Electricity and Employment Diversification

Evidence from sub-Saharan Africa.

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Abstract

This study examines the impact of electrification on employment diversification across the agriculture, service, and manufacturing sectors, with a particular focus on sub-Saharan African Countries (SSA). Motivated by the persistently low electrification rates in many SSA countries, I investigate whether electrification drives shifts in employment patterns and whether its effects are amplified in countries with lower baseline electrification. Using OLS, with a panel data for 66 countries from 2000 to 2019, I find that one percentage-point increase in a country's electrification rate reduces employment in agriculture by 0.33 percentage points, while employment in other sectors increases. Subgroup analysis of SSA and non-SSA countries reveals no significant divergence, except for manufacturing in SSA, where electrification appears to have a negative effect—though this result is inconclusive due to the potential omitted variable bias. These findings suggest that increasing electrification rates plays a crucial role in creating jobs and transitioning sub-Saharan African economies away from subsistence agriculture toward more diversified and productive economic activities.

I. Introduction

While developed countries are inventing and adopting cutting-edge technologies, like artificial intelligence, many developing countries are still lagging to catch up with the basic technology of the Second Industrial Revolution, such as electricity(Panos et al., 2016). We are currently experiencing the 4th industrial revolution[1] (Groumpos, 2016); however, many countries in sub-Saharan Africa have not yet fully embraced the first 3 industrial revolutions that formed the

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[1]As Groumpos shows, the First Industrial Revolution, characterized by the use of water and steam to mechanize agriculture and production, led to the second industrial revolution during which the discovery of electricity revolutionized manufacturing.

basis for the 4th. The electricity that revolutionized the economy throughout the history is still scarce and unreliable in the SSA region. More than 573 million people, one in two people, in SSA, lacks access to electricity, making it the region with the largest access deficit (International Energy Agency et al. 2019). In addition to this low electrification rate, SSA still has the highest employment rates in agriculture, as the agriculture sector is still manual and requires a great deal of labor(Table 7 & 8). The agriculture sector employs more than 50% of the workforce in the region on average, indicating a low degree of employment diversification. I analyze the relationship between electricity and employment diversification using 66 countries' data from different regions. I then conduct a separate analysis for 34 countries in sub-Saharan Africa. I hypothesize that for countries with low electrification rates and high agriculture employment rates, which include most of the SSA countries, an increase in electrification would lead to a greater change in employment rates than countries with already high electrification rates. Using Ordinary Least Square, controlling for country and time fixed effects, I begin with a general analysis of electrification and employment relationships in 66 countries and then proceed with a more targeted analysis to prove my hypothesis.

The importance of running regional or country-based analysis is to be able to give a personalized recommendation based on each country's situation. The models indicate that as electrification rates increase, agriculture employment declines while employment in service and manufacturing increases, which simply means that electricity shifts employment from agriculture to other sectors. The results I obtain from running two separate models on SSA and non-SSA groups do not support my hypothesis. However, more in-depth studies are necessary to find out what SSA should particularly do to diversify its employment while growing its economy. The rest of the paper is organized as follows: Section 2: Review of some literature and employment and electrification across countries. Section 3. Data. Section 4: Model and empirical methods. Section 5: Results and discussion. Section 6: Conclusion.

II. Employment and Electrification: Literature Review

Since its invention during the Second Industrial Revolution, electricity has played a paramount role in society. Today, many high-income and middle-income countries have reached their 100% electrification rates. However, many low-income countries across Asia and sub-Saharan Africa remain among the least electrified countries in the world. Figure 1 illustrates, for example, the average electrification rate across countries used for this study from 2000 to 2019. In blue are countries that are not part of SSA, while in red are countries that are part of it.

Average electrification rates are over 100% in countries like Australia, Belgium, the Netherlands, Switzerland, and so on, whereas they are less than 10% in countries like Mali, Chad, and Burundi. The electrification rate in SSA countries is generally lower than that in other countries, and most of them have a rate below 50%.

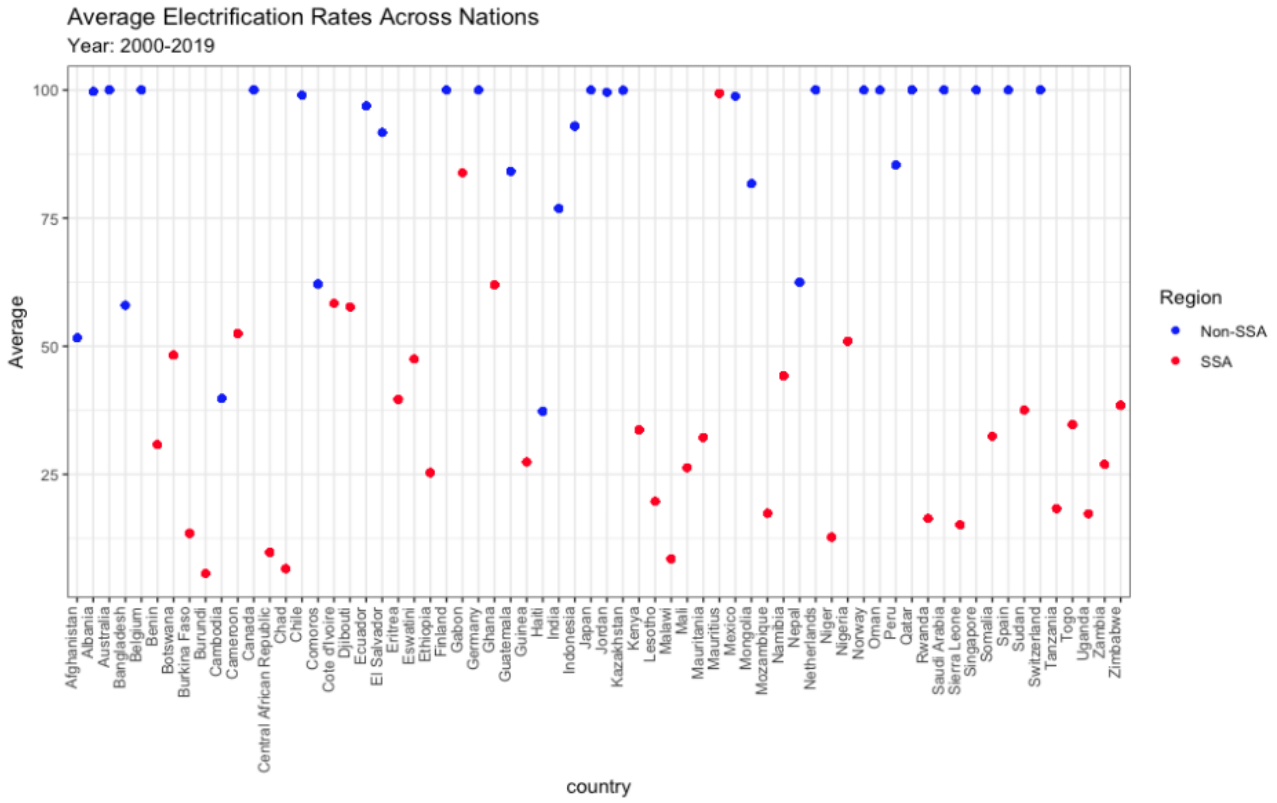

Figure 1: Average electrification rate.

As shown in Figure 2, the countries that had low electrification rates in Figure 1 now have the highest employment rates in agriculture. The average employment rate in agriculture in Belgium, Australia, the Netherlands, Singapore, etc., is currently below 5%, while it is above 75% in Burundi, Mali, and Chad. The sub-Saharan African region has the highest employment rate in agriculture, and most of these countries have average employment rates exceeding 50%. Many of the countries with a high concentration of labor in the agriculture sector still practice labor-intensive agriculture, which explains why the First Industrial Revolution has yet to fully take hold. Besides having the highest employment rates in agriculture, sub-Saharan Africa also has the highest unemployment rates among young people. According to the African Development Bank report in 2020, unemployment rates among people with intermediate or advanced levels of education in Africa are the highest globally because of the mismatch between skills and jobs. Africa needs to create 12M new jobs every year to keep the current unemployment rate constant (AFDB, 2020). Increasing the electrification rate in the region is necessary to create these jobs.

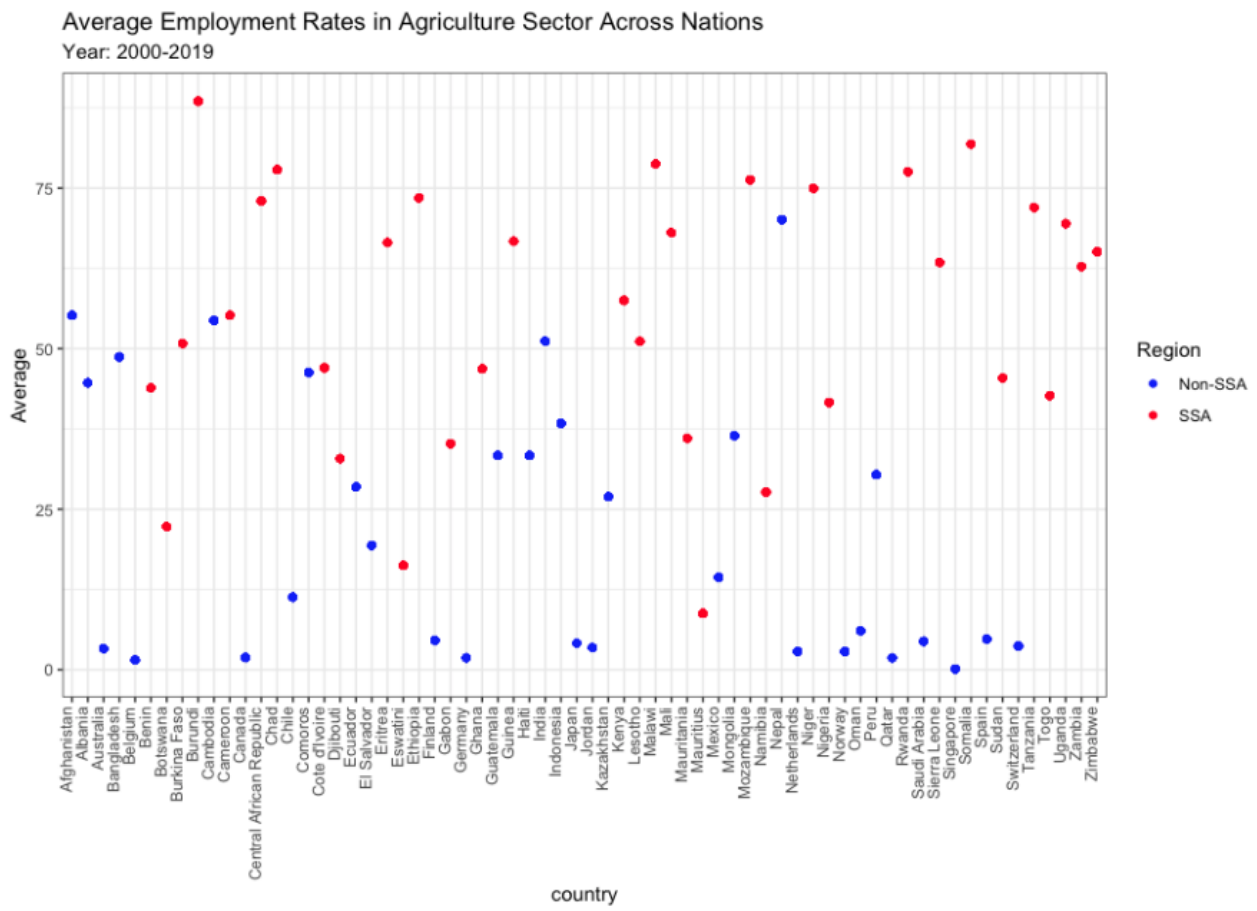

Figure 2: Average employment rate in Agriculture.

Several studies have shown that electricity stimulates investments and innovation, which leads to the creation of more jobs. According to Dinkleman(2011), rural electrification stimulated home businesses while increasing employment for women in South Africa. In 2004, the World Bank reported that electricity had allowed people in India to acquire electric stoves and other electric cooking appliances, which allowed them to spend less time looking for wood and more time on other economic pursuits. According to Grogan & Sadanand (2013), electricity increases the likelihood of rural Nicaraguan women working outside the home by about 23%. A study conducted by Falcone et al. (2020) in Nigeria shows a shift out of agricultural employment by approximately 7% and into non-agricultural employment by approximately 15%, with some evidence of a positive effect on overall labor participation. They suggest that increasing the electrification rate in Nigeria could help shift the economy from the agriculture sector. This paper contributes to the literature by studying the impacts of electrification on employment diversification in sub-Saharan Africa and comparing it to other countries in other regions.

III. Data

I use panel data, employment rates by sector and country electrification rates from 2000 to 2019 for 66 countries. The main sources of my data are World Bank and GapMinder open sources. Based on data availability, I use 34 sub-Saharan African countries and 32 non-SSA countries. These non-SSA countries include countries from different continents, low-, middle -, and high-income countries are all included. The countries are selected based on data availability. Table 1 and 2 show summary statistics of the key variables used in this paper. Electrification rate, which is the percentage of the population with access to electricity in each country and each year, is the independent variable or the regressor. The explanatory variables are: employment rate in agriculture, employment rate in manufacturing, and employment rate in service sector, which are the percentages of each country's workforce employed in respectively agriculture, manufacturing, and service sector. As presented in those two tables, there is a big difference in means. The mean of electrification rate is smaller in SSA countries while the average employment rate in agriculture is bigger, compared to the averages in non-sub-Saharan countries.

Table 1: Summary Statistics of the Variables for sub-Saharan African Countries

variable	Obs	min	mean	median	st.dev	max
Electrification Rate	680	1.30	33.86	30.05	23.24	100.00
Agriculture(Emp-rate)	680	5.97	55.81	60.95	20.68	91.80
Manufacturing(Emp-rate)	680	0.39	6.75	5.38	4.78	28.80
Services(Emp-rate)	680	5.98	33.15	30.35	15.09	70.40

Note: This is a summary statistics of the 4 variables used in this study. This table summarizes the rates of electrification, employment in agriculture, manufacturing,and service sectors from 2000 to 2019 among the 34 sub-Saharan African countries

Table 2: Summary Statistics of the Variables for Non sub-Saharan African Countries

variable	Obs	min	mean	median	st.dev	max
Electrification Rate	640	4.45	88.06	99.79	21.16	100.00
Agriculture(Emp-rate)	640	0.03	21.56	13.40	21.01	75.30
Manufacturing(Emp-rate)	640	1.31	11.44	11.30	4.44	23.80
Services(Emp-rate)	640	14.20	57.15	61.10	17.98	84.40

Note: This is a summary statistics of the 4 variables used in this study. This table summarizes the rates of electrification, employment in agriculture, manufacturing,and service sectors from 2000 to 2019 among the 32 non sub-Saharan African countries

For more details, I present summary tables, Table 7 and 8 in the appendix, that show the

averages of the variables used in this paper per country. Those tables contain all the countries used in my sample and the smaller averages in electrification rates and higher averages of employment in agriculture are still visible at country level.

IV. Methodology and Empirical Model

To estimate how changes in electrification rates drive changes in employment in my three areas of interest, a simple OLS model can be used. The baseline OLS model is estimated using the following equation:

$$Y_{it} = \beta_0 + \beta_1 electricity_{it} + \epsilon_{it} \tag{1}$$

Where Y is the dependent variable such as a country's rates of employment in the agriculture sector, service sector, and manufacturing sector in year t. However, relying simply on this approach can be subject to omitted variable bias.

To avoid running into omitted variable bias, I use country and year fixed effects, respectively controlling for unobservable time and country invariants. Including the fixed effects, the equation becomes:

$$Y_{it} = \beta_1 X_{it} + \alpha Z_i + \lambda T_t + \epsilon_{it} \tag{2}$$

Where αZ_i is country-fixed effects, factors that remain invariant across time but vary across countries (time invariants). λT_t is time-fixed effects, factors that vary across time but remain invariant across countries (Country invariant); ϵ_{it}: the error term. To estimate this fixed effect model, I use within-group estimation by demeaning the values. The second model becomes:

$$Y_{it} - \overline{Y_i} = \beta_1(X_{it} - \overline{X_i}) + \alpha(Z_i - \overline{Z_i}) + \lambda(T_t - \overline{T_t}) + (\epsilon_{it} - \overline{\epsilon_i}) \tag{3}$$

The purpose of this technique is to avoid reporting each country's coefficients individually. Otherwise, I would have to create a table for 66 countries, which would take up a significant amount of space.

In addition to analyzing the impact of changes in electricity on employment in general, I also perform the same analysis for specifically sub-Saharan African countries and compare the results with non-sub-Saharan African countries. According to the Solow growth model, economies grow faster at lower levels of capital until they reach a steady state. Based on this analogy, changes in electrification should have relatively bigger effects on changes in employment diversification in countries with lower electrification rates than countries with higher electrification rates, that have already reached a steady state. Increase in electricity should lead to more innovation and

rapid economic growth in countries with lower electrification rate, which would shift higher rates of employment from agriculture to other sectors. I use the 4th equation to model this potential difference in effects. I create an indicator variable that is equal to 1 if a country is in sub-Saharan Africa and zero otherwise.

$$Y_{it} = \beta_1 X_{it} + \alpha Z_i + \lambda T_t + SSA + \epsilon_{it} \tag{4}$$

I this equation estimate, analyze, and compare the effect of electricity on employment across those two groups. I run two separate regressions, one for countries within the sub-Saharan African region and one for countries outside the region.

V. Results and Discussion

A simple OLS linear model is presented in Table 1 columns 1 to 3, and an OLS with fixed effect is shown in columns 4 to 6. With Fixed Effects, the coefficients are generally smaller than just the OLS, implying a positive bias.

Table 3: Effects of Electrification on Employment

	Dependent variable: Employment Rates in:					
	Without Fixed Effects			*With Fixed Effects*		
	Agriculture	Manufacturing	Service	Agriculture	Manufacturing	Service
	(1)	(2)	(3)	(4)	(5)	(6)
Electricity	-0.656^{***}	0.473^{***}	0.087^{***}	-0.331^{***}	0.247^{***}	0.022^{***}
	(0.011)	(0.009)	(0.003)	(0.011)	(0.010)	(0.005)
Constant	78.665^{***}	16.331^{***}	3.788^{***}			
	(0.769)	(0.653)	(0.229)			
Observations	1,320	1,320	1,320	1,320	1,320	1,320
Adjusted R^2	0.728	0.658	0.347	0.379	0.302	−0.033

*Note: Robust standard errors are in parentheses, clustered per country. Columns 1 to 3 are estimated without country and year fixed effects and the last three columns include the fixed effects. Significance levels are : *p<0.1; **p<0.05; ***p<0.01*

The results from the last three columns show a significant effect of electricity on employment. One percentage point increase in electrification in a particular country within a particular year leads to a 0.33%-point decrease in employment rate in agriculture, a 0.022%-point increase in manufacturing, and a 0.25%-point increase in service employment, all else equal. All the

coefficients on electricity are statistically significant at a 1% significance level. These results are consistent with Falcone et al.(2020) study in Nigeria, where they show that an increase in electrification rates reduces agricultural employment by 7% while increasing employment in other sectors by 15%.

Since I was interested in determining whether electrification has a greater effect on employment diversification in SSA than in other countries, I ran an FE model on these two groups (SSA and non-SSA) separately. The results are presented in Table 4 where columns 1 to 3 are for the SSA group and the last 3 columns are for the other group. Except for employment in the manufacturing sector, there is no significant difference between the groups. The increase in electrification in SSA countries will result in a decline in manufacturing employment, whereas the opposite is true in non-SSA countries.

Table 4: Sub-Saharan Africa vs. Non-Sub-Saharan Africa

	Dependent variable: Employment in:					
	Agriculture	Manufacturing	Service	Agriculture	Manufacturing	Service
	(1)	(2)	(3)	(4)	(5)	(6)
Electricity	-0.315^{***}	-0.015^{**}	0.285^{***}	-0.347^{***}	0.059^{***}	0.209^{***}
	(0.019)	(0.006)	(0.014)	(0.011)	(0.007)	(0.013)
SSA	Y	Y	Y	N	N	N
Non-SSA	N	N	N	Y	Y	Y
Observations	680	680	680	640	640	640
Adjusted R^2	0.252	-0.043	0.353	0.608	0.067	0.252

Note: Robust standard errors are in parentheses. This is a fixed effect regression with region control. In the first three models, I restrict the sample size on for countries in sub-Saharan Africa. The the last three models have sample size of the non-sub-Saharan Africa countries. Significance levels are : $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

The same comparison can be done on country basis. I select a subset of countries used like a sub-sample of the bigger sample. I chose the countries based on their economic outlook to include all levels of economies. The summaries are presented in table 5 below.

Table 5: Average Rates Across Selected Countries from 2000-2019

country	Electrification	Agriculture	Manufacturing	Service
Afghanistan	70.05	50.90	6.32	33.55
Bangladesh	50.29	54.10	10.62	31.05
Benin	30.15	45.45	16.00	35.40
Burundi	5.98	88.10	1.70	8.84
Chad	5.93	78.70	1.16	19.30
Ethiopia	21.33	74.20	5.18	18.15
Guatemala	87.44	32.35	14.30	46.85
India	85.00	48.05	11.70	29.20
Indonesia	92.03	39.65	13.35	40.50
Mexico	98.52	15.25	17.25	59.60
Rwanda	8.50	83.35	1.84	12.25

Source: Author's calculation.

Table 6 presents the results of the country-based analysis model. Regression of individual countries is carried out based on their level of average employment and electrification rate. My objective is to determine whether an increase in electrification in a country with a low electrification rate would result in a greater change in employment than in a country with a high electrification rate. Based on the results of this analysis, my assumption is not 100% supported. One percentage point increase in electrification for a country like Mexico whose average electrification rate is 98.5% with 15% employment in agriculture would result in a reduction of 1.3 percentage points in agriculture employment. An increase in the electrification rate in Burundi, a country with an average electrification rate of 6% and an average agricultural employment rate of 88%, would result in an approximately 0.8 percentage point reduction in agricultural employment.

I can be hard to draw a full conclusion from these results without further studies. There might be other factors not fully addressed in this paper that might be affecting the results. One example of the factors that can cause less effect of electrification on employment diversification in those country whose electrification rates are low is unreliability of that electricity or simply electricity outages. According to Zhang et al. (2018), the greatest barrier to business development in developing countries is the lack of reliable energy infrastructure, which directly impedes industrial production. An increase in outage frequency can hinder both domestic and foreign investment as well as the creation of other small businesses that rely on power, which can hinder

Table 6: Country-based Analysis

	Dependent variable:										
	Employment Rate in Agriculture										
	(Afghanistan)	(Bangladesh)	(Benin)	(Burundi)	(Chad)	(Ethiopia)	(Guatemala)	(India)	(Indonesia)	(Mexico)	(Rwanda)
Electricity	-0.252^{***}	-0.377^{***}	-0.456^{***}	-0.791^{***}	-0.885^{***}	-0.322^{***}	-0.316^{***}	-0.503^{***}	-1.143^{***}	-1.629^{***}	-0.704^{***}
	(0.014)	(0.040)	(0.055)	(0.066)	(0.087)	(0.026)	(0.045)	(0.020)	(0.095)	(0.261)	(0.072)
Observations	20	20	20	20	20	20	20	20	20	20	20
Adjusted R^2	0.948	0.821	0.780	0.882	0.845	0.888	0.721	0.970	0.883	0.666	0.832

Note: Robust standard errors are in parentheses. This is an OLS regression model at country level using countries with low electrification rates and high employment in agriculture and countries with high electrification rates and low employment rates in agriculture to assess how effect of electrification on employment rate in agriculture compare. Unit of observation is year, from 2000-2019. Significance levels are : $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

the growth of employment in other fields. According to Osei-Gyebi and Dramani (2003), in their study of firms in sub-Saharan Africa, outage frequency and outage duration combined to reduce yearly sales of firms by $114.9, making them uncompetitive. Poczter (2016) concluded that unreliability negatively impacts productivity both initially and over time, with the effect being greater for smaller firms. Despite an increase in electricity, these frequent outages can discourage more innovation and growth of manufacturing companies, which can explain why we see a negative relation between electricity increase and employment in manufacturing. As many firms in SSA are still small and lack sufficient capital to grow quickly, increased electrification may not be benefiting them as it should be. This might impede their ability to grow and employ many people in comparison to countries that have reliable and cheaper electricity. It may be possible to address my initial hypothesis by controlling for outages and reliability of electricity in sub-Saharan Africa; however, this is beyond the scope of this paper and might be an appropriate topic for future research.

VI. Conclusion

I use OLS and control for time and country fixed effects to analyze the impact of electrification on employment diversification. The results with the full sample of 66 countries, show that a country's increase in electrification rate reduces employment in agriculture and increases employment in other sectors such as services and manufacturing. These results suggest that SSA should prioritize investments in the energy sector to raise electrification rates and reliable electricity provision. This can help SSA countries catch up to the rest of the world through new technologies and innovation. Increase in innovation and investments will spur production and labor productivity while creating more jobs, which will lower the reliance on agriculture for employment. Because SSA countries have the lowest electrification rates and the highest employment in agriculture, I was interested in understanding whether the effects of electrification on employment might be greater. Coefficients for SSA countries don't greatly differ from the rest of the countries and individual country analysis results don't align with my hypothesis. Rather, an increase in electrification is negatively associated with employment in the manufacturing sector in SSA. I do not assume a causal relationship between electrification and employment in manufacturing in SSA; I believe the model does not adequately capture other underlying factors, such as the reliability of electricity in the region. Even if I control for fixed effects, factors capturing the quality of electricity provision in SSA are time-variant and should be included in the model as regressors. This limitation opens doors for future research

to deeply examine the impact of electrification on employment by controlling for the frequency and duration of power outages and other factors affecting electricity reliability in SSA.

Appendix

Table 7: Averages per Country (SSA)

	country	mean_elect	mean_agri	mean_manuf	mean_service
1	Benin	30.78	43.89	15.66	37.21
2	Botswana	48.24	22.25	7.15	58.48
3	Burkina Faso	13.49	50.83	11.24	30.16
4	Burundi	5.66	88.54	1.70	8.51
5	Cameroon	52.48	55.18	9.13	32.62
6	Central African Republic	9.79	73.00	5.09	19.74
7	Chad	6.57	77.86	1.13	20.12
8	Cote d'Ivoire	58.37	47.02	8.29	41.05
9	Djibouti	57.68	32.88	8.51	53.72
10	Eritrea	39.64	66.51	4.82	25.38
11	Eswatini	47.47	16.22	18.04	57.83
12	Ethiopia	25.33	73.50	5.20	18.55
13	Gabon	83.84	35.19	2.05	54.56
14	Ghana	61.96	46.84	11.84	37.58
15	Guinea	27.40	66.72	2.72	27.76
16	Kenya	33.67	57.52	3.54	35.55
17	Lesotho	19.71	51.12	9.76	35.37
18	Malawi	8.54	78.78	4.10	15.43
19	Mali	26.33	68.06	5.03	23.90
20	Mauritania	32.21	36.06	11.43	46.04
21	Mauritius	99.33	8.74	18.64	61.20
22	Mozambique	17.38	76.30	2.34	18.16
23	Namibia	44.22	27.66	5.64	57.47
24	Niger	12.74	74.99	6.30	17.61
25	Nigeria	50.98	41.62	8.63	46.90
26	Rwanda	16.37	77.55	1.89	16.82
27	Sierra Leone	15.14	63.44	1.70	30.48
28	Somalia	32.43	81.88	1.58	15.47
29	Sudan	37.55	45.43	7.72	40.09
30	Tanzania	18.34	71.98	2.81	22.70
31	Togo	34.69	42.70	11.30	42.96
32	Uganda	17.34	69.48	5.14	23.07
33	Zambia	26.94	62.78	3.99	28.50
34	Zimbabwe	38.47	65.08	5.30	26.00

Source: Author's calculation.

Table 8: Averages Per Country (Non-SSA)

	country	mean_elect	mean_agri	mean_manuf	mean_service
1	Afghanistan	51.63	55.18	5.57	30.88
2	Albania	99.68	44.67	7.74	38.02
3	Australia	100.00	3.29	9.27	76.10
4	Bangladesh	57.99	48.71	11.88	34.76
5	Belgium	100.00	1.49	15.12	75.22
6	Cambodia	39.80	54.38	12.23	27.99
7	Canada	100.00	1.88	11.52	76.95
8	Chile	98.99	11.29	12.22	65.43
9	Comoros	62.12	46.30	8.85	36.89
10	Ecuador	96.87	28.46	11.27	52.80
11	El Salvador	91.70	19.36	16.12	58.25
12	Finland	100.00	4.58	16.10	71.16
13	Germany	100.00	1.85	20.92	68.82
14	Guatemala	84.16	33.35	14.70	45.63
15	Haiti	37.32	33.35	1.46	59.71
16	India	76.88	51.15	11.71	27.46
17	Indonesia	92.95	38.37	13.10	41.84
18	Japan	100.00	4.12	17.64	69.11
19	Jordan	99.56	3.41	12.78	71.86
20	Kazakhstan	99.92	26.92	6.98	54.24
21	Mexico	98.77	14.38	16.84	60.13
22	Mongolia	81.72	36.44	6.53	46.46
23	Nepal	62.47	70.11	7.37	17.01
24	Netherlands	100.00	2.83	11.80	78.67
25	Norway	100.00	2.82	10.19	76.64
26	Oman	99.99	6.05	5.95	67.56
27	Peru	85.35	30.35	9.77	54.05
28	Qatar	100.00	1.85	8.88	48.84
29	Saudi Arabia	99.99	4.42	7.37	73.58
30	Singapore	100.00	0.11	15.11	78.34
31	Spain	100.00	4.76	14.55	70.26
32	Switzerland	100.00	3.67	14.48	74.21

Source: Author's calculation.

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