previous one and highly significant. Now, we do not feel comfortable stopping the analysis here. Because households' yearly total income level may be a strong confounder for electricity effects. So, we need to make further adjustments to the "yearly total income level" and run again a logistic regression model. The result of this regression model is given below:

Table 4: Results of the logit regression model for further adjustment of the Propensity Score

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	HH1_EXPEN	.654	0.393	2.766	1	0.016	1.824
	Logit	1.856	0.704	4.106	1	0.019	5.945
	HH1_TOTAL	1.475	0.488	5.075	1	0.021	3.004
	Constant	-4.070	1.073	14.383	1	0.000	0.017
Variable(s) entered on step 1: HH1_EXPEN, logit, HH1_TOTAL.							

The result shows that the odds ratio becomes 1.824, which is also highly significant. So, we can see that households with electricity give us 1.824 times more significant results than non-rural households. We can say that the PSM technique showed us that rural electrification has a significant and generally positive impact on income, expenditure, and education. Households having electricity significantly impact education, economical and agricultural sectors more than households without electricity.

6.2 Findings from Binary Logistic Regression Model

The binary logistic regression model is used to identify the contributing factors and predict the probability of success, that is, the probability of occurring the event. If the outcome variable is dichotomous, then the logistic regression model gives precise results. Our response variables depend on several factors. Here, our motive is to identify the contribution of different factors that are found to be responsible for the occurrence of the event. We want to fit a logistic regression model for Rural Electrification, for which we select living conditions at electrification and non-electrification as the binary variable, and the independent variables are- Electricity type, Age, sex, Housing amount, Total Expenditure, and Income. For all independent variables, the last category is the reference category.

Original Value	Internal Value
RE	1
NRE	0

Table 5: Results of the Binary Logistic Regression Model

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	AGE1	0.003	0.014	0.042	1	0.037	1.003
	EDU1			6.266	4	0.018	
	EDU1(1)	0.201	0.518	.150	1	0.008	.818
	EDU1(2)	0.699	0.538	1.691	1	0.003	2.012
	EDU1(3)	0.643	0.491	1.714	1	0.044	1.902
	EDU1(4)	0.252	0.531	0.225	1	0.025	1.287
	HOUSING_A			0.636	2	0.824	
	HOUSING_A(1)	-0.253	0.340	0.555	1	0.456	0.776
	HOUSING_A(2)	-0.073	0.390	0.035	1	0.852	0.930
	HH1_TOTAL			0.607	3	0.046	
	HH1_TOTAL(1)	0.238	0.491	0.235	1	0.021	0.788
	HH1_TOTAL(2)	0.002	0.439	0.000	1	0.039	0.998
	HH1_TOTAL(3)	0.082	0.417	0.038	1	0.045	1.085
	HH1_EXP			0.496	2	0.040	
	HH1_EXP(1)	0.188	0.416	0.204	1	0.011	0.828
	HH1_EXP(2)	0.256	0.363	0.496	1	0.004	0.774

The variable "Education" is a categorical variable. This variable has "five" categories (i.e. 1=no schooling, 2=primary, 3=Secondary, 4=Higher secondary 5= Higher education). So, we need to consider one category as a reference category to interpret the results. Here, we consider the 1st category of no schooling to be a reference category. All p values for the remaining four categories of the variable

education are significant. For Edu(1), exp(B) = .818 indicates that the probability of a household under RE is .818 times by education level primary education over the no education, keeping all other covariates remain constant. For Edu(2), exp(B) = 2.012, which indicates that the probability of a household under RE is 2.012 times by education level secondary education over the no education, keeping all other covariates remain constant. For Edu(3), exp(B) = 1.902, which indicates that the probability of a household under RE is 1.902 times by education level higher education over the no education, keeping all other covariates remain constant. For Edu(4), exp(B) = 1.287 indicates that the probability of a household under RE is 1.287 times by education level higher education over the no education, keeping all other covariates remain constant.

The table shows that the p-value for housing is greater than 0.05, which is insignificant, so we deduct this variable from the model. For HH1 TOTAL(1),exp(B)=0.788, indicates that the probability of household under RE is .788 times by household head total yearly income 100001-200000 over the 50000-100000 keeping all others covariate remain constant. For HH1 TOTAL(2),exp(B)=.998, indicates that the probability of a household under RE is .998 times by household head total yearly income 200001-300000 over the 50000-100000, keeping all other covariates remain constant. For HH1 TOTAL(3),exp(B)=1.085, indicates that the probability of household under RE is 1.085 times by household head total yearly income of more than 300000 over the 50000-100000 keeping all other covariates remain constant. For HH1 EXP(1),exp(B)=0.828, indicates that the probability of household under RE is .828 times by household head total yearly expenditure 100000-200000 over the 40000-100000 keeping all others covariate remain constant. For HH1 EXP(2),exp(B)=0.774, indicates that the probability of household under RE is 0.774 times by household head total yearly expenditure 100000-200000 over the 40000-100000, keeping all other covariates remain constant.

7.0 Conclusion

The benefits of rural electrification have long been debated in the development literature. Although a large number of studies have found positive associations between rural electrification and development outcomes, there have been few studies that have tackled the issue of causality after taking care of endogenic biases. This study is one of the few that have addressed the issue of correlation versus causation head-on. This study has been made possible by employing robust econometric techniques that tackle counterfactual and endogenic issues, which often limit the quality of impact assessment exercises.

In the end, it must be admitted that all cross-sectional analyses have their shortcomings, and moreover, assessed impacts may be short-term. The patterns observed today may not hold in the future. Panel analysis gives a better opportunity for evaluation of longer-term impacts of development projects. REB in Bangladesh is now conducting a follow-up survey of the same households. Once that data is available for analysis, the findings of this study may be put to the test. According to the findings in this study, the rural electrification program has a strong and robust impact on both economic and educational outcomes.

Reference

Barnes, D. F., Peskin, H. M., & Fitzgerald, K. B. (2012). *The benefits of rural electrification: A reassessment of the costs and benefits*. The World Bank.

Kandahar, Shahidur R., Barnes Douglas F., Samad Hussain A. (2009). The welfare impact of rural electrification: A reassessment of the costs and benefits. An IEG Impact Evaluation. Washington DC: World Bank.

Kirubi M. (2008), Brew- Hammond (2009), Mustonen. Rural Electrification And Rural Development (Revised by cook, p.)

Kirubi M.(2008), Socio-economic impacts of rural electrification in Namibia:Comparisons between grid, solar and unelectrified households. Energy Sustain Development,5(3), 5–13.

Kraft & Kraft (1978). Rural Electrification And Rural Development (Revised by cook, p.)

Lampietti, N. (2004), Survey of Productive Uses of Electricity in Rural Areas.

Peters, W. (2009), Energy efficiency and conservation in the developing world. Policy paper.

Ruth (2005, 123–124), Rural electrification and development in the Philippines: Measuring the socialand economic benefits. Energy Sector Management Assistance Programme.

Socio-economic Baseline Study of the Rural Electrification Development Project (REDP) (2009).

Waddle, D. (2007). Rural Electrification Through Decentralized Off-grid Systems in Developing Countries, Green Energy and Technology.

Wamukonya G. and Davis Y. (2001), Rural electrification in developing countries: A reappraisal. Energy Policy, 329–338.

World Bank. (2008). *The welfare impact of rural electrification: A reassessment of the costs and benefits*. Washington, DC: The World Bank.