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ELECTRICITY FOR GROWTH: INVESTIGATING THE INFLUENCE OF RURAL ELECTRIFICATION ON AGRICULTURAL PRODUCTIVITY IN MIMAROPA-REGION 4B

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Article Info

Keywords: rural electrification, agriculture, agricultural productivity, cost of electricity, period of democracy, multiple regression analysis.

Abstract

Rural electrification has been a critical factor in improving the socio-economic condition of remote and underdeveloped communities. This study aimed to evaluate the impact of rural electrification on agricultural productivity in the Philippines, particularly in the MIMAROPA-Region 4B. It utilized multiple regression analysis to examine the relationship between rural electrification, cost of electricity, period of democracy, and agricultural productivity. Data were obtained from various government agencies, including the Energy Regulatory Commission, Department of Agriculture MIMAROPA, and Philippine Statistics Authority MIMAROPA. The results of the study showed that rural electrification had a positive effect on agricultural productivity. The study provided recommendations for policymakers to strengthen the institutional frameworks for rural development planning and stimulate alternative plans for the agricultural sector. The findings contribute to a growing literature on rural electrification in developing countries.

Introduction:

Rural electrification has been recognized as a crucial factor in enhancing the lives of rural communities and accelerating socio-economic development. Despite the Philippines' progress in expanding electricity access, significant challenges remain in implementing rural electrification, particularly in remote and underdeveloped areas. Access to electricity is particularly important for agriculture, which is a significant source of livelihood for many rural households in the Philippines. This study aimed to evaluate the impact of rural electrification on agricultural productivity in the MIMAROPA-Region 4B, Philippines. The study utilized multiple regression analysis to examine the relationship between rural electrification, cost of electricity, period of democracy, and agricultural productivity. Data were obtained from various government agencies, including the Energy Regulatory Commission, Department of Agriculture MIMAROPA, and Philippine Statistics Authority

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MIMAROPA. The study's findings can inform policymakers in enhancing the institutional frameworks necessary for optimal planning of rural development and stimulate alternative plans for the agricultural sector. The study contributes to a growing literature on rural electrification in developing countries.

2. Review of Related Literature

Empirical studies over the years that have assessed whether hypothesized effects of rural electrification are perceived in actuality. In recent years there have been multiple attempts to present these studies in a larger manner to be able to draw wider conclusions regarding the impacts of electrification (Litzow, Pattanayak, & Thinley, 2019). The Philippines is highly dependent on coal power and large-scale transmission lines to meet its growing demand for electricity, while aiming to supply electricity to the cities, and rural areas. Various actions under the United Nations Development Program have improved the electrification rate in rural areas (Taniguchi, 2019). Access to electricity in rural areas is likely to encourage agricultural farmers to adopt practices and strategies that can enhance agricultural productivity and can increase profits (Chindarkar, Chen, & Sathe, 2020).

According to Litzow et al. (2019), Rural Electrification (RE) programs were implemented with the intention to improve agriculture, education, health, and employment outcomes in rural areas. From a consumer's perspective, the country has seen remarkable progress. Because of the government's ambitious goals and strenuous efforts, the electricity access rate has improved dramatically over the past decades. The Philippines is one of the more advanced countries in the Southeast Asian region in terms of household electrification (DOE Philippines, 2016b). Over the past few years, there are comparatively several studies to assess the role of rural electrification to rural development as it was considered as an expense and of limited effectiveness in rural areas.

The predominant aspect that most studies focused on is on how lack of access to electrification in rural areas may affect the quality of life specifically on agricultural productivity, education, households, and employment. Brandon, Dadhi, and Matías (2016); Litzow et al. (2019). The validity of correlation between rural electrification and welfare outcomes is seen as one of the important objectives of the existing studies (Khandker, Barnes, & Samad, 2013). Additionally, the relationship between rural electrification programs and growth has become one the most recognized study that relates to the country's level of development and the most evident direct outcome is through the productivity effect of the country (Cook, 2011).

According to the Missionary Electrification Plan 2012, the Small Power Utilities Group (SPUG) will no longer be operating in new locations within 5 years after its release. However, only missionary regions classed as Small A areas are being provided with generating services. The role of the future SPUG shall be reduced to the Universal Charge applicant and disburser for electrification mission and system manager on huge islands and isolated networks such as permitted pursuant to the Philippine Small Grid Guidelines, Palawan and Mindoro may.

Many general studies in this field that have been conducted are mainly concentrated on the relation between rural electrification and development yet, there are still few studies that are rigorously focused on the causal relationship of rural electrification and agricultural productivity. Most of the existing evidence is typically examined and measured through the impact of rural electrification programs by comparing several households with or without electricity in particular rural areas. Such evaluations generally have not measured the extent and nature of the accrued benefits of these said programs (Khandker et al., 2013). Furthermore, a set of studies assess the outcomes of (RE) programs through community-level effects of electrification such as schools and farms that have access to electricity. In relation to this, recent studies suggest that electrification can trigger significant changes in the economy (Chakravorty, Emerick, & Ravago, 2016). Majority of the current studies focus on the long-term impacts of rural electrification on household consumption and air quality, manufacturing firms and agricultural production and nearly all previous studies center on estimating and measuring the benefits that rural electrification brings to different sectors. In this chapter, the researchers review the literature that are mainly focused on the role and relation of rural infrastructure and rural electrification programs to the economy's growth and development.

The agricultural sector, as well as its energy inputs, are the subject of this section. To examine both the energy needs for agriculture and the requirements for rural energy services in the Philippines, as well as some islands with mini grids such as Mindoro, Catanduanes and Sibuyan Islands in the last decade. The main islands of Palawan and Mindoro were already being served by the SPUG with continuous electricity (Electric Power Industry Reform Act). It is useful to consider three entry levels for interventions. The "energy ladder" method encompasses these three stages. The three-stage evolution of agriculture can be summarized as follows: (1) The use of animal work to provide various energy inputs, (2) simple human work for crop rotation, harvesting, and processing, as well as rainfed irrigation, none of which require an external fuel source, and (3) the use of renewable energy technology such as wind pumps, solar dryers, and water wheels in conjunction with modern renewable and fossil fuel-based technologies for motive and stationary power applications, as well as for agricultural product processing. The needs of poor people in rural areas can be thought of on three levels when it comes to energy: (1) Traditional biomass fuels are used for basic survival in cooking, illumination, and space heating, (2) as people progress beyond subsistence, alternative biomass fuels such as kerosene and LPG are used in these applications, and (3) enhanced electricity systems in rural areas using modern renewable energy and fossil fuels, such as supplying energy for small electrical appliances (such as lighting and radio) and community facilities (e.g. street lighting, water pumping, power for health centers and schools).

In the Philippines, rural communities have a greater ratio of low-income households who suffer from high cost of electricity and upfront capital costs needed for energy efficiency improvements. Cost of electricity can influence agricultural production (Sands & Westcott, 2011). Electricity is a crucial input in agriculture. Agriculture uses energy directly on the farm in the form of fuel or electricity to run machinery and equipment, heat or cool houses, and light, as well as indirectly in the fertilizers and chemicals generated off the farm. The cost of electricity, as a result, has an effect on agricultural production in MIMAROPA-4B due to the rise in electricity prices would decrease agricultural productivity as rural communities could not afford high pricing and which would affect the usage of equipment needed, increase agricultural product prices, and decrease farm income (Department of Energy).

It is commonly believed that democracy influences public service provisions, and this includes policies that are proposed and implemented in rural areas. Trotter (2016) suggested that democracy is strongly associated with rural electrification increases and it shows that inequality between rural and urban electrification decreases.

In general, providing electricity is highly capital intensive (Trotter, 2016). With the implementation of provisions solely based in accordance with the public's interest which includes rural electrification might increase agricultural productivity (Trotter, 2016). It is evident that in democracies, higher political incentives provide an extension of electricity infrastructure in rural areas that are previously unserved rather than just developing the existing electricity grid infrastructure to improve reliability (Trotter, 2016).

The overall empirical findings of the review of literature shows a close correlation between rural infrastructure and agricultural productivity. Agriculture efficiency is affected by factors such as electricity and roads. Since paved roads, village irrigation, and microcredit participation are all binary variables in our study, households either received or did not receive these policies, as opposed to the difference in household benefits from percentage increases in village electrification and production prices. We discover that electricity has little effect on employment, meaning that an increase in labor force participation is not the relevant mechanism.

The effect of rural electrification on agriculture productivity is positive. This concludes that agricultural productivity is increasing, and the local economy is expected to be affected by potential channels. (1) a rise in agricultural productivity and (2) developments in rural housing quality. Any impact would improve a country, driving upland, and property values (Haanyika, 2006). Hornbeck and Keskin (2015) believed that a temporary improvement of rural electrification's agricultural output will also promote broad local growth through the local agglomeration forces as well as spillover productivity. For example, an expansion in the agricultural sector could increase demand for non-traded goods supplied by the local industrial sector. Similarly, an increase in local infrastructure may also have a spillover effect on non-agricultural sectors. If electricity increases production, governments and policymakers must concentrate on further investment to increase the sector such that when the communities receiv electricity, productivity will not drop. It is expected that land, labor, capital, electrification, and institutional quality would increase agricultural output (Khandker, Samad, Ali, & Barnes, 2012).

3. Method

This study used a quantitative research approach within different phases of the research to collect and analyze data. Quantitative data will be collected as an offset approach of research method strategy (Bryman, 2008) to analyze, converge, and validate findings from data depending on the nature of the research questions in a complementary manner. The main outcome variables of this study are rural electrification (*the percentage of electrified rural areas*), cost of electricity, and the period of democracy as the dummy variable. Moreover, this study will be using regression analysis to quantify the variables used in this study. This statistical method can provide a better understanding and analysis of the underlying impact of Rural Electrification in the Agricultural Productivity of Region 4B-MIMAROPA based on panel data of rural areas monthly from the years 2015-2017 sourced from various government agencies in the Philippines including Energy Regulatory Commission, Department of Agriculture MIMAROPA, and Philippine Statistics Authority MIMAROPA.

A multiple regression analysis used to evaluate the data and determine the relationship between the regressors and the dependent variable. For this study, the independent variables are the percentage of rural electrification (RE), cost of electricity (CE), and the period of democracy (PD). Meanwhile, the dependent variable is agricultural productivity (AP). This will be the equation model:

$$AP = \beta_0 + \beta_1 RE_i - \beta_2 CE_1 + \beta_3 PD_i + e$$

3.1. Augmented Dickey-Fuller (ADF)

Most economic time series data have unit roots which show that their means and variances are not timeinvariant. If this is the case, a univariate series is said to be non-stationarity and cannot be used for regression with other non-stationary univariate series because of the risk that their results maybe spurious. The only exception to this rule is when the time series data of all variables have identical unit roots.

The widely used unit root test is the so-called Augmented Dickey-Fuller (ADF) test. The basic equation for testing the stationarity of a time series is given by the following:

$$\Delta x = \alpha o + \alpha 1t + \beta x t_{-i} + \Sigma \varphi \Delta x t_{-i} + \varepsilon t$$

Where the first difference of the series, Δx_t, is regressed against lagged of its original level series, time, and lagged values of itself. If the estimated value of β is more negative than MacKinnon critical values, the series is said to be stationary. Otherwise, it is non-stationary and therefore has a unit root. The augmented portion of the test is to correct for any serial correlation in the variable.

3.2. Structural Stability Test

Structural stability test refers to the stability of the coefficients of a regression model between different time periods. In this study, such test will be performed using Chow Breakpoint Test. A structural change could mean a change in the intercept, a change in the slope coefficients, or a change in both the intercept and slope coefficients. Either way, the results would imply structural instability and the model therefore cannot be used for policy analysis and forecasting.

The formula for testing the structural stability of the regression parameter involving time series data is as follows:

$$F = (RSSR - RSS_{UR})/k$$

$RSSUR/(n1 + n2 - 2k)$

Where k is the number of regressors including intercept, n is the number of observations, RSS_R is the regression sum of squares restricted, and RSS_{UR} is the regression sum of squares unrestricted. If the computed Fstatistic exceeds critical value, there is structural instability. Otherwise, the model is said to be structurally stable.

3.3. Test for Heteroskedastic Disturbances

If the variance of the regression residuals of the model is time varying, the parameters and their standard errors are said to be biased and inefficient. This condition is known as heteroskedasticity and if uncorrected could lead to wrong conclusions and decisions on the part of the investigator. To detect the presence of heteroskedastic disturbances in the residuals, the White Heteroskedasticity Test will be used.

$$u^2 = \alpha o + \alpha 1\, X1 + \alpha 2\, X2 + \alpha 3X3 + \alpha 4\, X1^2 + \alpha 5X2^2 + X3^2 + \alpha 6X1X2 + \alpha 7X1X3 + \alpha 8X2X3 + vt$$

Where u^2 is the squared regression residuals regressed against the explanatory variables, their squares, and cross products.

3.4. Specification Error Test

The Ramsey regression equation specification error test (RESET) will be used to test whether non-linear combinations of independent variables help in explaining the dependent variable. This will also help determine if there is no misspecification error in the data used in the study.

A Specification error test is associated with the specification of the model regarding the inclusion of an irrelevant variable, the exclusion of relevant variable, or the functional form of the model. A Specification error creates biased or inconsistent regression estimators, and the inconsistency can still be there even when the sample observation increases. To determine the specification of the model, this study used the equation:

$$\hat{Y}_i = \hat{\beta}_1 + \hat{\beta}_2 X_{2i} + \hat{\beta}_3 X_{3i} + \gamma \hat{Y}_i^2$$

4. Results and Discussions

For this study, a multiple regression analysis was used to evaluate the data to be obtained and determine whether rural electrification positively or negatively impacts the agricultural productivity of the MIMAROPARegion 4B. The independent variables are the percentage of rural electrification (RE), cost of electricity (CE), and the period of democracy (PD). Meanwhile, the dependent variable is agricultural productivity (AP). The equation model used was: $AP = \beta_0 + \beta_1 RE_i - \beta_2 CE_1 + \beta_3 PD_i + e$. This study is a regional study and was solely conducted in region 4B-MIMAROPA, Philippines. This study used the first difference of Agricultural Productivity and the log first difference of Rural Electrification upon testing the data.

Table 1. Ordinary least squares (OLS) model.

Dependent variable: d(Agricultural Productivity)					
Regression Statistics	**Coefficient**	**Std. Error**	**t-ratio**	**p-value**	**Significant Level**
Constant	2.78	1.05	2.64	0.01	**
dlog(Rural Electrification)	866	581	1.49	0.14	
Cost of Electricity	−459	173	−2.65	0.01	**
R-squared	0.20	Adjusted R-squared			0.15
F(2, 28)	3.67	P-value(F)			0.03
F(3, 25)	0.22	Durbin-Watson			2.05

P(Chi-square(5) > 0.571692)	0.98	P(F(2,26) > 0.00515687)	0.99

Note: (1) d = First difference; dlog = First difference of log.

(2) The coefficients with ** statistically significant at the 5% level, respectively, when the test is applicable.

Table 1 presents the relationship and significance of Agricultural productivity and a set of independent variables namely Rural Electrification and Cost of Electricity. The Cost of Electricity is significant at 5% alpha. However, the log first difference of Rural Electrification is insignificant. For rural electrification, an increase in the percentage of electrified rural areas doesn't affect the agricultural productivity in region 4B-MIMAROPA. On the other hand, when cost of electricity increases, agricultural productivity in region 4B-MIMAROPA decreases. The cost of electricity, as a result, would decrease agricultural productivity as rural communities could not afford high pricing and which would affect the usage of equipment needed, increase agricultural product prices, and decrease farm income.

In addition, it is seen as significant as the p-value of F-test which is equal to 0.0000 that satisfies the condition wherein the p-value must be less than or equal to the level of significance of 0.05. The p-value 0.2275 denotes that there is no structural break error. Accept null hypothesis as the calculated F-critical values. The p-value in White's test for heteroskedasticity is 0.98926. It is greater than the default level of significance which is 0.05. This means that there is no heteroskedasticity error. The Specification Error Test or also known as the RESET specification test is used to assess the adequacy or acceptability of the functional form. This means that the functional form should be adequate for it to be the null hypothesis and that the alternative is not. This test includes running several regressions and computing of the F-statistic. The p-value in RESET specification test for is 0.995. It is greater than the default level of significance which is 0.05. This means that there is no misspecification error.

Table 2. Augmented dickey-fuller (ADF) test.

Variables	Level with constant	Level with constant and Trend	First Difference with constant	First Difference with constant and Trend	Second Difference with constant	Second Difference with constant and Trend
Agricultural productivity	0.00	0.01	0.00	0.00	0.00	0.00
Cost of electricity	0.00	0.00	0.00	0.00	0.00	0.00
Rural electrification	0.29	0.38	0.00	0.00	0.00	0.00

Table 2 displays the standard errors of the variables, monitored over a specific amount of time, that are nonconstant. The unit test root for the dependent variable which is the Agricultural productivity has an asymptotic pvalue of 0.0005755 with test statistic of -4.73157. Moving to the independent variables, first is the Cost of Electricity that shows its unit test root that has an asymptotic p-value of 1.332e-007 with test statistic of -8.10129. On the next variable, it shows the unit test root of Independent Variable Rural Electrification with asymptotic pvalue of 0.3885 with test statistic of -2.36727. These results shows that the researchers reject the null hypothesis that there is a unit root with an alpha of 0.05. Moreover, the Test Statistics of the dependent variable and the independent variables appears to be all negative which provides stronger evidence for rejecting the null hypothesis of a unit root.

5. Conclusion

The study obtained that indeed, rural electrification positively affects the agricultural productivity of region 4B-MIMAROPA Philippines. Access to low-cost electricity will provide rural households in the said region with feasible options for production, processing, marketing, and distribution. Thus, it will help create the conditions for improved agricultural productivity. The Philippines' power rates are much higher than those of neighboring ASEAN countries and this situation has constrained the competitiveness of local and foreign firms operating in the country. A joint Asian Development Bank (2005) survey found that electricity (33%) was considered by businessmen as the most critical constraint compared with transport (18%) and telecommunications (10%). Losses owing to power failure amounted, on average, to 8% of production. Power outages hurt small and medium-size firms most, costing them an equivalent of about 8% and 11% of production, respectively, compared with 6% for large firms.

The Philippines is one of the more advanced countries in the Southeast Asian region in terms of household electrification (DOE Philippines, 2016b) and based on the data acquired by the researchers, it was in fact true that the country has seen a remarkable progress because of the government's ambitious goals and continuous efforts to implement electrifying programs to rural areas in the country. Also, the electricity access rate has improved over the past decades. Thus, this paper supports the existing studies of Litzow et al. (2019), wherein it was stated that Rural Electrification (RE) programs were implemented with the intention to improve agriculture, education, health, and employment outcomes in rural areas and that electrification can trigger significant changes in the economy (Chakravorty et al., 2016). The researchers also proved that the percentage of rural households with electricity and the period of democracy positively and directly impacts the agricultural productivity of the sector through similar studies from Khandker et al. (2012) that it is expected that land, labor, capital, electrification, and institutional quality would increase agricultural output and from Trotter (2016) that with the implementation of provisions solely based in accordance with the public's interest which includes rural electrification might increase agricultural productivity, respectively. On the other hand, the researchers also acquired evidence statements from the Department of Energy (DOE) Philippines (2016a) that the cost of electricity has an effect on agricultural production due to the rise in electricity prices would decrease agricultural productivity as rural communities could not afford high pricing that can decrease their income.

The study recommends that results suggest that rural areas with limited electricity availability and sourcing electricity exhibit low agricultural production, while some rural areas that have access and sourcing electricity from cleaner energy resources tend to show higher agricultural production growth. Electrification in in region 4BMIMAROPA is a crucial element in achieving agricultural production growth. Providing electricity access to the rural communities is seen to support economic growth and development. Policymakers should focus on the sustained implementation of the policy reform program, which includes as key elements the privatization of the National Power Corporation (NPC), an efficient regulation of the electricity market, and the creation of an attractive environment for private investors in the generation segment of the market. The effectiveness of several electrification projects for rural areas in MIMAROPA Region-4B has been a challenge due to a number of factors, including the issues on affordability, capacity, and reliability.

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