Labor supply and welfare effects of electricity in Ghana: Does geography matter?

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Abstract

This paper examined the causal effect of access to electricity on labor outcomes such as employment, wages, as well as employment shift in the agriculture and service sectors in Ghana. As an alternative measure of electricity access, this paper exploits the complementarities between access to electricity, water, and public transport by constructing an infrastructural index using principal component analysis. Using the three latest waves of the Ghana Living Standard Survey (round 5, 6, and 7), the slope of land was used as an instrument for electricity and the infrastructural index. The results of the instrumental variable estimation showed an increase in wages whilst inducing shifts in employment from the agriculture to the service sector because of access to electricity and improvement in the infrastructural index. The shift in employment is statistically significant for females only. Additional welfare analysis showed that access to electricity and improvement in the overall infrastructural index leads to significant increase in the demand for some durable goods whiles reducing the demand for others. Several policy measures in improving the labor market and investment in durable goods arising from availability of public infrastructures in the country were provided.

Keywords: Labor supply, Welfare, Electricity, Slope of land, Ghana.

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1 Introduction

Electricity demand is a good indicator of a country's economic growth and development. Whenever countries experience expansion in various economic activities as a result of improved access to public infrastructures (for instance electricity, clean water, road, public transport services, hospital, school), earnings and demand for labor in the traditional sectors may equally be affected (see for instance Lewis et al., 1954; Dinkelman, 2011; Khandker et al. (2012, 2013); Lipscomb et al., 2013; Grogan and Sadanand, 2013; Dasso and Fernandez, 2015; Storeygard, 2016; Van de Walle et al., 2017; Burlig and Preonas, 2016; Lee et al., 2020).

With the level of growth in Ghana where this study focuses, one will expect expansion in employment opportunities leading to reduction in unemployment.[1] Contrary to this expectation, underemployment and unemployment, particularly among the youth remains high. Understanding how access to electricity (and other public infrastructure) affects socioeconomic development is of importance to leaders and policymakers in Ghana as this will enable them to match the huge capital investment associated with these infrastructural projects to the benefits that they accrue.[2] Essentially, countries and development bodies are not only concerned about percentage increase in access to electricity (out of total population) but also on how such projects affect socioeconomic wellbeing of individuals, societies and enterprises in terms of labor supply, education, health, income, among others.

The main objective of this paper is to investigate effects of electricity on employment, earnings of wage and salaried workers, as well as employment shift in the agriculture and service sectors. In Ghana, like other developing countries experiencing services sector boom, the manufacturing sector has been leapfrogged by the service sector with limited labor capacity. This has caused employment shift to be directly from the agricultural sector into the service sector justifying the focus on these two sectors. This study contributes to an emerging literature analyzing the impact of public infrastructure on different outcomes in Ghana (Mensah et al., 2014, Akpandjar and Kitchens, 2017; Adu et al., 2018, Adusah-Poku and Takeuchi, 2019).

The paper also examine complementarities between access to electricity, water and public transport using principal component analysis to generate a composite index (hereafter, WEP) as

[1]The countries GDP growth (annual %) was estimated to be 8.1% by the end of 2017 (World Bank (2020b)).

[2]Universal electrification poses as a huge challenge for developing Asia and Africa. It is reported by IEA (2017) that an estimated amount of \$31 billion is needed annually in order to be able to electrify the whole of Africa by 2030 as part of the Sustainable Energy for All (SE4All) agenda of the United Nations together with the World Bank.

an alternative to electricity in our analysis. Every sector needs these three public infrastructures to function effectively, each of them play different roles in different sectors, some of which may be interdependent on the availability of others. For instance, access to water will be topmost priority for crop farmers even in the absence of electricity since they can use self-powered water pumps to irrigate their farms. After this, they may be concerned with transportation of the raw produce from the farmgate to market centers for sale Those in manufacturing and services sectors will mostly rely on available power to reach their productivity targets while taking advantage of the other infrastructural services.

In light of this, we argue that access to electricity may lead to contemporaneous expansion of other public infrastructures such as access to water grid and public transport services among others, thereby generating interactive effects on household outcomes. For instance, it is possible that access to electricity may lead to household's connection to water grid or use of electric water pumps, which in turn saves time from going to fetch water from the well or river (Grogan and Sadanand, 2013). Mensah et al. (2014) studied the individual impact of public infrastructures such as electricity, water and public transport using older waves of Ghana Living Standard Survey, GLSS (rounds 3, 4 & 5) and found all three infrastructural variables had different impacts on welfare (expenditure) in rural Ghana. Apart from using a new dataset with larger sample, the present paper differs significantly from Mensah et al. (2014) by constructing a composite measure of public infrastructure to account for the interaction among the individual indicators and analyzing its impact on labor market outcomes (employment).

Gertler et al. (2016) in their paper assessed households' acquisition of electronic assets as a result of increase in household's income. Following this strand of the literature, it is possible that access to electricity may have led to direct ownership of both electric and non-electric durable goods through income gains or just by means of taking advantage of available power. For this reason, we analyze how access to electricity has been welfare-improving in terms of individuals' demand for durable goods such as television, sewing machine, flush toilet, car, shares, among others. We equally examine how an increase in the composite index affects individuals' investment in these durable goods.

Additionally, this paper investigates the prevalence of power outages ("dumsor" as it is called in Ghana) on the outcome variables. Specifically, we contribute to the strand of the literature by analyzing the effect of quality of electricity supply on various outcomes. As documented earlier, researchers have found outages and inadequate supply of power to weaken or reduce the actual developmental effect of electricity since households and firms must incur additional cost by resorting to private generators, among others. For instance, Chakravorty et al. (2014) found that the income of households in rural India with consistent supply of electricity was about three times higher than their cohorts with interrupted electricity supply. For this reason, we estimate and discuss the implications of *dumsor* on the various outcome variables.

This paper differs from previous studies on Ghana by employing a different identification strategy. The dataset used is also different by including the most recent waves of the GLSS, which allows us to capture long-term effects of public infrastructure on the outcome variables of interest. For instance, using 2000 and 2010 census data, Akpandjar and Kitchens (2017) studied electricity on employment and household variables in an OLS approach where they assumed selection on unobservables. Basically, they claimed that, if additional covariates do not lead to significant changes in baseline estimates, then unobservables may not alter the results as well. We argue these conditional mean estimates does not solve endogeneity issues which can be as a result of reverse causality or non-random distribution of public infrastructure especially in a developing country like Ghana. More so, the decision on which covariates to include during baseline estimation and which ones to add for robustness check is an econometric difficulty that a researcher may attempt to overcome just to meet identification assumptions. They alternated this method by using a difference-in-difference analysis at the district level. This led to some changes in their results which they described as the "estimates are less precise" coming from trading-off the granularity of the data (Akpandjar and Kitchens, 2017, p. 3).

The core of empirical work is identification and data after making sense of the theory to be tested. From the above observations, this paper again contributes by resolving the empirical difficulty in the literature on Ghana in correcting for endogeneity in access to public infrastructure. We do this in an instrumental variable (IV) estimation approach, by using the median slope of land at the community level as an IV to correct for endogeneity in both access to electricity and the WEP index. This slope of land variable is taken from EarthEnv which is a part of the suite of topographical variables derived by Amatulli et al. (2018). This ready-to-use slope of land variable is fully standardized and based on the digital elevation model products of 250m Global Multi-resolution Terrain Elevation Data (GMTED) 2010 which is of higher resolution compared to what is mostly taken from the 90m Shuttle Radar Topographic Mission (SRTM). In using the slope of land as an IV, we argue that, conditional on a set of controls at the individual, household, and regional level, the probability of having access to electricity reduces as slope of land increase even before individuals decide to connect to the available grid in a community. It is possible that, based on engineers initial assessments countries that are monetary constrained (a development issue), may choose to supply communities where it is less costly to carryout developmental projects than others – causing supply to be non-random. For the WEP index, we do not disentangle the effect of the IV on electricity from access to water grid and public transport services for the above same reason.

Next, Adu et al. (2018) in their paper tested education and income from non-agriculture enterprises as the main pathways explaining the income and welfare gains for individuals living in electrified homes. As an addition contribution, we take a step further to investigate what non-agriculture enterprises may entail, among others. Specifically, we explore potential mechanisms explaining the main results of the paper by testing the effect of electricity and the WEP index on self-employment, hours of work, and the underground economy. Whenever the agriculture sector does not take advantage of the presence of power to increase productivity and employment, there is a shift in employment to non-agricultural sectors. This means when people have consistent access to electricity, water, and public transport they are more likely to shift to a non-agriculture enterprise as a means of taking advantage of the service sector income-generating activities. Obviously for most subsistence agricultural farmers, shifting to services may mainly be into the informal sector (self-employment and/or underground economy) through establishment of micro-enterprises and may not necessarily be formal based. This is the case in Ghana and for most developing countries since urban inhabitants are often in the service sector with subsistence farming and informal economic activities prevalent in rural areas. Again, access to infrastructure may extend active hours either for leisure or productivity purpose by limiting time spent on household chores, commuting time to workplace, being able to work late with improved lighting (see for instance Dinkelman, 2011).

The main findings of the can be summarize as follows. In general, the results do not suggest significant employment effect as a result of having access to electricity nor an increase in the composite infrastructure index in Ghana. On the contrary, access to electricity and a one standard deviation increase in the WEP index affects earnings of wage and salaried workers positively by 42.9 and 16.9 percent, respectively. When investigating employment shift, we find that access to electricity and a one standard deviation increase in the WEP index reduces employment in the agriculture sector by 64.6 and 37.2 percentage points respectively. On the other hand, access to electricity and a one standard deviation increase in the WEP index increases employment in the service sector by 41.1 and 23.6 percentage points respectively. This employment shift is only significant for females. On investment in durable goods, we find access to electricity and WEP leads to significant increase in the demand of durable goods such as television, refrigerator, mobile phone, flush toilet, car, and motorcycle while reducing demand in sewing machine with no significant effect for shares. Moderate levels (averaging between 6 -12 hours daily) of power outages have positive effect on employment and the agriculture sector with negative effect on service and earnings. Higher levels (between 18-24 hour, for instance) of power outages have no employment effect except it still has a negative impact on wages.

The rest of the paper is organized as follows. In Section 2, the contextual framework of the electricity and employment situation of Ghana over the last two decades is presented. Section 3 discusses the dataset, while Section 4 presents the model and identification strategy. Section 5 presents the empirical analysis and discussions of results, and Section 6 concludes the paper with summary of key findings and policy implications.

2 The context in Ghana

Ghana is unique in several regards: geography, ethnicity in terms of culture and language among others. By 2017, the population of Ghana was estimated to be 29.12 million with a population density of 128 per km^2 by the United Nations, Department of Economic and Social Affairs, Population Division (UN World Population Prospects, 2019).

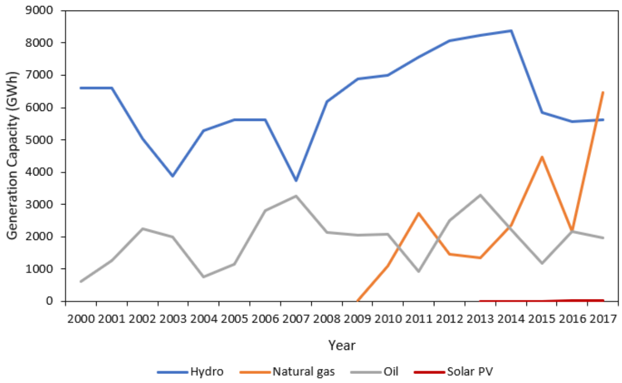
2.1 Energy Sector

The main producers of electricity in Ghana are the Volta River Authority (VRA) and the Ghana Petroleum Corporation. The energy sector has undergone several reforms as an attempt to reduce (if not eradicate) the various challenges either from the demand or supply side.[3] One of such reforms is the Rural Electrification Committee (REC) of 1970 whose main aim was to provide access to electricity for rural Ghana. This was not sustained for lack of funds, as well as lack of commitment from utilities among others. To replace the REC, the National Electrification Scheme (NES) was established in 1989. By the time of its establishment, less than half (i.e. 46 out of 110) of the district capitals were connected to the national grid from earlier

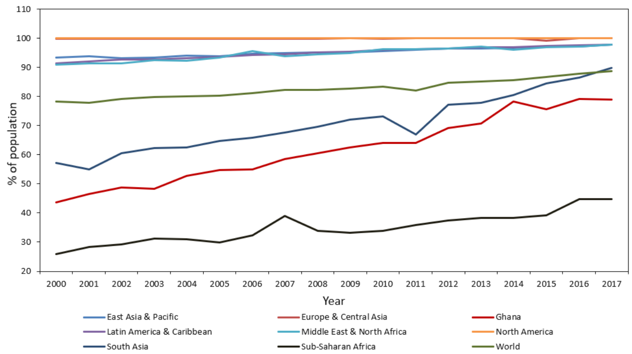
[3]For historical accounts see ISSER, 2005; Kumi, 2017; Kemausuor and Ackom, 2017; Adu et al., 2018; Adusah-Poku and Takeuchi, 2019.

electrification programs (Ministry of Energy, 2010). Unlike REC which focused on improving electricity access in rural Ghana, the focus of NES was to provide reliable power supply to all communities of at least 500 inhabitants by 2020 (30-year period). NES was supported by the National Electrification Program (NEP) and the Self-Help Electrification Program (SHEP). The main goal of SHEP is to encourage towns/communities to contribute in getting connected to the national grid earlier than scheduled (Kemausuor and Ackom, 2017).[4]

Figure 1: Electricity access and generation by source type (2000 – 2017)



(A) Electricity generation by source



(B) Access to electricity

Source: Author's construct from Energy Transitions Indicators, IEA (2020) and SE4ALL, World Bank (2020a)

Until two decades ago, the main source of power in Ghana was hydroelectric which could not meet the growing demand of the population, leading to the introduction of other forms of technologies. Panel (A) of Figure 1 presents the electricity generation capacity (GWh) by source type from 2000 to 2017 with the data taken from the International Energy Agency's Transitions Indicators (IEA, 2020). There have been massive increase in generation capacity from the four main sources, namely natural gas, hydro, oil and solar PV.[5] Hydroelectric sources generated about 5616GWh with natural gas generating 6463GWh, oil producing 1961GWh and solar PV around 28GWh amounting to a total electricity production of 14068GWh in 2017. The final consumption at the time was about 12094ktoe which was distributed among residential (6193ktoe), industry (3071ktoe), commercial and public services (2820ktoe), transport (6ktoe), and agriculture/forestry (3ktoe). This is more than double of what was consumed a decade

[4]Communities that can mobilize and initiate the electrification project who fall under the eligibility criteria are able to get connected earlier than expected. Some of the major eligibility criteria are; (1) a community must apply to be a part of SHEP, (2) the applying community must be at least 20km away from an existing 11kV or 33kV network, (3) the community must erect the low voltage poles needed for inter-house connection, (4) at least one-third of the households must be wired. The summary of this is that poor rural communities may not be able to qualify for SHEP until their scheduled time for connection is due. Which authorities say is purely equity based.

[5]Currently, there are other types of technologies running but their supply are negligible. Among them are wind, solar thermal, renewable etc.

before. In 2008, after a major energy crisis recorded in the previous years caused by drought which lead to reduced water supply in the main power generation source (Akosombo), the total final consumption was estimated around 6139ktoe: residential (2168ktoe), industry (2963ktoe), commercial and public services (1008ktoe). One clear observation is that, the agriculture sector has not benefited from the electrification reforms as intended by most of them.[6]

Data from the World Bank's Sustainable Energy For All, (SE4ALL, World Bank (2020a)) database (Panel B of Figure 1) ranked Ghana as the 7th among 46 countries in sub-Saharan Africa (SSA) with more access to electricity approximated around 79% (out of total population) by the end of 2017 (red line). This put Ghana after countries such as Seychelles (100%), Mauritius (97.4%), Gabon (91.9%), Cabo Verde (91.4%), South Africa (84.4%), Comoros (79.4%). Most of the regions of the world have done well in terms of access to electricity except SSA where this is still below 50% of its 1.05 billion people by 2017. The World Bank's Global Tracking Framework, (GTF) which tracks the progress of SE4All revealed approximately 1.06 billion of the world's population were without access to electricity in 2017 World Bank (2017)). Aside developing Asia, for the 2030 SDG 7 on providing access for all to be met, more capital investment needs to be put into electrification projects in SSA. For instance, as of 2017 the percentage of population with access to electricity in countries such as Burundi, Chad, and Malawi were recorded as low as 9.3%, 10.9%, and 12.7% respectively World Bank (2020a).

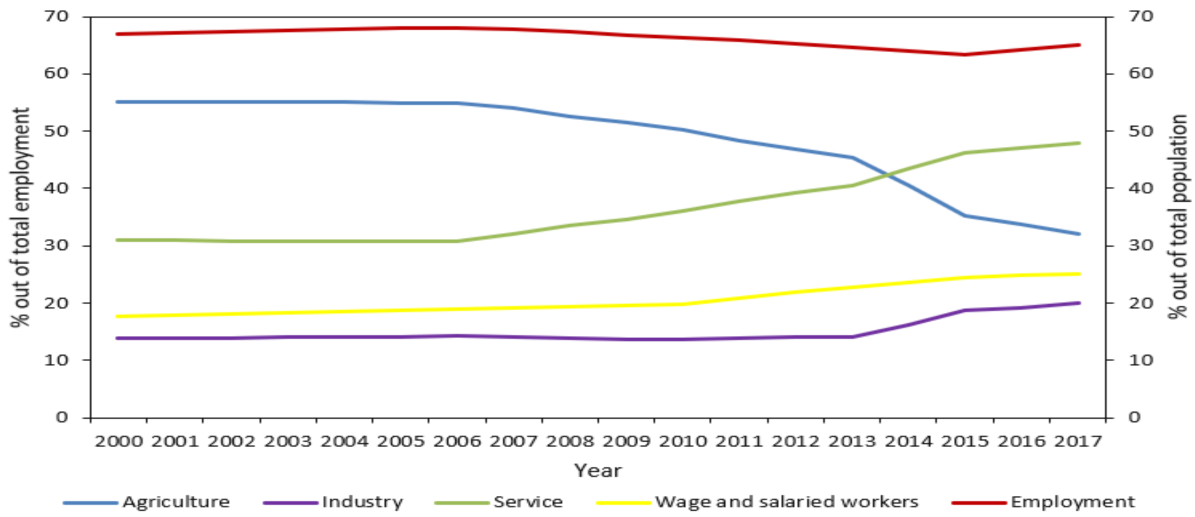
2.2 Employment

Aside the main goal of the various electrification reforms being to provide electricity Ghanaians, they were also aimed at creating jobs, increasing productivity, reducing rural-urban migration, promote agriculture and small-scale businesses, among others. Based on data from the International Labor Organization Statistics database, (ILOSTAT, 2020), Figure 2 presents employment trend from 2000 to 2017. The primary vertical axis accounts for employment in the traditional sectors, wage and salaried workers as percent of total employment and the secondary vertical axis represents percent share of employment out of total population.

Until recently, Ghana has mostly been agrarian with the agriculture sector being the largest contributor to GDP and employment. In general, the level of employment (red line) has not

[6]Although studying agriculture productivity is outside the scope of the current paper, it is possible one may not find any productivity gains for farmers looking at the current level of agriculture consumption. Even so this 3ktoe may have been for commercial purposes which does not reflect most subsistence farmers in Ghana. These farmers may not be able to afford available power in order to be able to adopt electric irrigation and mechanization as was observed in Rud (2012) in India and Lipscomb et al. (2013) in Brazil.

Figure 2: Employment in Ghana (2000 – 2017)



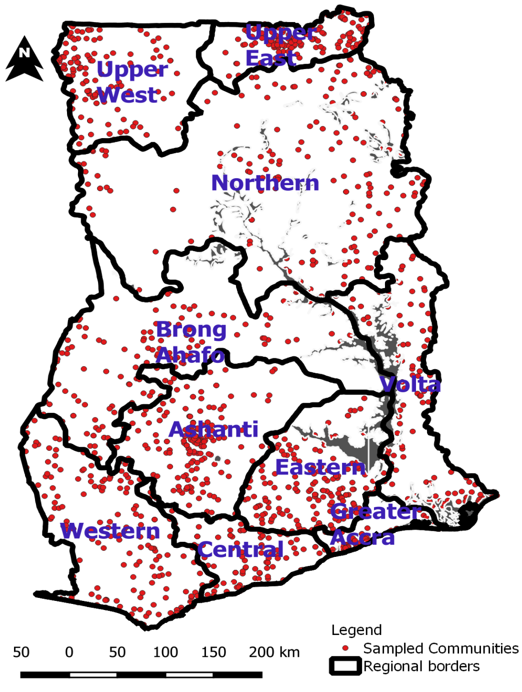
Source: Author's construct from International Labour Organization, ILOSTAT database (2020)

improved but rather decreasing slowly until 2016 when it started picking up. This is not surprising since the government of Ghana (GOG) has had some challenges to meet donor partners strict conditionalities leading to a ban on employment in the public sector. Restrictions from development partners obviously compromise a country's freedom to take certain decisions and in the case of Ghana, employment as that matter. A more recent one is the ban imposed by the International Monetary Fund on public sector employment except for those in the health and education sectors as part of austerity measures to cut spending (IMF, 2015). In that case, the goal to improve access and in turn to create employment can only be a story in the private sector and not in the public sector and as the figures show, they appear not to be performing well on that. What is rather going on is a shift in employment across the various sectors with the agriculture sector (blue line) seeing a drop whereas industry (purple line) and service (green line) sectors having an increased in employment out of total employment especially since 2012. This simply means instead of having agriculture productivity, there seems to rather be sectoral transformation from the agriculture sector to the other sectors. Also, wage and salaried workers (yellow line) are gradually increasing but at a slow rate.

3 Data Description and Measurement

Having looked at the electricity and employment situation in Ghana, we turn to the data used to achieve the objectives of the paper. Two main reliable databases were exploited for the variables used in this work aside the above mentioned. First, the median *slope of land* variable used as an IV is taken from EarthEnv as part of the suite of topographical variables derived by Amatulli et al. (2018).[7] Second, the last three rounds of the Ghana Living Standard Survey (GLSS 5, 6, & 7) data taken from the database of the Ghana Statistical Service (GSS, 2007, 2014, 2018) is also used. This rich geo-coded household survey data is conducted across the country with support from the United Nations Children's Fund (UNICEF), United Kingdom's Department for International Development (UK-DFID), International Labor Organization (ILO), and the World Bank. In all, there are 50,961 (aged 15+) individuals from 19,430 households coming from 1,441 communities in 200 districts across 10 administrative regions of Ghana. The variables used are average responses within the last 7 days prior to the day of the survey at the individual level. Figure 3 is a map of all the communities (red dots) included in the analysis since individual locations are protected for privacy purposes. From the figure we can see a fair representation of our sample across the country.

Figure 3: Sampled communities



Note: Source: Author's construct from GSS –GLSS 5, 6. & 7 with shapefile taken from GADM.

3.1 Key Variables

To achieve the objectives, several outcomes treatments and control variables are selected from the GSS's database.

[7]Details on the construction of this instrument is provided in section (3.3).

3.1.1 Outcome Variables

The *Outcome variables* include employment, wage, sector of employment and assets. $\textit{Employment}$ is measured as a dummy which is equal to one if an individual did any work in the last seven days for pay, profit, gain and zero otherwise. $\textit{Wage}$ is measured as the natural log of labor income for wage and salaried workers. To investigate sectoral shift, we used indicator variables for $\textit{Agriculture}$ which is equal to one if an individual works in the agriculture sector and zero otherwise. $\textit{Service}$ equals to one if an individual belongs to the service sector and zero otherwise. The manufacturing sector is used as a reference group mainly because they account for the smallest share of sectoral employment. To study the effects of electricity access and the infrastructural index, we consider eight different goods which are all dummy variables equal to one if an individual possesses the good and zero otherwise. These goods are $TelevisionSet$, $Refrigerator$, $MobilePhone$, $SewingMachine$, $FlushToilet$, Car, $Motorcycle$, $Shares$.

3.1.2 Treatment/Main explanatory Variables

The main *treatment* variable which is a dummy is equal to one if the household's main source of power is electricity from the national grid. In using this we do not ignore the possibility of access from other technologies such as solar photovoltaics (PV), rechargeable battery, private generators among others. However, we exclude them from our treatment group for three main reasons: (a) electrification from these sources are not affected by terrain, (b) they make up negligible amount of our total sample, (c) for most developing countries, these other sources appear to be too expensive such that their use may only be temporary (for instance for lighting, powering of phones, watching of television for instance) and not long-term employment purposes. Nonetheless we control for their effects especially in our investigation on demand for durable goods as a result of access to electricity since some electrical appliances can be powered from these sources.

3.1.3 Control Variables

This set includes $\textit{Gender}$ which is a dummy equals to one if an individual is a male and zero otherwise. Age and a quadratic ($Agesq$). $MaritalStatus$ is a dichotomous variable equal to one if an individual is married and zero otherwise. We also include household size and a quadratic. Individuals' highest level of educational attainment is captured by $Basic$, $Secondary$ and $Higher$

with *None* being the reference group. To capture household wealth, we control for dwelling place characteristics such as *Mud floor* which is a dummy equal to 1 if main construction material used for the floor where an individual lives is made from mud and 0 otherwise. *Roof material* is another dwelling place characteristic which is dummy equal to 1 if the material used as roofing is made from palm leaves, raffia, thatch, wood, bamboo, mud brick and 0 otherwise. [8]

Table 1: Summary Statistics

Variable	Mean	Std. dev.	Variable	Mean	Std. dev.
Employment	0.720	[0.449]	Gender(=1 if male)	0.472	[0.499]
Wage	8.391	[1.840]	Age	36.802	[17.901]
Agriculture	0.508	[0.500]	Age squared	1674.813	[1628.073]
Services	0.233	[0.423]	Marital status(=1 if married)	0.670	[0.470]
Sewing machine	0.156	[0.363]	Household size	6.120	[3.652]
Refrigerator	0.147	[0.354]	Household size squared	50.783	[69.890]
Television	0.339	[0.473]	Basic education	0.276	[0.447]
Mobile phone	0.668	[0.471]	secondary education	0.084	[0.277]
Flush toilet	0.051	[0.220]	Higher education	0.032	[0.177]
Car	0.029	[0.168]	Mudfloor	0.165	[0.372]
Motor cycle	0.130	[0.336]	Roof material	0.181	[0.385]
Shares	0.005	[0.070]	Local mini grid	0.001	[0.034]
Electricity Main grid	0.480	[0.500]	Solar	0.013	[0.112]
Rechargeable battery	0.004	[0.067]	Self generator	0.002	[0.042]
N			50961^{+}		

Note: (1) $^{+}$ total sample is 50961 except Wage which is 19477. (2) Standard deviation in parentheses [ ]. Source: Author's construct from GSS –GLSS 5, 6. & 7.

Table 1 presents the summary statistics of key variables. From the table, we observe approximately 72% of our sample were employed within the last 7 days of the day of interview. The sample to study earnings is restricted to wage and salaried workers only which is counted around 19,477 instead of the overall 50,961 individuals. On average, approximately 51% of individuals in the sample are involved in some forms of agricultural activities (fishing, crop and animal farming, for instance) with about 23% in the service sector. This is not surprising since it is representative of the work composition in Ghana. Almost half of the sampled individuals have access to electricity. Out of all those who reported to have access to electricity, 96% of them are connected to the national grid with the remaining 4% taking their light from other technologies. In terms of the controls, there are less males, average age around 37 years, mostly married, about 6 individuals in a household, less in mud floor, thatch, leaves, and bamboo

[8]Detailed definitions of the variables are provided in Table A.1 (see appendix A1).

houses.

3.2 Construction of WEP Index

Reduced transport cost and access to clean water contribute to the growth and development of a nation. Constructing an infrastructure index (WEP) which combines access to electricity, water and public transport services can help us understand their joint effect on an outcome (see for instance Raballand and Macchi, 2010; Storeygard, 2016). Using principal component analysis (PCA), we are able to capture complementarities between access to electricity, tap water and public transport services in Ghana. As highlighted above, these public infrastructures may have distinct and joint or complementary roles. Also, other infrastructures maybe extended contemporaneously together with the presence of electricity such as water grid, roads, and public transport services.

To construct the WEP index, by means of the PCA technique, there must be significant correlation among these three primary variables as evident in Table 3. From the matrix we observe significant correlation among the variables at 1% level. This suggest electricity, water and public transport extensions may be simultaneous. In a related study, Dinkelman (2011) rather controls for road which may be correlated with electricity as an additional covariate but for our case, in using the composite index we do not disentangle the effect of electricity, water, and public transport services (instead of road) towards an outcome.

Table 3: Correlation Matrix

	Water	Electricity	Public transport
Water	1		
Electricity	0.4118***	1	
	(0.000)		
Public transport	0.3183***	0.3869***	1
	(0.000)	(0.000)	

Note: P-value in brackets and statistical significance at $^{***}p < 0.01$

Table 4: Principal Component Analysis

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.746	1.063	0.582	0.582
Comp2	0.683	0.113	0.228	0.809
Comp3	0.571	.	0.190	1
Maintained component	1			
N	50961			

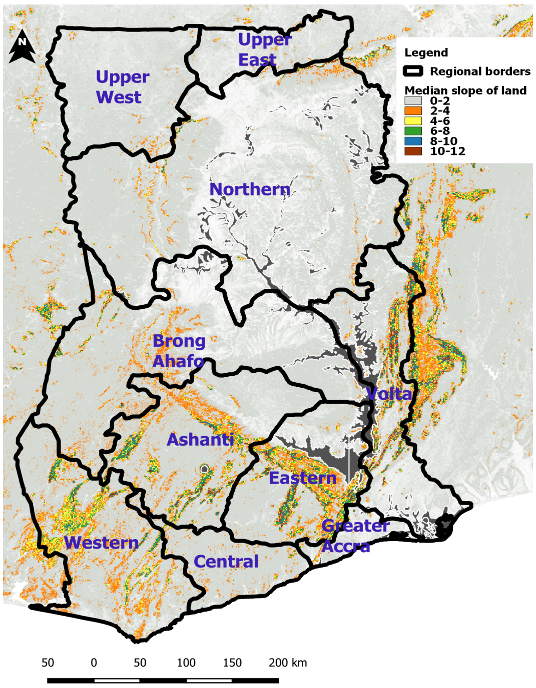
Moving from Table 3, we construct the index using PCA and report the results in Table 4. Using the eigen-value-greater-than-one criterion, we observe only the first component can be maintained. This component explains 58.2% of the cumulative variation across individuals over the survey periods. There seems to be substantial information loss, but we go ahead and use it as an alternative to electricity because the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) also passes the 0.5 threshold at 0.644. Table B.1 reports the proportion of variation explained in each variable towards construction of the index (see appendix B for more details).

3.3 Construction of IV

We now describe the IV used. The ready-to-use suite by Amatulli et al. (2018) take from EarthEnv contains several topographical characteristics including slope of land which they constructed from the 250m Global Multi-resolution Terrain Elevation Data 2010 (GMTED) and the near-global 90m Shuttle Radar Topographic Mission (SRTM). Although the SRTM is widely used, GTMED has higher resolution (250m). For our analysis we use the median slope of land data aggregated at one-kilometer spatial grain constructed from the 250m GMTED. This median slope of land is a continuous variable with higher values as slope of land increases. Since the suite is a raster file, we use geographical information system (GIS) tools to match the geo-location GSS-GLSS data and extract the slope of land at each point to be used as the main IV to correct for endogeneity in electricity access and the WEP index as well. Figure 4 shows the map of slope of land across Ghana.

About half of Ghana lies on low plain with the rest made up of scrubs, high plains with a plateau (Kwahu plateau) in the south-central part as well as rivers and its home to the largest artificial lake in the world (Volta lake). From the 1km median slope of land extracted, the lowest slope is 0 (sea level) and the highest is approximately 12 (Avenui in the Volta region). From section 2 above, one would expect the IV to affect our outcome variables, especially, employment in the agriculture sector. We do not expect this in our case considering majority of the people are involved in different kinds of agriculture farming depending on the part of the country they live: those around the coastal are mostly fish farmers, those in savannah Ghana are mostly into livestock with those in the forest areas involved in crop farming. We test the validity of the IV below.

Figure 4: Slope of land across Ghana



Source: Author's construct from EarthEnv with shapefile taken from GADM

4 Model and Empirical Strategy

Treating access to electricity as an exogenous variable especially in the context of developing countries has gradually become unacceptable among researchers for varied reasons. This is the case for Ghana too, a country where access may strongly be correlated with distance to existing grid (as a requirement of the SHEP), slope of land, among others. The literature in an attempt to correct for endogeneity have followed several approaches: from instrumental variable (Dinkelman, 2011; Khandker et al. (2012, 2013); Lipscomb et al., 2013; Chakravorty et al., 2016; Van de Walle et al., 2017) to regression discontinuity design (Burlig and Preonas, 2016) as well as randomize control trial (Lee et al., 2020). For a particular case in Brazil, Lipscomb et al. (2013) uses topographic characteristics of generation source as an IV for electrification. Hydroelectric source characteristics such as mean, median flow of water may be exogenous but, transmission and distribution to end-users may not be after economic considerations from engineers cost analysis for most developing countries. Even so hydro-electric sources are chosen endogenously taking environmental factors into account.

In the case of Ghana, aside hydro-power sources, other sources are endogenously placed as well. For instance, thermal plants stations are endogenously placed around seaports to reduce cost of transportation of imported fuel to generation centers. That aside, after generation there is transmission cost to sub-stations and eventually distribution to end-users except in the case of others such as biogas, solar. An indication that geographical scope aside eligibility criteria plays a part in the connection process. This means that, given any two eligible communities, electricity will first be extended to the community where the project will be less costly before the other in the face of monetary constraints which is a developmental problem.[9] To resolve the identification challenge, the paper uses slope of land as an IV for access to electricity following the earlier work by Dinkelman (2011). In using slope of land as an IV, we expect that, those on flatter lands should have higher chance of being connected to the national grid. In other words, chances of having access to electricity reduces as slope of land increases.

Now let's consider individual i, living in community c, at survey period t. The system of equations to be estimated in an IV approach can be given as follows:

$$Y_{ict} = \alpha_0 + \alpha_1 \hat{E}_{ict} + X'_{ict}.\lambda + \rho_r + \rho_t + (\mu_i + \epsilon_{ict}) \tag{1}$$

$$E_{ict} = \pi_0 + \pi_1 Z_c + X'_{ict}.\lambda + \rho_r + \rho_t + e_{ict} \tag{2}$$

where Y is outcome of interest (employment, wage, employment in the agriculture and service sectors, assets) and E is access to electricity. Here, X is set of controls which includes individual level characteristics such as gender, age and a quadratic, marital status, household size and a quadratic, educational level and dwelling place characteristics such as building materials used for the floor and roof of the house. Z is slope of land which is the instrumental variable. Also, ρ_r and ρ_t are region and survey year dummies to account for regional and year shocks common to individuals in a region r, at time t. Finally, $(\mu_i + \epsilon_{ic})$ and e_{ic} are clustered unobserved errors at the individual level.

The identification assumption is, conditional on individual and household characteristics, region and year fixed effects, the estimates from the IV are consistent if (a) slope of land does not affect any of the outcome variables except through having access to electricity, and (b) that slope of land is sufficiently correlated with chances of having access to electricity conditional on other covariates.

Using the same idea, we replace E by WEP in equations (1) and (2) so that the slope of land is used as an IV for the WEP index. This means the IV affects an outcome through various channels and not only through access to electricity but also through access to clean water and public transport services. More explicitly flatter surfaces can indirectly lead to

[9] Phone conversations with workers from the energy commission and electricity company of Ghana list equity as the main connection criterion and nothing to do with connecting potential economically attractive areas before others.

reduced construction costs of tap water (and bore holes) in the extension of water grids, as well as roads, railways, and directly translate into reduced transportation costs (for instance fuel consumption and travel time) when using public transport services. The identification now becomes, conditional on individual and household characteristics, region and year fixed effects, the estimates from the IV are consistent if: (a) the slope of land does not affect any of the outcome variables directly except through the WEP index; (b) that the slope of land is strongly correlated with the WEP index.

We are unable to tell the exact location of an individual household in a community because GSS does not provide information on individual-level-geolocation for privacy reasons. Obviously, for a community compromising of approximately sixteen households, it will be near precision to assume the terrain characteristics may not be significantly different for various households. Even if this difference exists (which is possible), it may be negligible. Since we do not know this, we leave it for future researchers to investigate this again in the presence of individual-level-geolocation-dataset which may be interesting, but for now, we use what is available. This may stand as a threat to our identification if there exists important difference in topographical characteristics across households in a community.

5 Empirical Findings

This section is divided into 5 subsections. First, preliminary results from both the IV and the main explanatory variables, that is electricity and the WEP index on the outcome variables while controlling for other characteristics. Second, the main results, followed by estimates using alternative outcome variable. This part also includes an alternative measure of access to electricity, that is, quality of electricity supply. The fourth sub-section is devoted to some heterogeneous analysis and finally, possible pathways explained in the fifth sub-section.[10]

5.1 Preliminary Results

Table 5 report results of electricity access and WEP index on various outcomes while controlling for a set of individual and dwelling place characteristics, as well as region and survey fixed effects in Columns I (models 1 - 4) and II (models 5 - 8) respectively. As stated above one of the identification conditions is that the effect of the IV is not direct towards an outcome but

[10] Appendix C report several heterogeneous analyses well.

through access to electricity and the WEP index. We standardize the WEP index to compare the results to our access to electricity variable. We make this comparison because access to electricity is by default standardized around zero mean for being a binary variable. Since this is well known, we will not be emphasizing on the standardization of the electricity variable but only on the estimates with the WEP index in our analysis. From the table, one can observe the estimated coefficients on the slope of land variable are not statistically significantly different from zero. Holding all other variables constant, the results from models 1 and 2 show that having access to electricity and a one standard deviation increase in the WEP index is surprisingly associated with a reduction in employment by 4.1 and 3.1 percentage points (pp) respectively. These results are inconsistent with the conditional mean estimates by Akpandjar and Kitchens (2017), since they found no significant association of electrification on unemployment in Ghana.

Table 5: Preliminary estimates of electricity & WEP on labor outcomes

	(I)				(II)			
	(1) **Employment**	(2) **Wage**	(3) **Agric.**	(4) **Services**	(5) **Employment**	(6) **Wage**	(7) **Agric.**	(8) **Services**
Electricity	-0.041***	0.285***	-0.167***	0.103***				
	(0.010)	(0.018)	(0.016)	(0.016)				
WEP					-0.031***	0.139***	-0.117***	0.073***
					(0.008)	(0.006)	(0.007)	(0.008)
Slope of land	-0.001	-0.002	0.007	-0.004	-0.001	-0.001	0.006	-0.004
	(0.002)	(0.003)	(0.005)	(0.003)	(0.002)	(0.003)	(0.005)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year & Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.204	0.580	0.210	0.156	0.206	0.580	0.229	0.167
N	50961	19475	50961	50961	50961	19475	50961	50961

Note: Control variables include gender (=1 if male), age and quadratic, marital status(=1 if married), household size and a quadratic, education, household wealth (i.e floor and roofing materials) Robust standard errors clustered at individual level in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ shows the level of significance.

On the contrary, the association between earnings and electricity access as well as an improvement in the WEP index is positive and estimated to be 28.5 and 13.9 percent from models 2 and 6 respectively. In investigating sectoral transformation, the results show that likelihood of being employed in the agriculture sector reduces by 16.7 pp whereas service sector employment is associated with a 10.3pp increase because of electricity access. The result on agriculture is consistent with the estimates of Akpandjar and Kitchens (2017) who found about 12pp reduction in agriculture employment due to electricity access. Again, a one standard deviation improvement in the overall infrastructure index reduces the likelihood of employment in the agriculture sector by 11.7pp whereas employment in the service sector rather increases by 7.3pp. This corroborates the findings by Mensah et al. (2014) who found positive effects of electricity and public transport on a measure of welfare (expenditure) and a rather negative effect from water on rural households in Ghana. They showed for a positive desired effect from access to water, the level of household's public capital endowment must be considered and thus being consistent with the prior expectation of possible complementarities between our primary public infrastructure variables.

5.2 Main Results

Now Table 6 reports consistent estimates from the two-stage least square (2SLS) estimator of the effect of electricity and the WEP index on various outcome variables in Columns I (models 1 –4) and II (models 5–8) respectively. The first stage results confirm the a prior expectation that an increase in slope of land reduces the chance of having access to electricity, as well as the composite index. To check the strength of the IV we report the Kleibergen-Paap rk Wald F statistic proposed by Kleibergen and Paap (2006). All the values are more than the threshold of 10, thus, passing the weak IV test. To compare the performance of the models in Columns I and II, we report the Akaike's information criterion (AIC) and Bayesian information criterion (BIC). These values show the model in investigating access to electricity on the outcome variables perform better compared to when we use the overall infrastructure index since all the information criteria (IC) in Column I are smaller than those in Column II.

Table 6: Baseline 2SLS estimates of electricity & WEP on labor outcomes

	(I)				**(II)**			
	(1) **Employment**	(2) **Wage**	(3) **Agric.**	(4) **Services**	(5) **Employment**	(6) **Wage**	(7) **Agric.**	(8) **Services**
(A) Baseline Results								
Electricity	0.050	0.429*	-0.646**	0.411**				
	(0.132)	(0.244)	(0.292)	(0.177)				
WEP					0.029	0.169*	-0.372**	0.236**
					(0.077)	(0.095)	(0.150)	(0.104)
(B) First Stage								
Slope of land	-0.014***	-0.013***	-0.014***	-0.014***	-0.025***	-0.033***	-0.025***	-0.025***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)
F-statistic	39.218	18.743	39.218	39.218	19.402	15.588	19.402	19.402
R-squared	0.303	0.303	0.303	0.303	0.300	0.264	0.300	0.300
N	50961	19475	50961	50961	50961	19475	50961	50961
AIC	55543.96	21021.39	55543.96	55543.96	126775.6	48401.65	126775.6	126775.6
BIC	55791.45	21226.18	55791.45	55791.45	127023.1	48606.44	127023.1	127023.1

Note: Estimates include the set of control variables, year and regional dummies. Robust standard errors clustered at individual level in parentheses. F-statistic is the Kleibergen-Paap rk Wald F statistic and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ shows the level of significance.

The results show that neither access to electricity nor the composite infrastructure (WEP) index exert significant impact on employment from models 1 and 5 respectively. Aside the Government of Ghana (GOG) having its own internal difficulties in terms of labor force participation, we may not be able to rule out development and donor partner restrictions on public sector employment in explaining the no effect we have. This moves in line with Dinkelman (2011) who found no significant increase in general demand for labor but a rather positive effect for females in rural South Africa. Our results are in contrast with those of Lipscomb et al. (2013) who found positive employment effect in Brazil.

On the other hand, it can be observed show that, holding all other factors constant, the earnings of wage and salaried workers with electricity access (model 2) are 42.9% higher than those with no electricity. The results move in similar direction from model 6 where a one standard deviation increase in the WEP index increases earnings by 16.9 percent holding all other factors constant. With access to electricity it is possible that hours of work among other things may increase which in turn may affect the earnings of wage and salaried workers. The difference in magnitude between the estimates with electricity and that of WEP may be explained by the complementarity effect from these public infrastructures towards wages as mentioned before. The result on wage concurs with existing studies such as Khandker et al. (2013) who found significant increase in wages in Vietnam on one hand, and in contrast to that of Adu et al. (2018) who found no effect from electrification on employment income for households in rural Ghana, on the other hand.

Again, estimates on sectoral shift shows a decrease in agriculture employment by 64.6 pp while observing a 44.1 pp increase in service sector employment as a result of having access to electricity holding all other factors constant in models 3 and 4, respectively. Both are statistically significant at 5% levels. The results in models 7 and 8 shows a one standard deviation increase in the WEP index causes a reduction of 37.2 pp in agriculture sector employment with service sector employment increasing by 23.6pp holding all other variables constant. This contrasts with Peters and Sievert (2016) who they found no employment shift into non-agricultural sectors in Africa. In Ghana, most of the people in the agricultural sector are subsistence farmers who are always looking for opportunities to better their living conditions. With the presence of public infrastructures, individuals may exercise their entrepreneurial skills in every smallest possible way in the (in)formal sector. For instance looking at the tropical placement of the country among other things, the presence of electricity and water may cause people to switch into businesses as small as sales of refrigerated water (popular known as "iced/ pure water sellers") which may be more lucrative than doing subsistence farming in Ghana. The story in Ghana from these results is that, there is a substitution in labor supply across sectors and not necessarily increasing labor force participation in general.

5.3 Alternative outcome and treatment

5.3.1 Alternative outcome: Sub-sector

We now investigate how access to electricity and an increase in the WEP index lead to employment in secondary sectors such as construction, transport and storage, accommodation and food, and finance and insurance. These outcome variables are binary variables equals to one if an individual works in any of the sub-sectors and zero otherwise. In general, having access to electricity and an increase in the WEP index have no significant effect on employment in the construction industry (models 1 & 5) as well as finance and insurance sectors (models 4 & 8). From the table, we observe statistical significant effects of access to electricity and a one standard deviation increase in the WEP index on transport and storage industry by 10.4pp and 6pp respectively.

Table 7: 2SLS estimates of electricity & WEP on employment in sub-sectors

	(I)				(II)			
	(1) Construction	(2) Transport & Storage	(3) Accommodation & Food	(4) Finance & Insurance	(5) Construction	(6) Transport & Storage	(7) Accommodation & Food	(8) Finance & Insurance
Electricity	0.047	0.104***	-0.040***	0.008				
	(0.044)	(0.034)	(0.012)	(0.010)				
WEP					0.028	0.060***	-0.023***	0.005
					(0.024)	(0.016)	(0.006)	(0.006)

Columns I and II are estimates when the main explanatory variables are electricity access (models 1 – 4) and the infrastructural index (models 5 - 8) on labor force participation in sub-sectors such as Construction (models 1 & 5), Transport & Storage (models 2 & 6), Accommodation & Food (models 3 & 7), Finance & Insurance (models 4 & 8). Estimates are done using the full sample of 500961 individuals. Also, see notes under Table 6.

In contrast, access to electricity and a one standard deviation increase in the WEP index reduce employment in the accommodation and food sector by 4pp and 2.3pp respectively holding all other variables constant. This is not surprising when technology substitutes skills since most of the operations and services which used to be man-powered are substituted by basic technologies as a result of access to basic infrastructures such as electricity, water, among others. For instance, lawns which used to be watered by multiple people can now be done from a central system, just a switch a way. Even so, those who used to fetch water from the river maybe displaced. Also, manufacturing, processing, cooking can all be done with less hands than before with access to basic public infrastructures, leading to a reduction in employment if these services are not on high demands.

5.3.2 Alternative outcome: Demand for durable goods

The work by Gertler et al. (2016) investigates how increase in income results in individual's investment in energy durable goods. In this part of the paper we check how access to electricity and WEP influences individuals demand for durable goods in Table 8. Use of electric and non-electric durable goods have enormous gains on health, education, income, among others. In principle, all the electric appliances reported in the table can be powered off-grid as a result of access to solar pv, local mini grid, private generator, rechargeable battery among others. For this reason, while our main electricity variable is still the dummy if connected to the national grid, we equally control for the other sources of power as additional controls in our estimation to capture any effect they may have on an outcome. As we observed above, individuals who reported using these other sources are of negligible number from our sample. We equally note that, poorer homes may not be able to use these other sources of electricity since they are generally more expensive compared to the cost incurred from on-grid technologies. This is mostly the case, such that even if they do, it's mostly temporary.

Table 8: 2SLS estimates of electricity & WEP on demand for durable goods

(1) **Television**	(2) **Refrigerator**	(3) **Mobile Phone**	(4) **Sewing Machine**	(5) **Flush toilet**	(6) **Car**	(7) **Motor Cycle**	(8) **Shares**
			(I) Estimates from electricity				
0.750***	0.352***	0.369***	-0.200*	0.223***	0.104***	0.170***	-0.020
(0.064)	(0.045)	(0.042)	(0.105)	(0.029)	(0.035)	(0.027)	(0.021)
			(II) Estimates from the WEP index				
0.442***	0.208***	0.218***	-0.116*	0.129***	0.060***	0.099***	-0.012
(0.041)	(0.030)	(0.022)	(0.066)	(0.015)	(0.022)	(0.017)	(0.012)

Note: Estimates in Panels (I) and (II) is using electricity and WEP to investigate the demand for various durable goods listed in columns (1) – (8). Sample includes the full set of observations of 50961. Also refer to notes under Table 6.

The results in general show that access to electricity and WEP leads to an increase in the demand for durable goods such as television, refrigerator, mobile phone, flush toilet, car, and motor cycle. On the contrary there is a reduction in the demand for sewing machine and no effect on shares as a result of access to electricity and a one standard deviation increase in the WEP index holding all other variables constant. The results suggest that access to electricity and an improvement in the composite infrastructure index can be welfare-improving such that individuals in possession of such goods gain access to knowledge and information (TV and mobile phone), saving time and money (refrigerator, car, motor cycle), improve sanitation (flush toilet) among others. Even so, it allows transactions among petty traders in Ghana with mobile phone for sending and receiving money (popularly known as "mobile money transfer"). We can also look at possession of these assets as contributing factors to movement across the various sectors and eventually increasing wages as knowledge and information increases (see for instance Peters and Sievert, 2016).

5.3.3 Alternative treatment: Power outages (Dumsor)

While previous results suggest that access to electricity has significant beneficial effects, it must be noted that it is not only access that matters for individuals welfare and national development, but also the quality of power supply and infrastructure accessibility to individuals. With the prevalence of power outages (known as "Dumsor") in Ghana and most developing countries, we investigate the effect of quality of electricity supply on the various outcome variables for individuals in electrified homes only (see for instance Chakravorty et al., 2014). Analysis is restricted to observations in GLSS 7 because this round of GLSS asked respondents to provide information on the average daily power outages recorded in a week. We used this information as the main explanatory variable in our analysis. Estimations are done using probit models for employment, agriculture and services, while using an ordinary least square regression for wage without instrumenting since all individuals in this sample reside in electrified households. Using individuals in households who on average have between 0 to 6 hours of dumsor (equivalent to 18 to 24 hours of consistent power supply) as reference group, we present results for those who have between 6 - 12, 12 - 18 and 18 - 24 hours of dumsor in Table 9.

Table 9: Effect of Dumsor (power outages) on labor outcomes

	(1) Employment	(2) Wage	(3) Agriculture	(4) Service
$Dumsor_{6-12hours}$	0.148***	-0.094***	0.343***	-0.143***
	(0.050)	(0.022)	(0.037)	(0.051)
$Dumsor_{12-18hours}$	0.027	-0.244**	0.181***	-0.101**
	(0.031)	(0.093)	(0.068)	(0.041)
$Dumsor_{18-24hour}$	-0.046	-0.130***	0.073	-0.001
	(0.111)	(0.039)	(0.064)	(0.073)
N	15312	5685	15312	15312

Note: $Dumsor_{6-12hours}$ $Dumsor_{12-18hours}$ $Dumsor_{18-24hours}$ is the average hours of power outages recorded between 6 - 12, 12 - 18, and 18 - 24 hours over a week. Estimates include all the control variables. Robust standard errors clustered at individual level in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ represent level of significance.

From the table, an average daily increase in dumsor between 6 to 12 hours recorded within a week increases the probability of being employed by 14.8pp with no employment effect as we move towards higher levels of power outages compared to dumsor between 0 to 6 hours holding all other variables constant. On the hand, wages are negatively affected at all levels of dumsor compared the reference group holding other variables constant. More interestingly (but not surprising) is that agricultural employment has higher probability to increase by approximately 18pp to 34 pp with moderate level of dumsor – between 6 to 18 hours compared to dumsor between 0 to 6 hours with no significant effect at higher level of dumsor –between 18 to 24 hours holding all else constant. It is possible these results are driving the positive effect recorded for general employment. On the other hand, increasing dumsor between 6 to 18 hours on average reduces the probability of being employed in the service sector by 10 to 14 pp with no effect when dumsor rises between 18 to 24 hours compared to dumsor between 0 to 6 hours holding all other factors constant. These results do not change the overall scope of existing literature on the harmful effect of power outages but rather shows the potential impact at different levels. This means utilities should work at providing adequate and reliable supply of power for governments, investors and individuals to be able to rip the benefits from having access to electricity towards socio-economic development since all that we are seeing is the substitutability effect across sectors.

5.4 Heterogeneous analysis: Gender

In this section, we will assess the variation among individual attributes such as (fe)male in Table 10.

Table 10: 2SLS estimates of electricity & WEP on labor outcomes by gender

	(A) **Females**				(B) **Males**			
	(1) **Employment**	(2) **Wage**	(3) **Agric.**	(4) **Services**	(5) **Employment**	(6) **Wage**	(7) **Agric.**	(8) **Services**
	(I) Estimates from electricity							
Electricity	0.145	0.872	-0.928**	0.671***	0.000	0.229	-0.392	0.190
	(0.265)	(1.099)	(0.423)	(0.172)	(0.320)	(0.326)	(0.050)	(0.186)
F-statistic	12.185	3.306	12.185	12.185	18.902	11.403	18.902	18.902
	(II) Estimates from the WEP index							
WEP	0.079	0.279	-0.505***	0.365***	0.000	0.100	-0.234	0.114
	(0.150)	(0.145)	(0.163)	(0.089)	(0.030)	(0.284)	(0.184)	(0.108)
F-statistic	6.944	4.474	6.944	6.944	8.163	7.544	8.163	8.163
N	26896	9691	26896	26896	24065	9781	24065	24065

Note: Estimates in Panels (I) and (II) is investigating the effect of access to electricity and an increase in the WEP index for females and males in columns (A) and (B) respectively. Also, refer to notes under Table 6.

Studies such as the ones by Dinkelman (2011), Grogan and Sadanand (2013), and Dasso and Fernandez (2015) have found gender differential effect of electrification on employment outcomes in rural South Africa, Nicaragua, and Peru respectively. The results in Table 10 are such that Panels I and II reports the estimates when using electricity and WEP for females and males in Columns A and B, respectively. From the table, there are no significant effects of electricity and WEP index on female employment and wages. This corroborates the results by Van de Walle et al. (2017) who found no significant increase in employment and wages for females in rural India. A contrast to this result is the finding by Dinkelman (2011) where she finds a reduction in the wages of females and an increase for males. Grogan and Sadanand (2013) and Dasso and Fernandez (2015) on the other hand found the likelihood of increasing female labor participation as well as earnings due to electricity access.

The results from the table also show significant employment shift from columns 3 and 4 where access to electricity leads to a reduction in employment in the agriculture sector by 92.8pp for females holding all other variables constant. This effect is huge and statistically significant at 5% levels. Using the WEP index in Panel II, a one standard deviation increase in the infrastructural index causes approximately 50.5pp reduction in the agricultural sector employment for females holding all other variables constant. Results on female service sector participation are positive and estimated to be 67.1pp and 36.5pp for those with access to electricity and a one standard deviation increase in the WEP index respectively. Again the results suggest a substitution effect in female labor supply from the agricultural to non-agricultural sectors and not an improvement in employment just have been observed in the baseline estimates above. In general, results are statistically not significant for males in our estimates when using electricity access and the WEP index.

5.5 Potential Pathways

This section is devoted to providing further heterogenous analysis to better understand the above results in Table 11. Aside education being a possible pathway (see Adu et al. (2018)), which we do test explicitly, we focus on self-employment, daily hours of work and the underground economy. Estimates on the underground economy is proxied by individual responses on whether they work in the informal sector or not. Also, using this outcome variable, analyses are limited to GLSS 5 & 6 since the 7th round does not contain this information.

As before, Columns I and II present consistent estimates as a result of having access to electricity and an increase in the WEP index, respectively. With the sluggish growth of employment in the formal sector, one way to explain this following the work by Dasso and Fernandez (2015) is to check how self-employment has been affected over time due to availability of basic public infrastructure. From model 1, we observe electricity access on average have a positive but not

Table 11: Possible mechanisms

	(I)			(II)		
	(1) **Self – employment**	(2) **Hourly work**	(3) **Underground Economy**	(4) **Self – employment**	(5) **Hourly work**	(6) **Underground Economy**
Electricity	0.011	4.700***	0.275***			
	(0.161)	(1.110)	(0.1049)			
WEP				0.006	2.645***	0.302***
				(0.095)	(0.691)	(0.107)
F-Statistic	72.702	25.702	53.616	34.534	25.496	3.159
N	50961	38097	27807	50961	38097	27807

Note: Columns I (models 1 - 3) and II (models 4 - 6) provide estimates in investigating the effect of access to electricity and an increase in the WEP index, respectively. Also, refer to notes under Table 6.

significant effect on self-employment. If public sector employment is restricted and private (self-)employment is equally not increasing, then this may explain why employment is in general not affected. This result is true when we use the WEP index from model 4.

Models 2 and 5 explore how daily active hours are affected in the presence of electricity and an improvement in the WEP index. Holding all others constant, the results from models 2 and 5 show that consistent access to electricity and an increase in the overall infrastructural index increases daily hours of work by approximately 5 and 3 hours respectively. These results are statistically significant at 1 percent level. One possible explanation to this is that, as daily active hours increases, production and services increases which can translate into increases in both household and labor income. As earning increases, individuals demand for durable goods also goes up as way of investing back into the economy which we see happening in Table 8 above. Average daily hours can also increase as a result of better lighting which can lead to extension of night activities such as work, studies, family leisure (sometimes just by watching television).[11]

In Ghana, most rural and agriculture sector employment are in the informal setting. To understand the shift in employment in the agriculture and service sectors we explore how employment in the informal sector has been affected as a result of having access to electricity and the WEP index by exploring how the underground economy has been affected. Holding all others constant, the results in models 3 and 6 show that electricity access and an improvement in the WEP index increases employment in the underground economy by 27.5pp and 30.2pp

[11] A step further is to have been able to investigate time spent in carrying out specific task since researchers have found access to electricity (and other public infrastructures) to reduce the time allocated in performing certain activities. This has been seen to increase chances of labor participation for women in terms of household chores as they take advantage of the available power for cooking, storage among others. This allows them to become entrepreneurs by setting up small home businesses, among others. Unfortunately, the data does not allow for this kind of analysis.

respectively. For farmers to take advantage of available infrastructure would mean adopting electric water pumps for irrigation purposes, more innovative ways of planting and harvesting, better processing and storage, among others. As we have already mentioned, agriculture activities in most developing countries are often left for subsistence farmers who may not be able to afford the cost of electricity for agriculture purposes, for instance. Instead, the presence of basic infrastructures increases non-agriculture services and activities causing the shift in employment from the agriculture sector as we have already seen.

6 Conclusion

We have used the last three rounds of the Ghana Living Standard Survey from the Ghana Statistical Service to investigate labor supply and welfare effects of electricity and a complementary index (WEP) constructed from access to electricity, water and public transport in an instrumental variable (IV) estimation approach. The slope of land used as an IV was seen to matter in the expansion of public infrastructure in Ghana. The main results revealed electricity access and an increase in the WEP index has no direct effect on employment but a rather increasing effect in earnings of wage and salaried workers. Again, the results in investigating sectoral transformation shows a shift in the agriculture sector to non-agriculture sector due to electricity access and an improvement in the WEP index. This employment shift is only significant for females. Further heterogenous analyses show no self-employment effect whilst hours of work and employment in the underground economy have increased. Also, there is increase in the demand for durable goods some durable goods with a reduction in the demand in others due to electricity access and WEP index. Additionally analysis reveals inconsistency in the supply of power to be detrimental to labor supply and welfare outcomes.

From all indications we observe the costs involved in public infrastructural projects do not seem to match the intended benefits especially in improving agribusinesses, job creation, among others. Aside individuals investing in durable goods which improves standard of living, policymakers should be concern about expanding and making the agriculture sector attractive to provide employment for the growing population of Ghana. Utilities should work at providing adequate and reliable supply of electricity, and water since access without utilization does not contribute to socioeconomic development. While the people of Ghana may rejoice over expansion in electricity access, GOG should regulate the prices of other sources like solar pv's to make installation affordable as a step towards the fight against pollution.

Also, we recommend development and donor partners to continue with their support in the provision of public infrastructures but with less stringent conditions since they in turn deter socioeconomic development. The Government of Ghana (GOG) must make it a priority to boost private sector activities by ensuring a favorable business environment in order to attract investors to support infrastructural expansion projects. This can also be achieved through concessions and franchise while at the same time ensuring the private sector absorbs some of the employment load on the public sector. The GOG should loosen the bureaucratic difficulties, integrate social protection programs for those in the informal sectors since the sector is seen to be playing a role in socioeconomic development. Again, policy makers and engineers should take advantage of the extension in electric grid and extend other infrastructures both directly and indirectly. Finally, our findings and recommendations can be extended to other developing countries.

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Appendix A Variable definition and measure

Table A.1: *Data Description*

Variable	Description
Employment outcomes	
Employment	A dummy equal to 1 if an ind. did any work in the last 7 days for pay, profit, gain and 0 otherwise.
Wage	Log of labor income for wage and salaried workers.
Agriculture	A dummy equal to 1 if an ind. works in the agriculture sector and 0 otherwise.
Services	A dummy equal to 1 if an ind. works in the service sector and 0 otherwise.
Asset Outcomes	
Sewing machine	A dummy equal to 1 if an ind. owns a sewing machine and 0 otherwise.
Refrigerator	A dummy equal to 1 if an ind. owns a refrigerator and 0 otherwise.
Television	A dummy equal to 1 if an ind. owns a television set and 0 otherwise.
Mobile phone	A dummy equal to 1 if an ind. owns a mobile phone and 0 otherwise.
Flush toilet	A dummy equal to 1 if an ind. Has flush toilet at home and 0 otherwise.
Car	A dummy equal to 1 if owns a car and 0 otherwise.
Motor cycle	A dummy equal to 1 if an individual owns a motor cycle and 0 otherwise.
Shares	A dummy equal to 1 if an ind. owns some shares and 0 otherwise.
Sub-sector outcomes	
Construction	A dummy equal to 1 if an ind. works in a construction industry and 0 otherwise.
Transport & Storage	A dummy equal to 1 if an ind. works in a transport and storage firm and 0 otherwise.
Accommodation & Food	A dummy equal to 1 if an ind. works in hotel, motel, food etc industry and 0 otherwise.
Finance & Insurance	A dummy equal to 1 if an ind. works in the finance & insurance sector and 0 otherwise.
Main explanatory variable	
Electricity	A dummy equal to 1 if an ind. uses electricity as main source of light at home and 0 otherwise.
WEP	Composite variable constructed from the presence of tap water, electricity and public transport services.
Instrumental variable	
Slope of land	Is the median slope of land taken from the GMTED2010 within 30 arcsecond (approx. 1KM resolution) digital elevation model.
Control variables	
Gender(=male)	A dummy equal to 1 if an ind. is a male and 0 otherwise.
Age	Age of ind.
Age squared	Quadratic of age.
Marital status (=married)	A dummy equal to 1 if an ind. is married and 0 otherwise.
Houshold size	Household size.
Houshold squared	Quadratic of household size.
Basic education	A dummy equal to 1 if an ind. has basic education and 0 otherwise.

Continued on next page

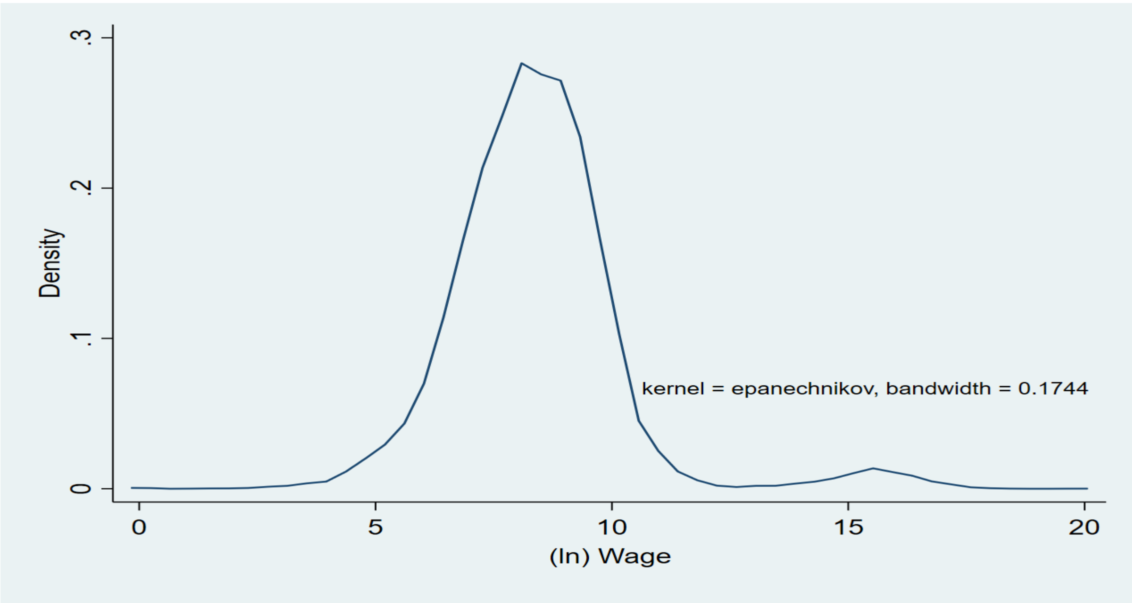
Data Description (continued from previous page)

Variable	Description
secondary education	A dummy equal to 1 if an ind. has secondary education and 0 otherwise.
Higher education	A dummy equal to 1 if an ind. has higher education and 0 otherwise.
Mud floor	A dummy equal to 1 if main construction material used for the floor where an ind. lives is made from mud and 0 otherwise.
Roof material	A dummy equal to 1 if the used as roofing is palm leaves/ raffia/ thatch/ wood/ bamboo/ mud brick and 0 otherwise.
Migration	A dummy equal to 1 if current place of residence is not where an ind. was born and 0 otherwise.

Sources: Authors compiled from GSS – GLSS 5, 6. & 7 except slope of land taken from EarthEnv as part of the suite topographical variables derived by Amatulli et al. (2018).

Figure 5 shows the natural log of wage distribution across our sample. The distribution is from using Kernel density estimate with bandwidth equal to 0.1744. From the graph we see our wage income variable is normally distributed across individuals.

Figure 5: Wage distribution across individuals (2005-2017)



Source: Authors construction from GSS –GLSS 5, 6. & 7

Appendix B Construction of WEP Index

As presented in the main work, there are other statistical requirement the literature mostly provide when using pca. One of such is to show the proportion of the variation explained or unexplained in each of the variable used during the construction of the WEP index, that is, access to electricity, clean water and public transport. Table B.1 reports the proportion of the variation (un)explained and the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO). We observe much of the variation in the electricity variable is captured, followed by water and eventually public transport. Also, the KMO is above the 0.5 threshold which averages around 0.644. This guarantees the use of the WEP as an infrastructural index. Figure 6 presents the scree plot of the eigenvalues after principal component analysis. Normalizing the WEP index, we plot a map of the average scores of households across Ghana and present it in Figure 7. The various colors represent the different scores from 0 to 1.

Table B.1: Principal component

(I) Variable	(II) Component	(III) Unexplained	(IV) KMO
Water	0.5707	0.4313	0.6516
Electricity	0.6037	0.3637	0.6188
Public transport	0.5566	0.4591	0.6703
Overall			0.644

Note:Where KMO is Kaiser-Meyer-Olkin measure of sampling adequacy.

Figure 6: Scree plot of eigenvalues after principal component analysis

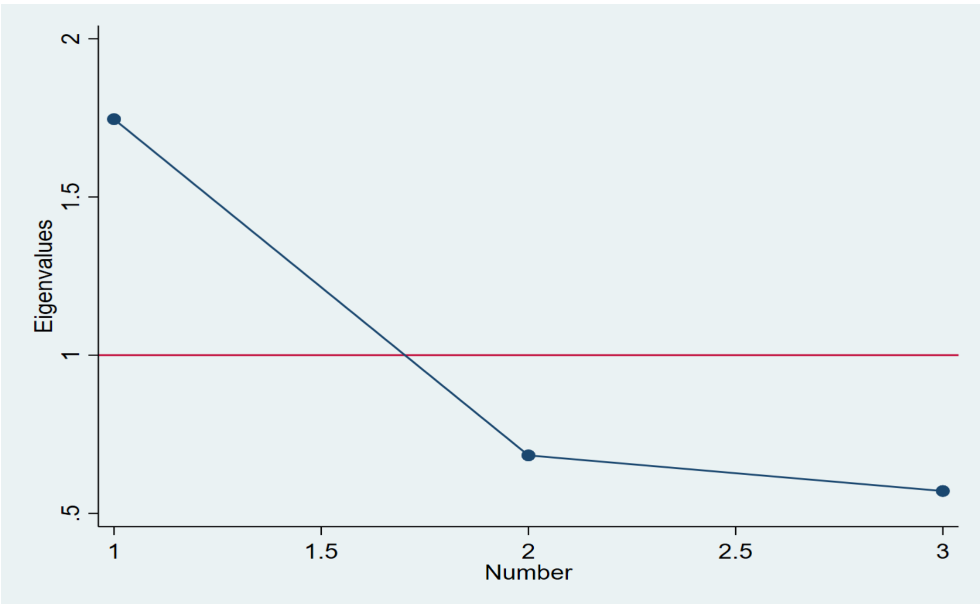
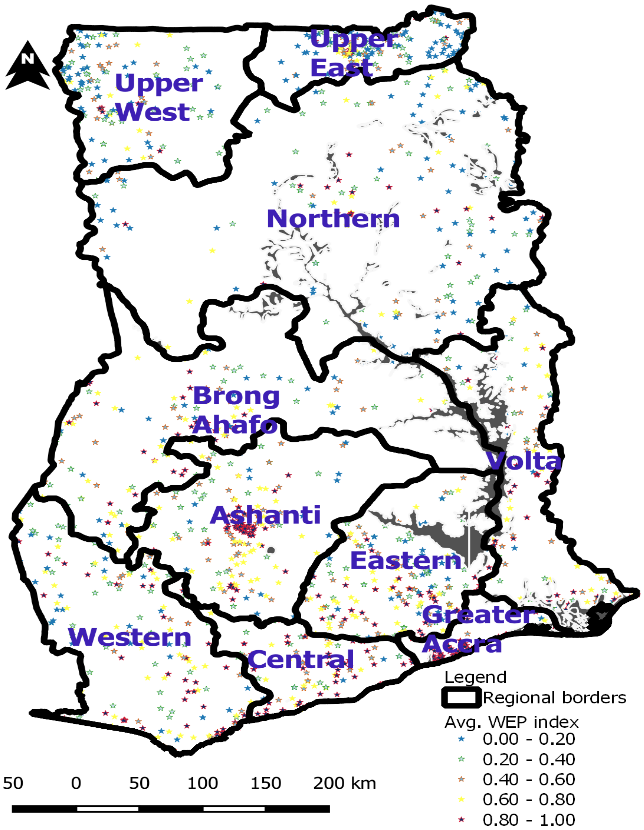


Figure 7: Average WEP Index across communities (2000 -2017)



Source: Authors construction from GSS –GLSS 5, 6. & 7