THE IMPACTS OF ACCESS TO ELECTRICITY ON EMPLOYMENT,

HOUSEHOLD INCOME GROWTH AND CHILD LABOR IN CAMBODIA

A Dissertation

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Abstract

As of 2014, 1.2 billion people in the world still did not have access to electricity. Cambodia, one of the fastest growing economies in Southeast Asia, faces the problem of a substantial disparity in access to electricity between urban and rural areas. Almost universal access to electricity has been achieved in urban areas, but in rural areas fewer than half of households have access. Moreover, Cambodia lags behind other lower middle-income countries in Southeast Asia with respect to investment in education and the incidence of child labor in Cambodia is the highest in the region.

To date, no study has examined the relationship between Cambodia's two foremost development priorities—electricity and children's schooling. The main objective of this dissertation is to examine the role of electricity in improving household welfare, with a focus on household income growth and reduction of child labor—both affected by the expansion of national electricity grid. The first analytical chapter presents an analysis of the impact of household electrification on labor market outcomes of the working age population and on household income, drawing data from nationwide socio-economic household surveys for the period 2004-2017. To eliminate concerns about endogeneity of electricity, I introduce two instruments, (1) population density at village level; and (2) distance between center of village and nearest electricity substation point. I find a strong and positive effect of household electrification on wage employment and self-employment in non-farm sector. The results also suggest that access to electricity decreases self-employment in farm sector and unpaid family work. With respect to household income, the findings show that increased access to electricity contributes to total household income

growth through growth of household nonfarm income. To sum up, this chapter shows that electrification facilitated a shift of household economic activities from farm to non-farm activities, which eventually served as the main driver of household income growth. Thus, it is essential to prioritize expansion of rural access to the national electricity grid.

The second analytical chapter examines the impact of access to electricity on school attendance and children's years of schooling, through three possible channels: (1) household income; (2) female spouse employment; and (3) incidence of child labor. The results indicate that access to electricity increases total household income, especially through increased non-farm income. However, the analysis does not find any statistical evidence that access to electricity increases female spouse labor force participation, which suggests that child labor is not necessarily reallocated to domestic tasks left behind by the female spouse. Finally, the estimation results show that electrification leads to a significant decrease in the probability that a child is engaged in economic activity. As for educational attainment, I do not find any statistically significant impact of electricity. Rather, I find that parents' education level has a positive impact on children's attendance in the school system and years of educational attainment. Moreover, there are other factors which increase children's educational attainment from the supply side factors of education, which points to the necessity of upgrading school quality by expanding electricity grid connections to schools. More importantly, the findings suggest a need for the development of the rural non-farm sector so as to increase household income, which in turn increases demand for education, and eventually leads to a decrease in the frequency of child labor.

Table of Contents

List of Tables

List of Figures

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Chapter 1

Introduction

1.1. Introduction

Access to electricity is essential for economic and social development. Provision of public services such as transport, health care, improved sanitation and schooling cannot be delivered effectively without electricity. Electrification also stimulates the growth of enterprises since it enables them to use and invest in capital goods (e.g., machinery and equipment, communication devices) which are essential for the growth of energy-intensive enterprises. This in turn has positive effects on labor demand through the fostering of business creation, job creation and sectorial diversification of activities. Furthermore, electrified firms are expected to be more efficient and productive, and thus able to increase wages and profits.

Access to electricity can improve the welfare of households through various channels. First, one of the immediate benefits of electrification is greater time endowment, which allows household members to allocate more time to market work, since electricity facilitates use of time-saving appliances. These benefits are greater for women since domestic chores are mainly performed by women. One of the important means of facilitating female labor force participation in developed countries—including US, OECD countries and Japan—in the 1960s was diffusion of home appliances, which enabled women to save time from domestic chores and thus enabled them to join the labor market (Coen-Pirani et al. (2010), Tavares (2008) and Shiohara (2005)). Eventually, that effect led

to changes in the household time allocation dynamics, including children's time, since household chores could be re-distributed among children. Second, households' economic activities benefit a lot from electricity. For example, crop productivity can be increased through the use of electric irrigation pumps; businesses can be in operation later in the evening; and electric tools and machinery can enhance the efficiency and productivity of household business activities (Khandker 2009). A third benefit of electrification is improved lighting, which promotes not only the extension of business hours of household enterprises, but extends the hours of study for children, contributing to improved educational achievement.

Thus, electrification offers positive effects in many aspects of both the economy and household welfare. One of the Sustainable Development Goals (SDGs) adopted by the UN Summit in 2015 is universal access to affordable, reliable and modern energy service for all by 2030 (SDG 7). From job creation to economic development, from empowerment of women to education for children, energy is a central enable for the 2030 Agenda for Sustainable Development. However, at the time of writing more than 1.2 billion people worldwide still lack access to electricity. The International Energy Agency (IEA) estimates that USD640 billion is required to achieve universal access to electricity by 2030.

At the macroeconomic level in India, access to electricity is associated with positive gains in manufacturing outputs, according to Rud (2012), who argues that access to electricity may decrease production costs and eventually lower product prices and prompt greater consumption of manufacturing goods. At the micro-economic level, Lee et al. (2017) observe a lack of micro studies that identify the mechanisms by which

electrification benefits society and the economy. For several outcomes such as employment, household income or education, results are highly heterogamous. Jimenez (2017) highlights this and points out the problem of external validity of each empirical studies conducted in very different contexts including different evaluation periods.

1.2 Objectives and contributions

The main objective of this dissertation is analyze empirical data towards a better understanding of the relationship between electrification and household welfare in Cambodia. To that end, the dissertation has two specific aims. The first aim is to identify the role of electricity in various types of working-age population employment and in household income growth. With regard to employment, I examine the effect of household access to electricity on propensity to engage in wage employment; self-employment in non-farm and farm sector; and unpaid family worker. I pay close attention to the role of electricity facilitating wage employment, since wage employment is generally categorized as formal employment, and the promotion of decent work is an essential step towards inclusive and sustainable growth in developing countries. Next, I examine the effect of access to electricity on several sources of household income (monthly total household income, monthly income in non-farm sector, monthly income in farm sector and monthly other income) and identify the effect of access to electricity on employment and household income, using 2004–2017 data from the Cambodia Socio-Economic Survey, a nationally representative household survey data set.

The second aim of the dissertation is to assess the effect of electrification on children's welfare on school attendance and children's years of education through three possible channels: (1) household income; (2) female employment; and (3) incidence of child labor. The second chapter is connected with the first analysis through household decision on labor allocation including adult and child labor. I use data from the Cambodia Socio-Economic survey, supplemented by data from the Cambodia Labor Force and Child Labor Survey.

The findings of this dissertation contribute to the existing literature in the following ways. First, it documents the causal impact of electrification and addresses the endogeneity problem of infrastructure through the use of instrumental variable strategy with fixed effects. In the context of Cambodia, only a few studies such as Saing (2017) and Han et al. (2020) have examined the effect of access to electricity on household welfare, addressing concerns regarding endogeneity of electricity. To address endogeneity of electricity, I introduce a new instrument, distance between village center and closest electricity substation point. This instrument is an improvement upon previous instruments because (for the first time in such studies of Cambodia) I use electricity substation point location data. Second, while most previous studies used single cross-sectional data to identify the impact of rural electrification, this study uses longer term nationwide household survey data for the period 2004–2017. Data covering only a short period of time makes it difficult to observe changes in household labor allocation and income gains resulting from electrification, but my data allow me to evaluate causal long run effects of electrification. Third, while most previous empirical studies examined rural electrification, this study investigates the impacts on both urban and rural areas, to consider differential access to

electricity where rural areas lag behind. It is important to identify the effects of electrification region by region so as to formulate appropriate policy recommendations for each region. Finally, in its descriptive analyses, this study uses not only household survey data, but also supplementary data from the Economic Census, which covers all establishments in Cambodia, in the interest of obtaining a more comprehensive picture of labor market in terms of the effect of the expansion of electricity on both labor supply and labor demand.

1.3 Organization of the dissertation

The dissertation is organized as follows. Chapter 2, titled "Impacts of Electricity on Labor Market Outcomes and Household Income Growth in Cambodia" explores the changing sources of household income growth from 2004 to 2017 by region. Then, the impact of access to electricity on employment of working age population and household income is examined using the data from 2004 to 2017. Chapter 3, titled "Impacts of Electricity on Child Labor and Education: Evidence from Cambodia" examines the impacts of access to electricity on school attendance and children's years of education. Finally, Chapter 4 summarizes the major findings of the two analytical chapters and identifies some policy implications.

Chapter 2

Impacts of Electricity on Labor Market Outcomes and Household Income Growth in Cambodia

2.1 Introduction

Eradicating poverty has been the foremost development goal of United Nations (UN) member countries in line with their international commitment to the 2030 Agenda for Sustainable Development adopted by the 2015 UN Summit. For the achievement of 17 Sustainable Development Goals (SDGs), access to modern energy such as electricity is one of the most essential and fundamental inputs to socio-economic development. Access to electricity is a crucial input for the provision of basic needs such as food, health, water, use of appliances, education and transportation. For the poor, it is also a crucially important input for income generation and productive activities such as agriculture and industry. Thus, provision of electricity is one of the most important tools for the improvement of livelihood opportunities and the eradication of poverty and it is among the national policy priorities of most countries including Cambodia.

However, providing electricity remains a critical challenge for economic and social development in many developing countries. It is estimated that 1.2 billion people, 16 percent of the global population, still had no access to electricity in 2014 (International Energy Agency 2016). In particular, some countries in Asia and the Pacific are struggling to ensure affordable, reliable and sustainable energy resources to meet their increasing energy demands. Like other developing countries in South-East Asia, Cambodia recognizes

that one of the key obstacles to their economic development is inadequate supply of electricity and basic infrastructure along with roads and water. As stipulated in Cambodia's socio-economic policy agenda, "Rectangular Strategy for Growth, Employment, Equity and Efficiency Phase 3", the national development strategy of Cambodia identifies electricity as one of the priority areas for investment to promote economic and social development in the country. Cambodia also participated in the United Nations' Sustainable Energy for All, which calls for universal access to sustainable energy by 2030. During the past two decades, Cambodia has received substantial development assistance for the expansion of coverage of electricity grids from multilateral donors such as the Asian Development Bank (ADB), the World Bank (WB), and bilateral donors including Japan International Cooperation Agency (JICA) and many European countries.

This chapter is intended to examine the impact of electricity on household welfare, namely labor market outcomes and household income growth in Cambodia. This study contributes to the recent literature in three ways. First, it documents evidence of the causal impact of electrification with addressing the endogeneity problem of infrastructure by employing instrumental variable strategy with fixed effects. In the context of Cambodia, except a few studies such as Saing (2017) and Han et al. (2020), previous studies tend to investigate linkages between various infrastructure such as roads, irrigation facilities and piped water, and household welfare qualitatively without addressing the endogeneity problem (Bliss (2007) and World Bank (2006, 2013)).To reduce concerns of endogeneity problem, I introduce a new instrument, distance between center of village and nearest electricity substation point. This instrument is an improvement upon previous instruments

because I use the information on the location of substation points, the first attempt in Cambodia. Second, previous studies tend to use single cross-sectional data to identify the impact of rural electrification, this study use nationwide household survey data from 2004 to 2017 for documenting evidence on causal long run effects of electrification in both urban and rural areas. Finally, not only household survey data, but the Economic Census data, which covers all establishments in Cambodia, is also used as supplementary data for the descriptive analyses to see comprehensive picture of labor market from both labor supply and labor demand side.

The rest of this chapter is organized as follows: Section 2.2 provides conceptual framework on expected outcomes of electrification. Section 2.3 provides literature review and testable hypotheses. Section 2.4 describes electricity coverage and macro-economic indicators in Southeast countries. Section 2.5 provides descriptive analysis including datasets, description of sample households and changing sources of household income growth. Section 2.6 describes estimation strategy and provides information on gaining access to electricity and the impact it has on employment and household income. Section 2.7 provides robustness analysis. Finally, Section 2.8 concludes this chapter.

2.2 Conceptual framework

Access to electricity could improve the welfare of households through various channels. In this chapter, I identify on the channels through which electrification affect both labor demand and labor supply side and how it contributes to household income growth. I focus on channels which affect household income growth, but I do not examine other

development outcomes such as education, health and fertility. Expected effects of electrification on household income are depicted in Figure 2.1 through households directly and through firms.

On the labor demand side, electrification enables enterprises to use and invest in capital goods (e.g., machinery and equipment, communication appliances) which promotes the growth of energy-intensive enterprises. This has a positive effect on labor demand through fostering business creation, job creation and sectorial diversification of activities. Furthermore, electrified firms are expected to be more efficient and productive, which would potentially increase wages and profits and in turn, contribute to household income growth. In contrast, electrification may also cause a decrease in labor demand since electrified firms shift from labor-intensive to capital-intensive mode which results in workforce reduction, which has negative effects on labor employment and eventually on household income. However, it is believed that electrification increases labor demand as a whole.

On the labor supply side, there are three main channels by which electrification affects household income. First, use of electrical appliances such as electronic water pumps, rice polishing machines, electric heaters and lights may have positive effects on agriculture income because it saves labor and reduces post-production work. Second, electrification may have a positive effect on household income since it gives more time for income-earning activities. For example, women can save time for domestic chores by using devices such as washing machines, rice cookers, refrigerators, electric water pumps which lead to women's reduction in the burden of home production. This extra time due to electrification

can be used for other activities such as joining the labor market, participating in income generating activities including starting up household businesses, and can increase household's total working hours due to longer lighted hours, all of which contribute to household income growth. Even if electrification enables households to save time, household members may decide to devote that extra time to leisure or other activities rather than to participate in the labor market, therefore improving their welfare. Finally, a shift of household economic activities from agriculture to non-agricultural activities, generally associated with productivity increases resulting from firm investment in capital goods such as machinery, communication appliances, may have a positive effect on household income growth.

2.3 Literature review and testable hypotheses

This section provides a brief review of the growing body of literature on the impacts of electrification. In particular, I organize this discussion to the impact of electricity on (1) industry, (2) employment and (3) household income.

2-3-1 Industry

To date, few empirical studies have examined the impact of electrification on labor demand. Little (1987) raised the importance of removing barriers to electricity access in order to stimulate firm development in developing countries. However, removing barriers to access to electricity does not necessarily result in micro-enterprise development. Little emphasizes the importance of other factors such as access to finance. Kirubi (2006)

confirmed the importance of access to finance and found that electricity provision, in combination with access to markets and other infrastructures such as roads and communication, contributed positively to robust growth in the number of microenterprises in rural Kenya. Bastakoti (2003) examined the effective use of electricity by enterprises in Nepal and noted that rural electrification in isolation, without any complementary service mechanism or policy coordination, will not create the required development impacts. Regarding the impact of electrification on firm productivity, Fernandes (2008) found that power supply problems have a significant negative effect on firm productivity in Bangladesh.

Using panel data of Indian states during the period 1965–1984, Rud (2012) found provision of electricity to be associated with 14 percent positive gains in manufacturing outputs in India. The study ascribed this result to the fact that better infrastructure can lower production costs, and in turn lower product prices and induce more consumption of manufacturing goods. Allcott et al. (2016) found that unreliable electricity supply has a negative effect on firm productivity and revenue in India, since plants tend to reduce inputs in response to electricity shortages. Using micro firm level data from the World Bank's Enterprise Surveys, Eifert et al. (2008) found that indirect costs and energy are decisive factors explaining the low productivity in Africa. Arnold et al. (2008) summarized their results of their investigation of the effect of electricity reliability and generator usage on firm productivity in 10 African countries. They found that electricity grid unreliability has a significant negative impact on firm total factor productivity. Gibson and Olivia (2010) confirmed that finding with evidence that incidence and average income of non-farm

11

enterprises is positively associated with higher quality infrastructure, including electricity

and roads. Many studies found no significant causal relation between electricity supply

with income generation, but World Bank (2008) identified the mechanism of positive effect

of electrification on firm revenues in Ghana, Peru and the Philippines. First, access to

electricity increases household member hours in business. Second, access to electricity

increases use of equipment and tools, which increases firm productivity. Finally, improved

community environment, increased productivity, and increased hours of operation result in

increased profits.

While the above studies emphasized the importance of electrification on firm

development and firm productivity, other studies found no evidence of a significant

contribution. For example, Peters and Sievert (2016) found that households hardly use

electricity for income generation activities, which implies that electrification doesn't lead to

firm creation and firm development in the African countries where agriculture sector

remains dominant. Grimm et al, (2012) also found no evidence of a significant contribution

of access to electricity to performance of informal firms in West Africa—rather, they found

a positive effect on firm revenues only in places where homogeneous samples of tailors are

located.

2.3.2 Employment

Several empirical studies of the effect of electrification on labor supply found mixed

results. Lipscomb et al. (2013) estimated the development effects of electrification across

Brazil over the   period 1960–2000 and found large, positive effects of electrification on

employment in both formal and informal sectors. Usmani and Fetter (2018) assessed the impact of electrification on structural transformation in rural India, and found that access to electricity in India's booming guar belt increased employment by electricity-intensive industrial firms and in turn significantly increased non-agricultural employment in villages located there.

Since domestic chores are mainly performed by women, it is expected that females can gain larger time endowment than males, and there are several empirical studies on employment by gender. In the context of developed countries, Greenwood et al. (2005) found that the introduction of new and improved household technologies such as refrigerators and vacuum cleaners explained more than half of the observed rise in U.S. female labor force participation between 1900 and 1980. Coen-Pirani et al. (2010) found support for that finding and attributed the increase in the married women's labor force participation rate in the United States in the 1960s mainly to the diffusion of three household appliances, washing machines, dryers, and refrigerators. The study found that household appliances account for about one-third of the observed increase in labor force participation by married women. In a study of the OECD countries, Tavares (2008) found that a decrease in the relative price of appliances led to a substantial and statistically significant increase in female labor force participation. For instance, in the United Kingdom, the decline in the relative price of home appliances alone accounted for about 10 to 15 percent of the increase in female labor force participation from 1975 to 1999. The emergence of household appliances, a significant technological advancement to save time

in domestic chores, also explains the rise in female labor force participation in Japan in the 1960s (Shiohara, 2005).

In the context of developing countries, Dinkelman (2011) observed positive impacts (9 percentage-point increase) of electrification on female employment in South Africa, while there is no statistically significant impact on male employment. The study argues that female shift away from household task (e.g., cooking with wood), which release female time from homework for market work which is consistent with the case of US and Japan in the 1960s. In addition, Dinkelman (2011) assumed home business activities to increase since electricity facilitates new activities for men and women that would allow them to start to produce market goods and services at home (e.g., food preparation, personal services requiring electric appliances).

Grogan and Sadanand (2012) found stronger effects in rural Nicaragua; agricultural activities decrease significantly, whereas non-farm salary work increases for women, versus no impact on male employment. Furthermore, they found strong negative association between electricity in the household and time spent in family agricultural activities, whereas non-farm wage work increase. Barron and Torero (2014) also found strong impacts of electrification on female employment in El Salvador; it leads to 46 percentage-point increase in participation in non-farm employment and 25 percentage-point higher probability of operating small-scale home business such as washing and ironing clothes, or preparing food for sale, while there is no impact on male employment. Dasso and Fernandez (2015) observed electrification raises female employment and earnings and increase the probability of working outside the agriculture sector in Peru. Among males, it

increases hours of work and diminishes the likelihood of having a second occupation. Vande Walle et al. (2015) found positive impact on both male and female labor supply in India. For men, the results indicate a significant substitution in labor supply from casual to regular work since electricity allows longer working times including night time. For women, the main effect is to increase casual wage work, while they found no evidence of wage increase.

While the above studies find positive impact especially on female employment, other studies failed to observe such effects. ADB (2005) found limited impacts of electrification on household income and occupational change in rural Thailand. Costa et al. (2009) found no evidence of impact of electrification on probability of engaging in income generating activities in Ghana. Grogan (2015) also finds no impacts of household electrification on probability of engaging in self-employment or wage employment in Columbia between 1973-2005. Peters and Sievert (2016) found that electrification did not lead to increases in employment in Sub-Saharan African since the households rarely use electric appliances for productive uses.

Given the aforementioned, I propose the following hypotheses relating electricity to employment:

Hypothesis 1 (H1): Access to electricity increases the probability that household members are engaged in wage employment in non-farm sectors.

Hypothesis 2 (H2): Access to electricity induces household members to start their own household businesses in the non-farm sector; this effect is stronger among females than males.

2.3.3 Household income

A large number of studies have found positive association between electrification and household income, but the results are mixed. Some studies found positive impacts, especially on non-farm income, but less strong impact on farm income (Kumar & Rauniyar, 2018; Charkravotry et al, 2014; Khandker et al, 2009 & 2014; Ramos et al, 2012; World Bank 2002; Rao, 2013), while other studies failed to observe such effects at all (Bensh, Kluve, & Peters, 2011; Peters & Sievert, 2016; Lenz et al, 2017; Arraiz, 2015; Herrin, 1983; ADB 2005). In most cases, the effects found for Asia are positive. For example, Kumar and Rauniyar (2018) found a statistically significant impact of electrification on nonfarm income; nonfarm income increased by 61 percent in Bhutan, but not on farm income. Due to data limitations, the study fails to provide empirical evidence on the pathways through which access to electricity affect household income. However, it does suggest one possible reason for no impact on farm income: that people switch out of agriculture into non-agriculture activities as a result of electrification. Using panel data, the study by Charkravotry et al. (2014) estimated the effect of quality of electricity supply on household income in India. They found that higher quality of electricity (in terms of fewer outages and more hours per day) increased non-agricultural incomes by about 29 percent, but due to data limitations, they failed to identify various channels by which electrification affected household income. Using cross-sectional survey data, Khandker et al. (2009 & 2014) also found a positive effect of electrification on household income, primarily due to an increase in nonfarm income, but a less strong effect on farm income in Bangladesh and

rural India; they also failed to explain the pathways by which electrification affects household income.

The study by UNDP (2011) found average yearly household income in newly electrified communities surveyed in Nepal was higher than that in similar communities without electricity. Electricity access alone explains more than 30 per cent of the increase of household income possibly by (1) establishing new productive activities including food agro-processing mills, poultry raising, furniture factories and services activities (e.g. computer, photo studio, sewing/knitting); (2) increased agricultural production, especially rice and potato production; and (3) reduced energy expenditures. Ramos et al. (2012) also found that electricity exerted a positive impact on the total nonfarm, formal salary work and domestic remittance. Moreover, access to electricity also improved home-business productivity. Gibson and Olivia (2009) revealed that lack of access to electricity constrained the non-farm enterprises of households in rural Indonesia. The study also found that improvements in village level infrastructure are associated with increased share of households with non-farm enterprises. Rao (2013) found access to electricity have a robust effect on non-farm household enterprises in urban India. World Bank (2002) found that electrified households had a larger variety of home businesses in Philippines, indicating that electricity makes a wider range of profitable alternatives possible. Furthermore, households that use electricity in their businesses spend about four hours per day more running their businesses than those without electricity. However, that finding is not related to total amount of business income produces, which implies that the quality or type of

service the business provides is more important to income generation than total hours spent running the business.

Only a few studies found a positive impact of electrification on farm income. Lewis and Severnini (2017) examined the impact of rural electrification on the agriculture sector in the US over a three decade from 1930 to 1960. The study found that rural electrification led to an expansion in agricultural output through increases in number of farms and total land in agriculture. In the context of developing countries, the study by Khandker et al. (2013) found positive effect of electrification on farm income in Vietnam; electrification led to a 25 percent increase in household income, most of which came from increases in cash farm income. The study explained that households connected to a grid have a higher possibility of using electric water pumps for irrigation, which can dramatically improve farm productivity.

In contrast, several studies found limited impact of electrification on household income; Arraiz (2015) found effects of electrification on household income in Peru to be insignificant. The study also found that people in households with access to electricity via solar-powered home systems spend more time working, and women in particular change patterns of time use: they spend more time taking care of children, cooking, doing laundry, and weaving for their families instead of engaging in paid work. The study also found that in electrified homes, a larger proportion of women spent time working on their home businesses without payment, so those and those changes did not affect overall household income. Bensh et al. (2011) and Lenz et al. (2016) found effects of electrification on income to be insignificant in rural Rwanda, since households in the region with access to

18

electricity seldom use electricity for income generating activities. Peters and Sievert (2016) confirmed the same finding in 10 African countries as well. They also found that electrification does not lead to a change in occupation of household member. ADB (2005) confirmed that finding and found limited impact on occupational change and household income in Thailand. Herrin (1983) found no evidence of impact of electrification on household income. Instead, the study found that education, occupation and area characteristics, especially distance of household from a national highway are statistically significant factors explaining household income in rural Philippines. World Bank (2002) found that electricity had no statistically significant effect on agricultural income—the only factor affecting agricultural production was use of animal manure as fertilizer.

Based on above observations, I postulate the following hypotheses on electricity and household income growth:

Hypothesis 3 (H3): Access to electricity contributes to total household income growth through increased household nonfarm income.

Hypothesis 4 (H4): Access to electricity does not significantly affect agricultural income.

2.4 Electricity and macro-economic indicators in Southeast countries

2.4.1 Evolution of electricity and growth in Cambodia

Cambodian economic history since 1970 can be divided into three phases: (1) civil war (1970–1979); (2) post-rehabilitation phase (1979-1993); and (3) evolution of the power sector (1993–).

(1) Civil war (1970–1979)

Cambodia experienced about three decades of political upheaval, followed by several civil wars from 1970 to 1979, fought between the forces of the Communist Party of Kampuchea (known as the Khmer Rouge) and the government forces of the Kingdom of Cambodia. During 1975–1979 the Cambodian economy was severely damaged under the Pol Pot regime; an estimated 1.5 to 2 million Cambodians were killed; and the economy plunged to almost zero growth after vital physical infrastructure including roads and electricity and others were destroyed. Importantly, human capital, which takes considerable time to rebuild, was destroyed. During this time, almost all electricity facilities, including generation, transmission and distribution facilities, were destroyed throughout the country (Breeze 2010). There were no new investments in human capital and possibly the existing stock was deteriorating since many intellectuals were killed.

(2) Post-rehabilitation phase (1979-1993)

After the liberation of Cambodia from the Khmer Rouge regime, the new regime, People's Republic of Kampuchea (PRK), was established with little effort to restore the Cambodian economy. During that time, the economy was dominated by subsistence agriculture. From 1979 to 1989, economic policy focused on food security and the eradication of hunger throughout the country. State-owned enterprises including tobacco, cotton, mechanical workshops and electricity companies, were re-established, all with the aim of providing basic consumer goods and public utilities. The share of state-owned

20

manufacturing output was around two-thirds of all manufacturing output in 1989 (Chhair and Ung (2013)).

With the fall of the Soviet Union and the reform of Vietnam's economic policy, Doi Moi, Cambodia started the gradual process of economic liberalization. In 1989, the country underwent drastic economic reform, moving from a centrally planned economy to a market economy. The priority for the rehabilitation phase was social development and the provision of basic needs such as food security, health facilities, housing, training, education, public utilities, and basic transport infrastructure. The economic liberalization included the privatization of State-Owned Enterprises (SOEs), abolition of the state monopoly on foreign trade and the attraction of Foreign Direct Investment (FDI), stimulated by the establishment of Special Economic Zones (SEZ). In the early 1990s, trade policies were further liberalized, and Cambodia became a member of the ASEAN Free Trade Area in 1999 and ascended to the World Trade Organization (WTO) in 2003. Moreover, the country also improved the investment and business environments for foreign investors by establishing the Investment Law in 1994. As a result, FDI has played a significant role in creating a production base: the inflow of FDI increased considerably from US$124 million in 1993 to US$520 million in 2009 and to over US$1,500 billion in 2012. FDI inflow stimulated GDP growth from 0.09 percent in 2009 to 7.3 percent in 2012.

(3) Evolution of the power sector (1993–)

After liberalization in 1979, the government of Cambodia started to restore electricity infrastructure in the main city of Phnom Penh and the main provincial towns of

the country. At that time, the entire electricity supply in Cambodia was under the management of the Ministry of Industry, which re-established the state-owned enterprise *Electricité du Cambodge* with a mandate to supply electricity in Phnom Penh and established small electricity enterprises responsible for supplying electricity to each the province. Due to those economic activities and the rapid improvement in the living standard of the people of Cambodia, since 1993 there has been increasing electricity demand, especially in Phnom Penh and main town centers. Initially, the infrastructure of the electric power system was developed in two main regions: (1) the southern region consisting of Phnom Penh City, Kandal, Kanpong Spu, Takeo, Kampot and Sihanoukville provinces and (2) the western region consisting of Bantey Mean Chey, Battambang and Siem Reap provinces. After the construction of a high voltage system integrating the main town centers of the two regions, the government planned to provide electricity service from that system to the population living in the regions surrounding the two town centers.

Although Cambodia have received grant and aid from other countries and from financial institutions for the rehabilitation and construction of electric infrastructures, it was not sufficient to meet the rapidly increasing electric demand of each region. Considering this situation, the Royal Government has promoted the private sector to invest and do business in power sector to supplement the capability of the State in development of power sector infrastructure. To ensure transparency and safety of the investment in power sector, the government has promulgated the Electricity Law in 2001 to regulate the business in power sector and to govern the relation between electricity suppliers and consumers in a more transparent manner. Along this, the government has established a legal public entity,

the *Electricity Authority of Cambodia* (EAC) to act as the regulator and arbitrator of power sector business activities. Furthermore, in order to meet growing electricity demand, the Power Purchase Agreement (PPA) was signed in 2007 to import power from Vietnam to the southern region especially Phnom Penh under the assistance of World Bank, Asian Development Bank and KfW of Germany. For the western region, PPA with Thailand was signed in 2007 and started to import power from Thailand. In addition to that, PPA was signed with Lao People's Democratic Republic (Lao PDR) in 2018. As a result, as Figure 2.2 shows, the proportion of import out of total energy is increasing from less than 10 percent in 2004 to 41 percent in 2009 and 37 percent in 2014. Cambodia import electricity primarily from Vietnam followed by Thailand and Lao PDR. Due to expanding electricity generation projects, domestic energy production increased substantially especially from 2009, which led to the reduction of the proportion of import to 15 percent in 2018. However, it is expected that Cambodia have to rely on imports to meet increasing energy demand.

Regarding the sources of power, Cambodia's power generation capacity was almost entirely based on diesel generators up to 2010. From 2011, there were significant changes in the source of energy. Total installed capacity has substantially increased and become more diversified, with hydro, coal, heavy fuel oil, gasoline, wood, biomass (Figure 2.3). In particular, hydropower holds considerable potentials for power production in Cambodia, which is expected to become the major source in the long term (World Bank, 2006).

Finally, Figure 2.4 presents the percentage of population who have access to electricity and Gross Domestic Product (GDP) annual growth rate. As a result of the

23

combination of economic reform policies and political stability, Cambodia experienced high rates of economic growth in the last decade especially during 2001-2010. The economy experienced the highest growth rate at 13 percent in 2005. Later, it declined from 6.8 percent in 2008 to 0.09 percent in 2009 due to global economic downturn in 2008-2009 since Cambodia's major economic sectors such as garments, tourism and construction dramatically showed decline due to the decline in domestic and global demand. Real GDP growth started to edge up again to around 5.9 percent in 2010 and 7 percent in 2017 with global recovery. With increasing electricity demand due to rapid economic growth, several electrification projects were implemented and the percentage of population with access to electricity increased significantly from 24 percent in 2004 to 34 percent in 2009 and to 56 percent in 2014.

2.4.2 Electricity and poverty reduction in the CLMV and ASEAN 6 countries

Table 2.1 presents economic indicators and the percentage of population with access to electricity in the CLMV and the ASEAN 6 countries, along with the progress towards electricity access in urban and rural areas. In 2017, the real GDP growth of the CLMV countries remained high, more than 7 percent, which is higher than that of ASEAN 6 countries. In Cambodia, 2017 real GDP growth was 7.1 percent, mainly the result of an influx of foreign capital and the country's involvement in multilateral infrastructure projects (OECD 2018).

In line with that high real GDP growth, income poverty in Cambodia has decreased dramatically since the mid-2000s. Cambodia's poverty headcount ratio at national poverty

line decreased from 45 percent in 2006 to 18 percent in 2012, the highest proportional

reduction in the group of countries including Myanmar, Laos and Vietnam. According to a

World Bank analysis, most of the poverty reduction in Cambodia occurred during 2007–

2009, in rural areas, where rice farming is a major source of livelihood. That dramatic

poverty reduction can be explained largely by four factors: 1) an increase in the price of

rice; 2) increased rice production; 3) growth in agricultural wages; and 4) higher average

income from self-employment in nonagricultural businesses (World Bank, 2013). These

factors emerged because of the world food crisis in 2007–2008.

Generally, economic structure is an important indicator of the development level of

a country. In principle, a country's economy tends to have a large share of agriculture in the

early stage of development, and as the country develops, the share of agriculture declines

and the shares of industry and services increase. Cambodia experienced a structural shift

from agriculture to industry and service in the 1990s. The ratio of agriculture decreased

from 33.5 percent in 2012 to 23.4 percent in 2017, but the share of the agriculture sector in

GDP was still the highest among the CLMV countries, aside from Myanmar. Compared

with the ASEAN 6 countries, the economic structure of CLMV countries remains

predominantly agrarian. Yet the nature of agriculture in the CLMV countries is quite

different from that in Vietnam and Cambodia, who, along with Myanmar, are major players

in the world rice market. The rice sector in these countries is changing dynamically with the

advent of new technology and commercialization.

In terms of infrastructure, Cambodia's infrastructure access and stock are low

compared to other lower-middle income countries. That low rating is the result of conflict

and civil war under the Pol Pot regime. While there has been considerable progress towards 100% energy access in the ASEAN countries and Vietnam, the percentage of households with access to electricity in Cambodia is the lowest among all the countries, 50 percent, followed by Myanmar with 57 percent. The rural areas in particular in Cambodia and Myanmar still had very low access to electricity in 2016, only 36.5 percent and 39.8 percent, respectively. In contrast, urban households in Cambodia have 100 percent access to electricity. Thus, rural electrification is one of the priority challenges in Cambodia and Myanmar.

Figure 2.5 shows the relationship between the percentage of the population with access to electricity and the sectoral share (agriculture, industry and service) of the economy in 20 Asian countries. In addition to the fact that Cambodia has the lowest percentage of access to electricity among all the countries, it should be pointed out that there is a negative relationship between percentage of access to electricity and share of agriculture sector (Panel A), while there is a positive relationship for the industry and service sectors (Panel B and C). Expansion of electricity appears to be associated with economic transformation from agriculture to the manufacturing and service sectors.

2.5 Descriptive analysis

2.5.1 Data sets

This study mainly uses Cambodia Socio-Economic Survey (CSES) data for 2004, 2009, 2014 and 2017. These are nationally representative household survey datasets collected by the National Institute of Statistics under the auspices of the Ministry of

Planning of the Royal Government of Cambodia. The main objective of the survey is to collect statistical information about living conditions of the Cambodian population and the extent of poverty. The sampling in the survey is done in three stages. First, villages are selected from a village frame containing all the number of villages in each rural/urban area within each province / strata, using the probabilities proportional to size approach. Second, a number of electoral areas (EAs) are selected from among the villages. Third, households are mapped in each village and then subjects are randomly selected. CSES contains information related to income and welfare indicators such as health, education, housing conditions, economic activities, victimization, vulnerability and access to infrastructure including electricity, roads and piped water.

In this study, I conducted descriptive analyses using CSES data for 2004, 2009, 2014 and 2017. For the regression analysis, I selected three waves of the survey, 2004, 2009 and 2014, since the survey has been conducted with a large sample size every 5 years since 2004. The dataset for 2017 is not used in the regression analysis. The total body sampled consisted of 14,983 households, 74,719 individuals and 900 villages in 2004; 11,971 households, 57,105 individuals and 720 villages in 2009; 12,093 households, 53,968 individuals and 1,008 villages in 2014; and 3,840 households, 16,909 individuals and 384 villages in 2017 (Table 2.2). The data chosen here have several advantages. First, the datasets are nationally representative, covering all 24 provinces of Cambodia. Second, the data includes comprehensive information on household income sources along with descriptions of occupation and industry, employment status (employee, employer, own account worker and unpaid family worker), and wages of paid employees among household

members. Furthermore, the data includes all sources of household income, such as income from agriculture (production of crops, livestock and poultry raising activities), fishing, forestry and hunting); income from non-agricultural economic activities; and income from other sources such as remittances and pensions. This enables the calculation of total household income from all income sources. Finally, the survey includes questionnaires related to infrastructure including source of lightning (publicly provided electricity / city power, generator, battery, kerosene lamp, candle and other) at both household and village level.

In addition to CSES data, Economic Census of Cambodia (ECC, an inter-censual survey) data for 2011 and 2014 are used for descriptive analysis, so as to better capture a comprehensive picture of the mechanism of electrification from the labor demand side. The data was collected by the National Institute of Statistics under the auspices of the Ministry of Planning and supported by JICA. The objective of ECC is to provide fundamental statistics on the current status of the business activities of establishments. The data cover all establishments in Cambodia except establishments under classification such as agriculture, forestry and fishing. There were 505,134 establishments covered in ECC 2011, 513,759 in ECC 2014. Data from the country's Population Census for 1998 and 2008 were used to construct one of the instrumental variables, which is discussed in section 2.6.2.

2.5.2 Description of sample households

(1) Main source of lighting

Table 2.3 shows main source of lighting in 2004, 2009, 2014 and 2017 by geographical category (all, Phnom Penh, urban areas (except Phnom Penh), and rural). More than half of all households used kerosene lamp as main source of lightning in 2004, but that percentage decreased considerably to 31 percent in 2009, 7 percent in 2014 and only 1 percent in 2017. Second main source of lightning in 2004 was battery (24 percent of households), which became the largest main source of lighting in 2009 (39 percent of households). From 2009, battery was still commonly used by households as an energy source for lighting (29 percent in 2014, 10 percent in 2017). Over the years, the percentage of households with access to publicly provided electricity / city power increased from 16 percent in 2004 to 28 percent in 2009, 61 percent in 2014 and 82 percent in 2017. The coverage rate expanded significantly from 2009 as a result of several electrification programs: the percentage of households with access to publicly provided electricity in rural areas increased significantly from 3 percent in 2004 to 70 percent in 2017. There remains a significant urban-rural gap in the percentage of population with access to electricity: 70 percent in rural areas, compared to almost universal access in urban areas in 2017, but the gap has been shrinking, especially since 2014. In Phnom Penh, almost all households have had access to publicly provided electricity since 2014. Most electricity projects are strategically located in Phnom Penh and its suburbs and in urban areas where electricity projects are profitable (Figure 2.6).

During the study period of liberalization, substantial development assistance has been made available for the extension of coverage of electricity grids in urban and rural Cambodia; multilateral donors include the World Bank (WB) and the Asian Development

Bank (ADB), and bilateral donors, including Japan, Germany and France. One source was the WB's 150 million USD "Rural Electrification and Transmission Project" implemented from 2003 to 2009, funded partially by the ADB and Japan. The mission of the project is to expand the existing supply network of the state-owned utility, *Electricite du Cambodge* (EDC) and *Rural Electricity Enterprises* (REE). The ADB also started the Medium-Voltage Sub-Transmission Expansion Sector Project (formerly Rural Electrification Project) in 2012 to expand the supply of reliable and cost-effective grid electricity and to construct 2,110 km of 22 kV sub-transmission lines in Banteay Meanchey, Kampong Cham, Kampong Thom, Kandal and Siem Reap provinces. The project also supports improvement of operational effectiveness and efficiency of EDC and includes a grant to the REF to finance service connection costs for poor households in the project provinces. Furthermore, the ADB initiated the "Greater Mekong Sub region Transmission Project" to build power transmission lines from Vietnam to Takeo province in southwest Cambodia (a typical plain wet area, largely rice fields and other agricultural plantations); and to the capital city, Phnom Penh, during the period 2007–2011. The project had two main objectives: to provide sustainable and reliable electricity at affordable prices to consumers in Phnom Penh and along the transmission corridor; and to enhance accessibility to power for the poor by establishing a pro-poor policy environment in the sector. The project provided for the construction of 109 km of 230 kilovolt (kV) transmission lines from the Vietnamese border to Phnom Penh, together with associated substations in Takeo and West Phnom Penh provinces. The project provided power to about 90,000 households: 50,000 rural households in areas of Takeo province where the majority of residents are rice farmers

30

living below the poverty line; and 40,000 new customers, individuals and businesses, within Phnom Penh. In addition, in 2007 the ADB approved another 8 million USD loan for the construction of 221 km of 115 kV transmission lines, which allowed the import of reliable, lower-cost, cleaner electricity from Thailand to end-users in three provinces; Banteay Meanchey, Siem Reap and Battambang (Power Transmission Lines Co., Ltd. Power Transmission Project). The volume of power consumed was largest in Siem Reap province, where it supports the vital and growing tourism industry, providing power for the airport, large and small hotel operations, restaurants, electronic booking systems, and popular marketplaces as well as local homes. The ADB also approved a 20 million USD loan, co-financed by JICA, for the construction of 82 km of 230 kV transmission lines from Kamport to Sihanoukville in 2013 and the construction of a 115 kV substation and associated distribution lines in Sihanoukville town in 2014 (Second Power Transmission and Distribution Project).

Other development partners have focused primarily on financing power infrastructure, particularly expansion of high-voltage transmission lines. For example, the German Federal Ministry for Economic Cooperation and Development (KfW) approved a EUR 30-million project to upgrade and expand the national electricity grid in three provinces; Kamport, Takeo and Kampong Speu in 2007 (KfW Development Bank, 2014). Agence Francaise de Developpement (AFD) is engaged in technical assistance and the financing of energy projects. One of their projects, "EDC grid extension" started in 2015, with the aim of expanding the transmission network to areas not connected to the grid in Koh Kong, Kratie and Kampong Cham provinces. Finally, JICA approved a 65 million

USD loan for the upgrading of transmission lines, substations and distribution lines in the Phnom Penh metropolitan area in 2014. Together with the ADB Greater Mekong Sub-region Transmission Project, these projects are the foundation of the near universal access to electricity in Phnom Penh in 2014.

Table 2.4 presents the main sources of lighting in 2004, 2009, 2014 and 2017 for the targeted provinces of electricity projects mentioned earlier. As can be seen in the table, the proportion of households using publicly-provided electricity as the main source of lighting increased significantly from 2004 to 2017. In 2004, aside from Phnom Penh and Sihanoukville province, the main source of energy for household lighting was kerosene, followed by batteries. Thanks to extensive projects aiming to expand the electricity grid in targeted provinces, the proportion of households using publicly-provided electricity as the main source of lighting increased steadily over the years, especially from 2009 to 2014. By 2017, eight provinces out of 11 provinces had achieved almost universal access to electricity.

(2) Time use in the 2004 CSES

As discussed in section 2.2 electrification affects individual time use patterns, impacting in turn on individual decision to work, leading eventually to increase in household income. Thus, it would be of interest to analyze the time use data of individual household members and compare individuals with access to electricity and those without electricity. However, detailed information on the time use of household members is only available in CSES data for 2004—surveys in other years did not collect data on time use.

32

Since the focus here is on the effect of household electrification on labor supply, the samples are restricted to household members of working age (15–58 years old) (sample size: 41,509 individuals) in 2004. The data were collected from February 2004 to January 2005: each household member was asked to complete a diary sheet for one sampled day.

Table 2.5 presents the daily time use of household members of working age, along with the results of a test of mean difference between individuals with and without access to electricity. I examined activities related to work (time working in employment; time working in own business; and time working in agriculture), time doing household chores and leisure time, by gender and geographic area.

First, regarding time use for work as employed, men spend more time doing market work than women. Furthermore, individuals residing in urban areas spend more time on market work, implying there are more wage employment opportunities in urban areas than rural. As for electrification status, having electricity is associated with greater time for salaried work for both men and women, which implies that electrification increases discretionary time endowment, and that extra time enables individuals to engage in paid work. However, it should be pointed out that there is statistically no significant difference in rural areas between individuals with electricity and those without, which suggests that there were fewer opportunities for salaried work in rural areas.

Second, regarding time to do own business work, women spend more time on own business work than men since women tend to engage in self-employment, as it is easy to combine household chores and own business work. By geographic area, individuals living in urban areas spend more time doing own business work than those in rural areas. By

electrification status, individuals with access to electricity spend more time on own

business work as a result of the extended working hours due to electrification. Third,

regarding time for agriculture work, men spend much more time than women. Furthermore,

individuals living in rural areas spend more time on agricultural work since agriculture is

the main source of income. As for the effect of electrification status, individuals without

access to electricity spend much more time doing agricultural work than their counterparts

with access to electricity. Significant gender differences can be observed in time for

household chores, which includes time for cooking, washing and cleaning, weaving,

fetching water, collecting firewood and taking care of children or the elderly. Women

spend an average of 3.3 hours a day on household chores, while men spend less than one

hour. By electrification status, individuals with access to electricity spend less time doing

household chores, since using electronic appliances such as washing machines, rice cookers,

refrigerators, and electric water pumps ill reduce the burden of household chores.

Finally, regarding time for leisure, males spend more time than women on leisure,

partly due to the fact that women bear a disproportionate share of responsibility for

housework and caregiving.

In summary, electrification leads to a larger time endowment, which in turn enables

household members to save of time for household chores and allocate more time for work

in wage employment, especially for men, and time for work in own business (self-

employment for women). On the other hand, electrification leads to less time to work for

agricultural work. Finally, regardless of electrification status, women bear a

disproportionate share of the responsibility for household chores, which can partly explain the observation that men spend more time than women on leisure.

(3) Description of sample households by electrification status

Table 2.6 presents test of mean difference between households with access to electricity (defined as households using publicly provided electricity/city power as main source of lighting) and households without electricity (defined as households using generator, battery, kerosene lamp and the like as main source of lighting) for outcome variables and explanatory variables by year.

Important variables in this study are classified into employment at individual level and income at household level. Employment of individuals includes into: (1) probability that household members of working age (15-58 years old) are paid employees; (2) probability that working age members are engaged in self-employment in the agriculture sector; (3) probability that working age members are engaged in self-employment in the non-agriculture sector; and (4) probability that working age members are unpaid family workers. Income at household level is classified into (1) total monthly household income (USD PPP); (2) monthly farm income; and (3) monthly non-farm income.

The explanatory variables include household, individual and village-level characteristics. Household-level variables include proportion of female-headed households; number of household members of working age (age cohorts:15-20, 21-30, 31-40, 41-50 and 51-58); proportion of working-age members who completed primary, secondary and tertiary school, proportion of female household members; and area of irrigated parcel land

35

for rice and other crops, in hectares. Individual level characteristics include the probability that a household member of working age did any work (even one hour) during the past seven days (worked on a farm, worked in a business or a workplace (private or public sector, own account or in business belonging to someone else in household)); and weekly working hours of household head and spouse. Village-level characteristics include distance to the nearest bus stop; a binary variable reflecting whether a village has any large industrial or commercial enterprise (e.g., factory, hotel, restaurant or company), and a binary variable reflecting whether there are any functioning infrastructure development projects such as road development.

Regarding outcome variables related to employment, almost all the variables were significantly different from zero at the 1% level, indicating that the characteristics of households and working age members with electricity and without electricity are different. For example, the proportion of working age members with access to electricity who are engaged in wage employment and self-employment in the non-agriculture sector is higher than that for households with no access to electricity, across all years. In contrast, the proportion of working age members without access to electricity who are engaged in self-employment in the agriculture sector is higher than that for those with access to electricity. These findings are consistent with those from the analysis of 2004 time use data.

Regarding outcome variables related to income, households with access to electricity are clearly better off: they have higher income, especially non-farm income. For explanatory variables, except a few variables related to some age group and the proportion of female household members, almost all the variables were significantly different from

zero at the 1% level. Households with access to electricity are better off than those without electricity in terms of general characteristics, such as number and educational level of working age members. Households with no access to electricity have a larger area of irrigated land for rice and other crops since most of them live in rural areas where agriculture is the main livelihood. At the individual level, proportion of household members of working age who did any work during the last seven days is higher for those residing in households with no access to electricity, i.e. 86 percent for those without access to electricity and 80 percent for those with access to electricity. Regarding working hours, average weekly working hours in wage employment, own account work or unpaid family work are higher for those with access to electricity. At the village level, villages with access to grid electricity have much shorter distance to bus stop, which suggests that transport accessibility is better. Probability that there are functioning large industrial enterprises and infrastructure development projects is higher for villages with access to grid electricity than for those without electricity. However, these results do not necessarily imply a causal effect of electrification. How much of the observed differences can be attributed to electrification is discussed in detail in section 2.6.

2.5.3 Changing sources of household income growth

This section explores changes in household income sources and main sources of household income growth by year and by geography (all households, Phnom Penh, urban areas except Phnom Penh and rural areas). Monthly household income structure in Cambodia, Phnom Penh, urban areas except Phnom Penh and rural areas in 2004, 2009,

37

2014 and 2017 is presented in Figures 2.7 and 2.8 and in Table A2.1 to A2.4 in the appendix.

All income data are deflated across years using the 2005 PPP (purchasing power parity) conversion factor, with 2010 as base year, taken from World Development Indicators (WDI) to make income comparable. The PPP adjusts income for price differential across time and space.

(1) Structure of household income

Corresponding to decreasing poverty headcount ratio presented in Table 2.1, average total monthly household income increased steadily across the years observed, from USD215 PPP in 2004 to USD423 PPP in 2009, to USD640 PPP in 2014 and USD686 PPP in 2017. CSES data includes all sources of household income; this can be divided into (1) income from wage work, (2) income from self-employment (agriculture and non-agriculture) and (3) income from other sources such as pensions, remittances (from abroad and domestic), and dividends and so on. The three types of income sources are discussed below.

First, regarding income from wage work, CSES collects information including the wages / salary of each household member and industry code (ISIC classification), which enables us to calculate monthly income from wage work by industry. The composition of each sector is as follows: agriculture; mining; manufacturing sector (garments, food, wood, metal and other); and service sector (construction, retail, government services, transport,

business services and other). The share of income from wage work out in total income, now increasing, accounted for 57 percent of total household income in 2017.

Second, income from self-employment can be divided into two parts: (1) income from self-employment in agriculture; and (2) income from household non-agricultural economic activities. Income from self- employment in agriculture consists of (1) production of crops including fruits and vegetables, (2) livestock and poultry raising activities, (3) fish cultivation and (4) forestry and hunting. Until 2014, income from self-employment in agriculture and non-agriculture consist of the largest income source for all households in Cambodia. Regarding income from self-employment in non-agriculture, CSES collects information including industry code and all revenue and cost items related to activities at household level.

Finally, household income from other sources which are non-labor incomes includes pensions, remittances (abroad and domestic), government scholarships and stipends, transfers from NGOs or other institutions, income from lotteries and gambling, bank interest, dividends and interest on loans made to others.

(2) Income sources of all households in Cambodia

A summary of household income structure of all households in Cambodia is presented in Figure 2.7 and Appendix Table A2.1. Average total monthly household income in Cambodia increased from USD215 PPP in 2004 to USD686 PPP in 2017, a more than threefold increase. Until 2014, the primary income of households was mainly from self-employment, which accounted for 55 percent of total household income in 2004. In

2009, the proportion of income from self-employment in agriculture and non-agriculture increased to 72 percent due to a significant increase in income from self-employment in agriculture, i.e. crop income. In 2009, crop income accounted for 27 percent of total household income, as a result of increased value of production of rice due to increase in rice prices and rice production. According to World Bank (2013), the price of rice (in constant value) increased by 37.1 percent from 2004 to 2009, boosting farmer income and providing incentive to increase production. In addition, according to the FAOSTAT data, the area used for rice production expanded from 2.1 million hectares in 2004 to 2.7 million in 2009 (27 percent increase) and rice yield increased from an average of 2 tons per hectare in 2004 to an average of 2.8 tons per hectare in 2009 (43 percent increase). Furthermore, income from wage work in the agriculture sector was a main source of income until 2014.

From 2009 onward, the main source of household income growth shifted from agricultural to non-agricultural activities. In 2014, income from self-employment in non-agriculture constituted more than 30 percent of total income. In particular, income from retail services, including wholesale and retail sale of food, beverages, tobacco, household goods, motor vehicles, agricultural raw materials, and IT equipment, was the largest income source across all the years, accounting for nearly 20 percent of total income. Income from wage work was the second largest income source in Cambodia until 2014: in 2017, it became the largest income source, accounting for 57 percent of total income that year. On the other hand, the share of income from self-employment decreased to about 39 percent. In terms of salaried jobs, the garment industry is one of the main employers. Figure 2.9 presents Cambodia's export share by sector in manufacturing, based on data from the UN

COMTRADE database. As the figure shows, the garment sector, which generates more than 90 percent of Cambodia's total exports, has become the backbone of Cambodia's economy. High wage income in the garment sector is a main explanatory factor of the rising minimum monthly wage in this sector only. It should be noted that about 80 percent of workers in the garment industry are female, and the higher wages paid by garment factories have benefitted women in Cambodia. Increased income from wage work in the garment sector is facilitated by expansion of publicly provided electricity, especially since 2014, since the garment sector requires electricity to run factory machinery such as sewing machines and air pumps. As for other industries, income from wage work in the mining sector is negligible and other wage work shares of income come from the service sector. In particular, government services (administration of the state, provision of services to the community, and compulsory social security activities) are the main sources of wage income across all the years. As a result of Cambodia's real estate boom, fueled by investment by China, income from the construction sector became the second largest income source in Cambodia's service sector in 2009, followed by income from business services (financial intermediation, renting and business activities) and transport services (transport, storage and communication).

Finally, it should be pointed out that remittances (both domestic and foreign) were an important element of household income growth in 2014, which accounted for 9 percent of total household income. The rise in foreign remittances to Cambodia from neighboring countries suggests that cross-border temporary migration has become more important than permanent migration. This may be the result of the policy framework on labor migration,

41

"Policy on Labor Migration for Cambodia for 2010-2015" which in 2010 stipulated three main objectives; better governance of labor migration; protection and empowerment of migrant workers; and harnessing the potential of labor migration for development. It is estimated that Cambodia received remittances of USD381.7 million in 2014, equivalent to 2.3% of the country's GDP. However, in 2017, average amount of remittances decreased both in absolute terms and as a proportion of total household income, indicating growing importance of domestic income sources.

(3) Income sources of households in Phnom Penh

The structure of household income in Phnom Penh is presented in Table A2.2 and Figure 2.8. As shown in the table and the figure, average monthly household income in Phnom Penh is the highest in Cambodia. Income from agriculture is negligible in the Phnom Penh region, and the strongest driver of income growth there is income from wage work, which accounts for more than half of total income from 2004. In 2017, the proportion increased significantly to 77 percent. Within income from wage work, the largest income sources are income from the garment sector and governmental and business services. According to data from the 2011 Cambodian Economic Census, which surveys all establishments in Cambodia, including both formal and informal firms, 21 percent of the establishments in the garment sector and 15 percent of establishments providing government services are located in Phnom Penh, which demonstrates that industrial activity is concentrated in this area.

The second largest income source in Phnom Penh is income from self-employment in non-agriculture, which represents 45 percent of total household income until 2014 (the proportion decreased to 20 percent in 2017 because of the increasing importance of wage income). Within this category, income in retail service is the largest income source, accounting 28 percent of total income until 2014. Expansion of electrification contributed to household income growth in Phnom Penh, reflecting the fact that key industries such as the garment industry and retail services require electricity services.

(4) Income sources of households in urban areas other than Phnom Penh

Income structure of households in urban areas other than Phnom Penh is presented in the Appendix Table A2.3 and Figure 2.8. Average monthly household income increased from USD329 PPP in 2004 to USD798 PPP in 2017. The largest income source in this area is income from self-employment in non-agriculture, which represents nearly half of household income until 2014. In particular, income from retail services accounts for 30 percent of total across all the years, followed by income from transport services. The second largest income source is income from wage work in the non-agriculture sector, which accounts for 51 percent of total income in 2017. In particular, income from the garment sector increased significantly, fivefold from 2014 to 2017 (Table A2.3). Within the service sector, income from government sector is the largest income source, followed by income from business services and construction. As share of income from wage work increased, the share of income from self-employment in agriculture decreased from 28 percent in 2004 to 9 percent in 2017.

43

(5) Income sources of households in rural areas

The structure of household income in rural areas is presented in Table A2.4 and Figure 2.8. The table shows that average total monthly household income more than tripled, increasing from USD139 PPP in 2004 to USD597 PPP in 2017, which led to a narrowing of the income gap between Phnom Penh and urban areas. Until 2009, the main driver of household income growth was income from self-employment in agriculture, accounting for more than half of total income. In particular, average monthly crop income, mainly from rice, increased significantly from USD26 PPP in 2004 to USD142 PPP in 2009, which accounted for 42 percent of total income in 2009. Furthermore, income from wage work in agriculture is one of the important sources of income in rural areas. However, the share of income from the agriculture sector started to decline in 2014, when rice prices began to fall after the food crisis. Instead, the proportion of income from wage work including both agriculture and non-agriculture increased from 31 percent in 2004 to more than half of total income in 2017. Among income from wage work, income from the garment sector is the largest source of income, followed by income from construction, agriculture and governmental services. Domestic remittances also accounted for a significant share of household income growth in 2014, 11 percent of total income. However, that proportion decreased to around 2 percent in 2017. In absolute terms, total domestic remittances decreased from USD56 to USD12 in 2010 PPP.

(6) Comparison of change in incomes sources by region

Households in Phnom Penh have the highest household income in the country, with income from wage work being the main income source there, particularly income from the service sector, notably business and governmental services. In 2017, wage income from the garment sector increased significantly, from USD18 PPP in 2014 to USD107 PPP in 2017, mainly due to an increase in the minimum wage in that sector. The second largest income source is income from self-employment in the non-agricultural sector, especially retail services. From 2009 onward, almost all households had access to grid electricity, so expansion of access to electricity could have contributed to household income growth in Phnom Penh.

In urban areas other than Phnom Penh, the largest income source is income from self-employment in non-agriculture, especially retail services. In 2017, income from wage work, especially in the service sector, became the largest source of income. Similar to the situation in Phnom Penh, households in this area may have benefited from expansion of electrification, which contributed to household income growth through increased time devoted to wage work and own business activities. As a result, the income gap between rural areas and Phnom Penh began to decrease in 2014.

Finally, for households in rural areas, accounting for 70 percent of total households, the main driver of household income growth from 2004 to 2009 was increased crop income resulting from higher rice prices and greater rice production. However, with an increasing proportion of households having access to grid electricity, there has been a growing tendency for households in rural area to shift their main income sources from agriculture to non-agriculture since 2014. In particular, income from self-employment in retail service

was the largest income source from 2014 onward. In 2017, average income from wage

work in the garment sector increased significantly from USD5 PPP to USD75 PPP. Income

from wage work in the service sector also increased significantly, with the proportion of

income from wage work accounting for more than half of the total income in rural areas.

In summary, it seems that expansion of electrification is associated with household

income growth through increase in household nonfarm income, most importantly in

nonfarm wage work, and in particular in garment industry. Clearly, access to electricity and

the expansion of the garment sector had positive impacts on household income growth.

2.6 Estimation strategy

Section 2.2 explores the mechanism by which household electrification affects labor

supply and household income. Descriptive analyses in section 2.5 reveal that the time use

pattern of individuals with access to electricity is different from that of those without

electricity, especially in terms of time for work. Furthermore, we see growth in household

income in Cambodia from 2004 to 2017, especially through increased income from wage

employment in non-farm sector. However, these results do not take into account

heterogeneity across households, namely a systematic difference that may exist between

households with access to electricity and those without electricity. Therefore, we discuss in

this section our strategy for identifying causal effect of electrification on employment and

household income.

2.6.1 Methodological challenges in impact evaluations of electrification projects

A large body of literature on the relationship between infrastructure projects and economic growth acknowledges that the placement of infrastructure projects is not random, and thus controls are required for rigorous impact evaluation. For example, governments allocate projects to areas where population is growing and the economy is expanding. Alternatively, if infrastructure provision is part of a poverty reduction strategy, the government might favor lagged areas where the poverty rate is high. Such selection bias should be controlled for, since presence of endogenous selection of treatment group means that simple regression analyses are biased either upwards or downwards. Furthermore, confounding trends in the economy make it more difficult to identify the effects of infrastructure on economic outputs.

Recent studies focusing on developing countries have addressed these issues in different ways, depending on the nature of electrification expansion and related assumptions regarding the relationship of the electricity roll to other factors. First, some studies use "before and after" or "with and without" comparisons (Barkat et al. (2002), World Bank (2002), UNDP (2011) and Grogan (2008)). However, those analyses are prone to confusion regarding changes in outcomes, since results of and changes in electrification can be attributed to dynamic changes that naturally occur in a household's environment. For example, in their study of rural electrification in Bangladesh, Barkat et al. (2002) conclude that average annual income of households in villages with electricity is 64.5 percent higher than that of households in non-electrified villages. Furthermore, within electrified villages, based on with and without comparison, they determine that the income of connected households is 126 percent higher than that of non-connected ones. However, it

is likely that households in electrified villages were initially wealthier than non-electrified counterparts, and thus the observed differences are only partly explained by electrification.

Over the past decade, robust impact evaluation studies based on the comparison of treatment and control groups are widely accepted. One common way of addressing bias due to endogeneity issues is the use of the instrumental variable (IV) approach. IV method requires a conditional independence assumption, namely that the error term in the outcomes regression must be conditionally independent of its instrumental variable. Previous studies have used a range of instruments, and geographic variables have played an important role. For example, Dinkelman (2011), Grogan and Sadanand (2012) and Lipscomb et al. (2013) use a community's land gradient as a predictor of electricity availability, under the assumptions that land gradient significantly affects electricity line construction costs, and it is not directly related to outcome variables such as employment and income. However, it should be pointed out that land gradient may affect crop production in a region, in turn influencing outcome variables of agriculture income. Similarly, Ramos et al. (2012) use number of islands per province as an IV for electricity access with consideration of unique geographic characteristics of the Philippines. Number of islands indicates the presence of communities that demand electrification. Grogan's (2015) use time-varying distance between main town of a municipality and the nearest operating hydroelectric dam in Columbia. Van de Walle et al. (2015) and Squire (2015) use distance from each village to the nearest power plant to predict electricity availability in India and Honduras. Charkravotry et al. (2014) use not only distance to substation points, but also district level density of transmission cables to predict electricity availability in India. Furthermore,

Khandker et al. (2009 & 2014) use household proximity to power line and proportion of households in a community which have electricity, respectively. Grogan and Sadanand (2012) use population density prior to electrification as an IV in addition to the geographic based variable, mean slope gradient of the land, in their study in Nicaragua.

Given the availability of panel data, employing the difference-in-differences (DID) approach in combination with "with and without" and "before and after" using baseline and follow-up data, could boost the credibility of this kind of analysis since it enables control for both observable and unobservable time-invariant characteristics. Khandker et al. (2013) rely on 2001 and 2005 data from surveys conducted in 42 communes electrified in Vietnam, using DID with fixed effects at community and household levels to compare the outcome variables of treatment and control groups. They find that electrification led to an increase in farm income, but not in other sources of income.

Propensity score matching (PSM) has been used in numerous impact assessments of electrification, e.g., Kumar and Rauniyar (2018), Khaneker et al. (2009) and Peters et al. (2011). Instead of directly matching observable characteristics of two groups, PSM calculates the probability of treatment for both treatment and control group, based on their observable characteristics at baseline, and keeps only the subset of samples where the propensity scores of the treatment and control groups match.

Another technique for identifying the impact of electrification is Regression Discontinuity Design (RDD), used by Usmani and Fetter (2018) to assess the impact of large-scale electrification on the structural transformation in rural India. In that case, use of

this approach is appropriate since the eligibility criterion for electrification is very clear: containing a habitation with at least 300 people in a village.

Finally, Bernard and Torero (2013) and Barron and Torero (2014) use the Randomized Encouragement Design (RED) technique to examine the effect of electrification on the economic lives of rural households in developing countries. This approach consists in randomly allocating incentives for connecting to the grid and using them as instruments. Barron and Torero (2014) randomly allocated vouchers for 20 percent and 50 percent inspection fee discounts in El Salvador, generating exogenous variation in the connection fee and used them as an IV for household electricity connection status.

2.6.2 Identification strategy

To examine the impact of access to electricity on employment and household income growth in Cambodia, this study evaluates overall access to electricity across the country, since multiple electrification projects were implemented during the study period, as discussed in as section 2.5.2. I obtained household electrification status from data from a household questionnaire within CSES survey data. I define treatment households as those having access to publicly provided electricity or city power (national electricity grid provided by the government), and control households as those which do not have such connection and hence use generator, battery or kerosene lamp as their main source of lighting.

First, to identify the causal effects of household electrification on employment of a household member aged 15 to 58, we calculated Y_{ihvt}, conditional on the treatment of

household electrification (*Elec$_{hvt}$*), expressed by the following equation, and estimated by means of a linear probability model:

$$Y_{ihvt} = \alpha_1 + \beta_1 Elec_{hvt} + \delta_1 X_{ihvt} + \pi_1 H_{hvt} + V_{vt} + \lambda + \theta t + \varepsilon_{ihvt} \tag{1}$$

where *Y$_{ihvt}$* represents the outcome variables of individual *i* of household *h* in village *v* at time *t*. We examine four outcomes related to employment at individual level: (1) a binary variable for an individual *i* of working age (age 15–58) who is a paid employee, generally categorized as wage employment; (2) a binary variable for an individual *i* of working age who is a self-employed in the non-farm sector; (3) a binary variable for an individual *i* of working age who is a self-employed in the agriculture sector; and (4) a binary variable for an individual i of working age who is an unpaid family worker. Since our outcome variables have values 1 or 0, using a linear probability model which accommodates values below 0 or above 1 may not be appropriate, so I also employ probit and instrumented probit models to address this problem, as discussed in the appendix.

Elec$_{hvt}$ is our interest variable, measured by the coefficient (β), a binary variable related to access to electricity at household level, which has value 1 if household *h* uses publicly provided electricity or city power as their main source of lighting and 0 otherwise. *X$_{ihvt}$* is a vector of individual level characteristics including gender (has value of 1 if female and 0 otherwise), age, age squared (to detect non-linear effect of age), a dummy variable for married status of individual *i* (has value 1 if married), and years of education. *H$_{hvt}$* is a vector of household level characteristics including a binary variable household living in urban area (has value of 1 if living in urban area and 0 otherwise), number of toddlers aged 0 to 6, and area of irrigated land for production of rice and other crops (hectares). *V$_{vt}$* is a

vector of village level characteristics including distance to nearest bus stop, a binary

variable for presence of large industrial enterprises (e.g., factory, company employing more

than 10 persons, hotel or restaurant), a binary variable for presence of infrastructure

development projects (e.g., road development), proportion of female and male who are

employed in the village and mean monthly earnings from wage employment in the village,

which may partly reflect the scope of local labor market opportunities. District level fixed

effects are denoted as λ and year-fixed effects are denoted as θ_t. ε_{ihvt} is an error term

representing unobserved variables. Finally, standard errors are clustered at the village level[2].

Second, the impact of household electrification on household income is identified

using the equation:

$$Y_{hvt} = \alpha_2 + \beta_2 \text{Elec}_{hvt} + \pi_2 H_{hvt} + V_{vt} + \lambda + \theta_t + \varepsilon_{hvt} \qquad (2)$$

where, Y_{hvt} represents the outcome variables of household h in village v at time t.

We examine three outcomes related to household income, (1) log of[3] monthly total

household income, (2) log of monthly income in non-farm sector (including both wage

income and income from self-employment), (3) log of monthly income in agriculture sector

and (4) log of monthly other income.

Same as the equation (1), $Elec_{hvt}$ is our interest variable, measured by the coefficient

(β), a binary variable related to access to electricity at household level H_{hvt} is a vector of

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[2] I also conducted regression analyses with standard error clustered at district level. The results are very
similar to the ones that standard error clustered at village level.

[3] 1,280 households out of a total of 37,782 households (equivalent to 3% of all samples) had 0 or
negative income values. Thus, it is plausible that no selection bias problem would result from taking the
log of household income rather than absolute values. Other studies of the impact of electrification on
household income also use log of income (Khandker et al. (2009, 2013, 2014), Kumar (2018),
Chakravorty et al.(2014)).

household level characteristics including the dummy variable whether a household head is female, the number of household members aged 15 to 20, 21 to 30, 31 to 40, 41 to 50 and 51 to 58 years old, proportion of household members who are female, proportion of household members who completed primary school, secondary school and tertiary school, a binary variable for household living in urban area, and size of irrigated land for production of rice and other crops (hectares). V_{vt} is a vector of village level characteristics including distance to the nearest bus stop, a binary variable for presence of large industrial enterprises (e.g., factory, company employing more than 10 persons, hotel or restaurant) and a binary variable for presence of infrastructure development projects (e.g., road development) and proportion of female and male who are employed in the village. District level fixed effects are denoted as λ and year-fixed effects are denoted as θ_t. ε_{hvt} is an error term, representing unobserved variables. Finally, standard errors are clustered at the village level.

The main drawback of the above two control methods are that the endogeneity of the electricity dummy is not controlled and the estimates are subjected to be biased if household's access to electricity is influenced by unobserved variables. As a consequence, a household's decision to have electricity may be correlated with the error term, (ε_{ihvt}). As indicated in Cambodia Energy Sector Strategy 2004, the electrification strategy in Cambodia tends to give priority to areas with the best potential for economic development and with higher income levels, which suggest that project placement is not random. Therefore, as a second approach to resolve the endogeneity problem, this study employs an instrumental variable (IV) estimation with fixed effects. The idea of the IV estimation is that suitable instruments can affect household's access to electricity ($Elec_{hvt}$) but not the

error term (ε_{ihvt}). Namely, instruments should not affect the outcome variables, Y_{iht} and Y_{ht} directly, but only through the intervention, that is, access to electricity. Household's access to electricity ($Elec_{hvt}$) is predicted by using instrumental variables, and then the predicted value of the access to electricity ($\widehat{E}_{hvt}$), instead of the actual ($Elec_{hvt}$) is used in the second stage outcome equation. This is effective since instrumental variables break the correlation between the treatment and the error term, eliminating the endogeneity bias (Khandker et al. (2009)). The equations to estimate are the following:

$$\widehat{E}_{hvt} = \alpha_3 + ZV + \pi_3 H_{hvt} + V_{vt} + \lambda + \theta_t + \varepsilon_{hvt} \tag{3}$$

$$Y_{ihvt} = \alpha_4 + \beta_4 \widehat{E}_{hvt} + \delta_4 X_{ihvt} + \pi_4 H_{hvt} + \lambda + \theta_t + \varepsilon_{ihvt} \tag{4}$$

$$Y_{hvt} = \alpha_5 + \beta_5 \widehat{E}_{hvt} + \pi_5 H_{hvt} + V_{vt} + \lambda + \theta_t + \varepsilon_{hvt} \tag{5}$$

where a vector Z_v is instruments at village level that determine electricity connection but are uncorrelated with the error term of (4) and (5).

Selecting appropriate instruments is crucial, but it is a difficult and time-consuming task, since Cambodia does not set clear program criteria for placement of electricity. Based on long discussions with specialists who are familiar with the energy situation in Cambodia, I propose two instruments; (1) population density at village level; and (2) distance between center of village and nearest electricity substation point. One plausibly exogenous factor in prediction of electrification is population density at village level before commencement of expansion of the electrification projects. If the extension of a given length of grid cable reaches fewer customers in an area where customers are widely dispersed, namely areas with low population density, the marginal cost of an additional household connection is

relatively high. Thus, population density is a cost-related factor; and is one of the keys to our identification strategy. In my study I use population census data collected in 1998 and 2008 by the Cambodian Ministry of Planning. The proportion of households with electricity grid is 13 percent in 1998 and 26 percent in 2008. Thus, it is plausible to conclude that the period 1998–2008 is the period before the electrification projects expanded and historic population density at the village level is exogenous and the one of the significant factors influencing the status of village electrification.

Second, I propose the "distance between center of village and nearest electricity substation" as a second instrumental variable to predict electricity availability. In general, there are four steps in the provision of electricity by an electrical network. First, power is produced at the power plant. Second, it is transmitted along transmission lines to substations. Third, at the substation, the voltage is lowered from 230kv to a level that can be distributed to consumers. Finally, power is distributed along distribution lines from substations to households in a connected village. Thus, it is plausible to say that if a household is located in a village close to an electricity substation, the probability of its being connected to an electricity network is higher than for a village not near any substation points. Furthermore, that distance does not affect our outcome variables related to employment and household income. The steps for constructing the variable are as follows. First, locational data from the ArcGIS file of all the villages were taken from the Population Census data of 2008 provided by the National Institute of Statistics. Second, same village code used in Population Census data and CSES enabled me to select locational data of all the surveyed villages in CSES data. Third, I combined locational data of all the surveyed

villages in CSES with the locational data of all the electricity substations provided by *Open Development Cambodia* (ODC). The ODC provided an Arc GIS file of the electrification grid containing all distribution lines and the location of electricity substations (Figure 2.10). Finally, the distance between centers of each village and the nearest substation point was calculated using the Arc GIS Pro software. It is appropriate to use the distance instead of density or length of electricity distribution lines since there are many cases where the lines cross the village, but the village cannot access the grid. Furthermore, according to the government's announced electricity expansion strategy, the focus is on areas which are far from the substation points, indicating that distance is one of the important elements for targeting electrification areas in Cambodia. Thus, based on above arguments, the proposed two instruments sufficiently address the household level endogeneity issue.

2.6.3 Empirical results

First stage results

To see whether there are any obvious violations of the instrumental variables approach, I first test whether or not the instruments are good predictor of the endogenous variable, household access to electricity. Tables 2.7 and 2.12 show the first stage results of prediction of household access to electricity using two instruments, (1) population density at village level in 1998; and (2) distance between village center and nearest electricity substation point. The fit is very strong: findings with both instruments are statistically significant at 1 percent level. Furthermore, they are also jointly significant with a p-value equal to 0 and a high F-statistics, 19.93, indicating that the instruments are strong.

Second, it is essential to ensure that one of the instrumental variable conditions is valid (i.e. instrument exogeneity) meaning that the instruments are not correlated with the error term of the outcome equation. This test can be performed using Hansen's J statistic, under the null hypothesis that the over-identification restriction is satisfied, that is, the instruments are not correlated with the error term of the outcome equation. As can be seen in the Table 2.7 and 2.12, the results of Hansen's J statistic are insignificant, suggesting that the null hypothesis cannot be rejected, which in turn implies that the over-identification restriction is satisfied. Thus, it is plausible to say that the proposed IVs do not affect our outcome variables and are not correlated with the error term. Regarding the control variables at individual and household level, years of education (a dummy variable for household living an in urban area) has a positive effect on the probability of obtaining a connection to the grid. At village level, a binary variable, presence of large industrial enterprise (e.g., factory, company employing more than 10 persons, hotel or restaurant) also makes a significant contribution to explaining access to electrification. In contrast, size of irrigated land for production of rice and other crops has a negative effect on the probability that households have access to grid electricity.

The third test is to check the exclusion restriction of the instruments to the outcome variables before the expansion of electricity projects following Squires (2015). If the instruments satisfy the exclusion restriction, we would expect them to have an impact on the probability that households have access to electricity, but not on the outcome variables before electrification. Appendix Table A2.5 shows that except for a few cases in case of the distance between center of village and nearest electricity substation point with respect to

57

employment, the instruments do not significantly impact the outcome variables before electrification.

Overall, these tests suggest that the two instruments, (1) population density at village level; and (2) distance between center of village and nearest electricity substation point have a strong first-stage impact on electrification and there is no evidence that the instruments fail the exclusion restriction.

Second stage results

(1) Electricity and employment

Since household income sources are affected by the probability of employment of working age members, I explore factors affecting individual member employment as related to the impact of electricity. The results for both ordinary least squares (OLS) and IV estimations with year and district fixed effects related to employment ((1) wage employment, (2) self-employment in non-farm sector, (3) self-employment in farm sector and (4) unpaid family worker) at individual level are reported in Tables 2.8 to 2.11. (The results by probit model are reported in appendix tables A2.6 to A2.9).

Table 2.8 *shows* the impact of household electrification on wage employment for all individual samples of working age. The estimation is also performed for women and men separately. As the table shows, both the estimation results for both OLS and our preferred estimation model, 2SLS, with year and district fixed effects show that our interest variable, a binary variable, household access to electricity grid, is positive and significant, which supports our *H1*: *Access to electricity increases the probability that household members are*

engaged in wage employment in non-farm sectors. The preferred 2SLS estimations show

larger effect than does the OLS specification. This difference is associated with bias caused

by unobservable in the un-instrumented OLS specification. For women, the 2SLS

estimation result suggests a positive impact of having electricity on wage work propensity:

we find that women are 20.8 percent more likely to work outside the home when there is

electricity in the household. The coefficient is much greater for men, i.e. men are 40.8

percent more likely to work outside in formal sector. It should be noted that the dummy

variable individual married or not is negative and statistically significant at the 1% level.

Furthermore, for women, number of small children aged 0 to 6 years old is negative and

significant, while for men, there is a positive association between electrification and the

number of small children. These results, along with the analysis of time allocation shown in

Table 2.5, indicate that the effect of household electrification on male time allocation is

much larger than on that of women because men are usually the main earners of households

and spend more time working as employees. As a result, women are involved in taking care

of younger children and doing domestic activities, and thus have less time to work as

employed.

Next, Table 2.9 shows the impact of household electrification on self-employment

in the non-farm sector. Again, the coefficient of the dummy variable of household access to

electricity is positive and significant for all specifications. By gender, the coefficient of the

dummy variable of household access to electricity for male is slightly greater than that of

female (48.6 percent for male and 47.9 percent for male), which partly supports my *H2*:

Access to electricity induces household members to start their own household businesses in

the non-farm sector; this effect is stronger among females than males. Different from the results in case of wage employment, years of education, the dummy variables individual is married or not and number of small children aged 0 to 6, are positive and significant for all specifications.

Third, the results of the estimation of the impact of household electrification on self-employment in the farm sector are reported in Table 2.10. Self-employment in the farm sector is largely related to rice production, as rice is the staple food. For all specifications, the effect of electrification on the probability of engagement in self-employment in the farm sector is strong and negative, which is consistent with the analysis of time use data in Table 2.5: individuals with access to electricity spend less time doing agricultural work. Then surely electricity increases the profitability of wage employment and self-employment in nonfarm sector more than that of self-employment in farm sector. Furthermore, no clear gender difference is observed in the case of self-employment in farm sector.

Finally, the results of the estimation of the impact of household electrification on unpaid family worker are reported in Table 2.11. The coefficient of dummy variable of household access to electricity is negative and significant in all the specifications, suggesting household access to electrification contributes to reduction of unpaid family worker and the effect is greater among male. It should be noted that the coefficient of a dummy variable whether an individual is married or not is positive for women, whereas negative for men, suggesting entering into a marriage increases a probability to become unpaid family worker for women, but the direction is opposite for men.

The estimation results of both probit and instrumented probit models are reported in appendix tables A2.6 to A2.9. As the tables show, the results are similar to those for the linear probability model: the coefficients on the electrification dummy are positive and significant in the case of wage employment and self-employment in non-farm sector, and negative and significant for self-employment in farm sector and unpaid family worker.

In summary, the estimation results show that household access to electricity increases the probability of work in wage employment and self-employment in non-farm sector, and decreases the probability of self-employment in farm sector and work as unpaid family worker; all of which indicates that electricity induces working age individuals and households to shift their economic activities away from farm and toward non-farm activities.

(2) Electricity and household income

Next, I examine the impact of electrification on household income, namely: (1) log of monthly total household income; (2) log of monthly non-farm income; (3) log of monthly farm income; and (4) log of monthly other income. The results for both OLS and IV estimations with year and district fixed effects are reported in tables 2.13 to 2.16. All estimations are performed by geographic category and urban-rural areas.

First, Table 2.13 shows the results of estimation of the impact of electrification on monthly total household income. As discussed in section 2.5.3, household income sources can be divided into: (1) income from wage work; (2) income from self-employment (agriculture and non-agriculture); and (3) income from other sources such as pensions,

remittances, dividends. As can be seen in the table, both OLS and 2SLS estimation show household access to electricity having a significant positive impact on monthly total household income. Our preferred model of IV estimation (2SLS) shows that access to electricity increases average monthly total household income by 54.9 percent, as seen in column (2). The effect of electrification is much stronger in urban areas than in rural areas, where the impact is insignificant, since households in rural areas rely on farm income, which has a negative association with access to electricity, as explained in detail later. Regarding other control variables, educational level of household member, in particular higher education, has a positive and significant impact on total household income. In addition, area of irrigated land for production of rice and other crops has a positive and significant effect, except in urban areas. Finally, there is a negative association between the dummy variables female-headed household and total household income.

Second, the results of estimation of non-farm income (including both income from wage employment and self-employment) are reported in Table 2.14. The effect of electrification is much stronger than that of total income, which includes farm income. As the table shows, access to electricity had a significant and positive impact on both OLS and IV estimations using all samples, which supports *H3*: *Access to electricity contributes to total household income growth through increased household nonfarm income*. As for geographic area, the effect is much stronger and positive for urban areas although it was insignificant. In rural areas, the effect is positive and significant: electrification increases monthly non-farm income by 90.5 percent, as can be seen in column (4). Furthermore,

quantity of labor and educational level of household members also significantly affected non-farm income growth.

Fourth, the results of estimation of farm income are reported in Table 2.15. The effect is negative and statistically significant at the 1% level, which rejects *H4*: *Access to electricity does not significantly affect agricultural income*. This can be explained by the tendency for people to switch out of agriculture into non-agricultural activities as a result of electrification, which is consistent with the time use data shown in Table 2.5: individuals with access to electricity spend less time doing agricultural work than individuals with no access to electricity. By region, the negative effect is much stronger in rural areas, which decreases monthly farm income by 164 percent, as can be seen in column (4). This strong negative effect on farm income in rural areas indicates that household access to electricity has a positive but not significant effect on all household income sources reported in column (4) of Table 2.13. Regarding other control variables, area of irrigated land for production of rice and other crops has a positive and statistically significant at the 1% level, except in urban areas. Quantity of labor as well as educational level of household member have a significant impact on farm income growth. In contrast, the dummy variables household head is female; household lives in an urban area; and proportion of females in household have a negative impact on farm income.

Finally, the results of the estimation of log of other income[4] (non-labor income) are reported in Table 2.16. Other income includes income sources such as remittance, pensions,

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[4] Other income includes pensions, social benefits, remittances (domestic and abroad), scholarships, transfer from NGO, income from lottery and gambling, bank interests and dividends and interest on loans to others.

and interest on loans. In particular, remittance (both domestic and abroad) accounts for about 70 percent of other income sources (Appendix Table A2.1). That result suggests that household access to electricity only had a significant positive impact for OLS estimation. Results differ across the un-instrumented and instrumented specifications using whole samples. While the OLS specification suggests a positive association between electrification and other income, this association disappears once potential endogeneity has been accounted for. Furthermore, the effect of household access to electricity on other income became insignificant in the 2SLS estimation. By region, there was positive association between access to electricity and urban areas, while a negative association was observed in rural areas—though none of those associations are significant. Overall, there is no clear indication of the mechanism by which electrification affects non-labor income.

2.7 Robustness check

In this section, I examine the sensitivity of my results using two methods: (1) employing the OLS with village fixed effect using panel data at village level; and (2) investigating the spillover effect of village electrification.

2.7.1 Panel data at village level

To control for time-invariant confounding factors at village level, I restrict the samples to panel data at village level.[5] Estimation strategies are the same as equations (1)

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[5] CSES data are cross-sectional data, but can be paneled at village level partly using geographic code. Using the panel data at village level reduce our sample size significantly, only 91 villages out of 900 villages in 2004, 720 villages in 2009 and 1,008 villages in 2014 are panel data.

and (2) in section 2.6.2 and employ village fixed effect rather than district fixed effect. The results for ordinary least squares with year and village fixed effects related to employment ((1) a binary variable for individual i of working age (age 15–58) who is a paid employee; (2) a binary variable for individual i of working age who is self-employed in the non-farm sector; (3) a binary variable for individual i of working age who is self-employed in the agriculture sector; and (4) a binary variable for individual i of working age who is an unpaid family worker) are reported in Table A2.10 to A2.13 in the appendix.

Overall, the effect of household access on employment is similar to our main results. First, in the results of estimation wage employment are reported in Table A2.10, consistent with the main result, there is an increase in wage employment with access to electricity, with the effect much stronger for males. In case of self-employment in the non-farm sector, the effect is positive and significant for all specifications. The effect is slightly higher for women, which reflects the fact that self-employment activities in the non-farm sector are mainly performed in households, so women can easily combine them with household chores and domestic activities (Table A2.11). Furthermore, consistent with the main results, there is a negative association between access to household electricity and self-employment in farm sector, although for males the effect is small and insignificant (Table A2.12). Finally, the electrification effect is negative in the case of unpaid family worker, but not significant (Table A2.13).

Next, the estimation results with village fixed effect on outcomes related to household income ((1) log of monthly total household income; (2) log of monthly non-farm

income; and (3) log of monthly agricultural income) are reported in tables A2.14 to A2.16 in the appendix.

Again, overall, the estimation results are similar to the main results. First, as can be seen in Table A2.14 and A2.15, the impact of access to electricity on log of total monthly household income and non-farm income are positive and significant. By geographic area, the effect is stronger for urban areas, but weak and insignificant for rural areas. In contrast, there are negative associations between farm income and household access to electricity for all specifications, but none of them are significant (Table A2.16).

2.7.2 Spillover effect

Non-electrified households within electrified villages may experience a change in their outcomes related to employment and household income as a result of spillover effects of village electrification. In this analysis, my treated group corresponds to non-electrified households in electrified villages; control households are households in non-electrified villages. That is, I discarded electrified households in electrified villages. Estimation strategies are the same as equations (1) and (2) in section 2.6.2 and our interest variable is the binary variable village connected to grid electricity, rather than access to electricity at household level.

First, Table A2.17 shows the results of IV estimation for the examination of spillover effect on outcomes related to employment. As can be seen in the table, village electrification increases wage employment and self-employment in the non-farm sector at individual level, suggesting that there are changes in local labor market conditions that

66

generated new employment opportunities which in turn prompted more people to enter either the wage labor market of self-employment in the non-farm sector. This is consistent with firm characteristics in electrified villages and villages without electricity grid, as per the Economic Census data of 2011 and 2014, shown in Table A2.18.[6] As can be seen in the table, in electrified villages the proportion of formal firms increased from 5 percent in 2011 to 50 percent in 2014, which suggests that labor-intensive jobs that employ larger number of workers in wage employment are increasing in number in electrified villages. By contrast, Table A2.17 indicates that village electrification decreases self-employment in farm sector and unpaid family worker.

Second, Table A2.19 shows the results of IV estimation of village level effect of electrification on household income. The effect is negative and significant for income from farm-sector, while there are positive associations for total household income and income from farm sector, although none of the results are significant.

Overall, the analysis confirms the presence of spillover effect from village connection on non-electrified households, especially in terms of employment. Furthermore, I confirm a demand effect working through changes in local labor market conditions: wage employment is increasing in electrified villages.

2.8 Summary and conclusion

Cambodia, one of the fastest growing economies in Southeast Asia, recognizes inadequate supply of electricity as one of the key obstacles to its economic development.

[6] I subtracted the CSES surveyed villages from the Economic Census (EC) data of 2011 and 2014 and matched with the village electrification status from CSES2009 and CSES2014.

Given the numerous recent enhancements of electrical grid infrastructure in developing countries, it is important to have an understanding of the mechanism by which access to electricity impacts household welfare. This study examines the impacts of access to electricity on employment of working age population and on various sources of household income. Using the instrumental variable approach, I obtained estimation results that suggest a strong and positive effect of household electrification for both women and men on wage employment in formal sector and on self-employment in non-farm sector. With regard to household income, the findings indicate that increased access to electricity contributes to total household income growth through increase in nonfarm income. Furthermore, the effect of electrification on income growth is much stronger in urban areas. These results are consistent with estimation results using OLS with village fixed effects; and the analysis of spillover effect of village electrification. In addition, the descriptive analysis using the data from labor demand side shows that labor-intensive jobs that employ larger number of workers in wage employment are expanding in electrified villages.

To sum up, the findings show that electrification facilitated a shift of household economic activities from farm to non-farm activities, and that shift could be the main driver of household income growth. These results suggest that electricity projects are the main driver for the extensions of current welfare gains in Cambodia. Furthermore, I find that expanding access to national grid electricity contributes to the creation of formal sector jobs. In light of the above findings, it is essential to give top priority to energy poverty in policy discussions related to development in other areas of the world.

Chapter 3

Impacts of Electricity on Child labor and Education: Evidence from Cambodia

3.1. Introduction

Access to modern energy services, importantly electricity, is widely acknowledged as a prerequisite for economic and social development. As of 2014, there are over 1.2 billion people who still lack access to electricity worldwide and it is estimated that 512 million people in developing Asia have no access to electricity (International Energy Agency (IEA) 2016). The lack of access to electricity believed by many to be a major impediment to economic and human development. Based on this assessment, the United Nations aims for universal access to electricity by 2030 via their initiative *Sustainable Energy for All*. However, the investment requirements of electrification are enormous, and the IEA estimates than an investment of 640 billion USD is necessary if universal access to electricity is to be achieved by 2030.

In chapter 2, I observe household income growth in Cambodia mainly through increased non-agricultural activities due to electrification. One of the other major benefits of electrification is increased educational attainment of children because of increased household income. However, the impact of access to electricity on educational attainment is empirically unclear since there could be multiple mechanisms at work. Electrification creates employment opportunities for adults, leading to an increase in household income and demand for schooling. Access to electricity also increases time available to children for

study at home due to extended lighting hours. However, access to electricity simultaneously increases demand for low-skilled labor. This would increase the opportunity cost for children to stay in school, which could lead to a drop in schooling participation and educational attainment, including study hours.

There is also no consensus in the empirical literature on the impact of access to electricity on educational attainment. While some studies do find a positive effect, others find no effect. Barron and Torero (2014), Samad (2013), and Khandler et al. (2013) find an increase in hours spent for studying, but Bensh et al. (2011) finds no effect. As for the impact on enrollment and educational attainment, Khandker et al. (2009 & 2013 & 2014), Lipscomb et al. (2013), and Vande Walle et al. (2015) find an increase in both enrollment and school attainment. In contrast, Barron and Torero (2014) find no such effect and Squire (2015) finds a negative effect on school attendance since electrification increases childhood employment. Despite the fact that there has been an increasing interest in the status of child work in developing countries and its implications for children's human capital development and poverty alleviation, there exist only a few empirical studies that investigate the role of electrification on human capital formation and child labor.

To fill this literature gap, this chapter explores the impact of electrical expansion on children's educational attainments in Cambodia, whose infrastructure, including the power sector, was severely damage by years of war. After the restoration of peace and order in the country, the Royal Government has focused on rehabilitation and development of the basic infrastructure including electricity, with the aim of improving the socio-economic conditions and as a further step for development. Thus, Cambodia identifies electricity as

one of the priority areas and the country has received substantial foreign development assistance for the expansion of coverage of electricity grids. I exploit this increase in access to electricity, which occurred at different points in time for each province, to estimate the impact of electricity on child education.

To measure electricity's impact on children's educational attainment, I focus on three possible channels. The first is electricity's impact on the demand side of education through an increase in household income, as one of the main reasons for letting children work is to supplement household income. The second channel that I look at is electricity's impact on the employment of the female spouse, which affects the demand for child labor. This is because if female spouse is being drawn into the labor market, children at school age may need to stay home to take care of their younger siblings and performs household chores. The third channel I examine is childhood participation in the labor market to investigate if access to electricity reduces educational attainment through increased employment opportunities for children (demand side for children's labor).

Finally, to address endogeneity concerns related to household access to electricity, I employ the instrumental variable approach with fixed effects. I use multiple instrumental variables and I introduce a new instrument, distance between center of a village and a closest electricity substation point, which was discussed in the Chapter 2. Using these instruments, I find that my results hold and remain robust across regression specifications.

The rest of this chapter is organized as follows: Section 3.2 provides a conceptual framework and literature review. Section 3.3 describes children in school and employment in the Cambodia, Lao PDR, Myanmar and Vietnam (CLMV) and Association of Southeast

71

Asian Nations (ASEAN) countries. Section 3.4 describes educational background and Child Labor Law in Cambodia. Section 3.5 provides descriptive analysis, including datasets and the characteristics of child labor and education. Section 3.6 describes estimation strategy. Finally, Section 3.7 concludes this chapter.

3.2. Conceptual framework and literature review

3.2.1 Conceptual framework

Access to electricity could affect children's educational attainments through various channels. The main channels through which electrification may affect education could be grouped into the supply side and demand side factors of education. For the supply side, electrification improves the quality of schools, through either the provision of electricity-dependent equipment, or increased teacher quantity and quality. In this chapter, I focus on the demand side of education, in particular households' decision to let children work and its impacts on children's educational outcomes.

The expected effects of electrification on children's educational attainments are depicted in Figure 3.1. There are mainly three channels how electrification affect children's educational attainment. First, electrification could have a negative effect on child labor and positive effect on children's educational attainment mainly through an increase in household income. Use of electrical appliances such as washing machines, refrigerators, and rice polishing machines allows household members to extend operating hours of household business. Moreover, it enables people to save time on domestic chores, freeing up additional time each day for income-generating activities. The impact is greater on

women since domestic chores are mainly carried out by them. This release of domestic time facilitates women to join the labor market as wage employees or through self-employment in household businesses, which contributes to the household income growth. Second, increase in female labor force participation would lead to changes in the household time allocation dynamics, since household tasks may be redistributed. One of the ways that this might impact children's educational attainment is that if a mother goes to work outside, a child may have to work and help home-based production activities as an unpaid family worker or stay home and take care of younger siblings. This may have a negative impact on children's educational attainments since they have to stay home instead of going to school. Third, access to electricity enables children to extend their study time which consider to have a positive effect on children's educational attainment. Finally, even if electrification enables households to save time, household members may decide to devote this extra time to leisure or other activities, which decreases household income and the demand for child education, but beyond the scope of this study.

3.2.2 Literature review

In this section, I provide a brief review of the empirical literature that investigate the impact of electrification on education.

Several studies analyze the effect of electrification on study time and school enrollment. First, with regard to study time, using propensity-score matching and an instrumental variable strategy, Khandker et al. (2012) find that in households with electricity, boys study 22 minutes more and girls 12 minutes more per day in Bangladesh.

From a sample of 4,000 rural households in Bangladesh, Samad et al. (2013) found that having a solar home system is associated with an increase in boy's study time by 8 minutes and girl's study time by 7 minutes during the evening. Using an instrumental variable approach with a sample of 24,000 rural households in India, Khandker et al. (2014) found that household electrification led to an increase in study time by more than an hour per day. Using a randomized control trial approach in rural El Salvador, Barron and Torero (2014) explored time-use changes induced by electrification. They found that electrification increased the probability of engaging in educational activities such as study time and time at school.

In the African context, Peters and Sievert (2016) find an increase in study time after nightfall, but only in Senegal. Other studies find no effect. For example, using a difference-in-differences and a propensity score matching approach with a sample of 537 households in rural Rwanda, Bensch et al. (2011) find a small positive effect of electrification on children's study time at home (20 minutes more per day for primary school children), but the effect disappeared when they accounted for regional differences. Bernard and Torreo (2013) assess a random allocation of vouchers as extra incentive for individuals to connect to the electrical grid in Ethiopia. By collecting time-use information, they found no impact of electrification on study time over the 12 months. Using a sample of 8,897 households in rural and urban locations in Tanzania, Chaplin et al. (2017) investigated the impact of a large-scale electrification program using a difference-in-differences and group randomized controlled trial approach. By examining three interventions, they found no impact on study time at night. Similarly, using an RCT with 1,281 rural households in India, Aklin et al.

(2017) found no systematic evidence for changes in time spent for studying after one year

of accessing off-grid solar power. Finally, in a study of 5,004 rural households in

Guatemala, Grogan (2018) found no impact of household electrification on children's time

spent for studying. In summary, the findings in the literature on the impact of electricity on

child study time are mixed.

Next, with regard to impact of electrification on enrollment, Khandker et al. (2014)

found that household electrification led to a 6-percent increase in school enrollment for

boys and a 7.4-percent increase for girls in rural India. In Vietnam, using a panel sample of

1,120 rural households, Khandker et al. (2013) observe that household electrification led to

an increase in school attendance by 6.3 percentage points for boys and 9 percentage points

for girls. In both India and Vietnam, it appears that the impact of electricity is greater for

girls. Using an instrumental variable approach, Van de Walle et al. (2015) detect an

increase in school enrolment rates and in years of schooling for girls in rural India. Using

CSES panel data at the village level, Saing (2017) finds that rural electrification increases

boys' and girls' years of schooling completed by 0.85 and 0.62, respectively, in Cambodia.

Lipscomb et al. (2013) found that electrification at the county level led to improvements in

both enrollment and a reduction in illiteracy rates in Brazil. Other studies find no evidence

or find a negative relationship between electrification and children's educational

attainments. Tenezakis and Tritah (2019) find a strong and positive, though insignificant,

effect of electricity on work propensity and a negative effect on wage-work hours in

Rwanda. Among educational outcomes, they do not find any statistically significant impact.

In Peru, Dasso et al. (2015) find that household access to electricity generates negative

impacts on educational expenditures among boys, and small but positive effects on enrollment rates among girls. Furthermore, using an instrumental variable approach, Squires (2015) finds access to electricity reduces educational attainment in Honduras, and this was accompanied by an increase in childhood employment.

The literature review illustrates that there is no clear-cut consensus on the impact of electricity on education for several reasons. First, despite the usefulness of time-diary data, the short reference period implies that any given time diary is a poor indicator of that individual's long-run time use pattern. Variation in time-diary data should be mixture of variation in the mean of long-run time use and short-run variation around the mean, but it is particularly challenging to collect such data in household surveys (Frazis and Stewart, 2012). Second, most empirical papers concentrate on rural electrification. Although the electrification rate in rural areas is lower than in urban areas, but urban electrification remains a challenge, and it is important to compare the effect of electrification in both urban and rural areas. Finally, the linkage between a change in employment opportunities for children due to electrification and their educational attainments remains missing. This chapter tries to fill this gap by investigating the impact of electrical expansion on children's educational attainment with focusing on three possible channels, namely household income, female spouse employment and childhood labor.

The first channel I look at is electricity's impact on household income, which categorized as indirect effect on children's education. The second channel I analyze is electricity's impact on female spouse employment, which also categorized as indirect effect. If more women are being drawn into the labor market, children may need to stay home to

help home-based production activities or take care of younger siblings. The third channel I examine is childhood participation in the labor market to see if access to electricity is reducing education through increased employment opportunities for children. Therefore, I postulate the following three hypotheses on electricity, child labor, and children's education:

Hypothesis 1 (H1): Increase of total household income decreases child labor.

Hypothesis 2 (H2): Access to electricity induces the female spouse to work outside, which results in redistribution of household tasks and an increase in child labor.

Hypothesis 3 (H3): Electrification decreases the incidence of child labor, which leads to an increase in educational attainment.

3. 3 Children in school and employment in the CLMV and ASEAN countries

Although Cambodia is emerging as one of the fastest growing economies in the world, a major constraint in Cambodia's development is the low level of human capital development.

Table 3.1 presents indicators related to education, namely net enrollment rate of primary school (% of primary school age children), children out of school (% of primary school age), and enrollment rate of secondary education (% net) by gender in the CLMV and ASEAN countries. First, net enrollment rate[7] of primary school is high, over 95 percent across all the countries. In case of Cambodia, it is reported that 95.3 percent of primary

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[7] Net enrollment rate is the number of pupils of the school-age group for primary education, enrolled either in primary or secondary education, expressed as a percentage of the total population in that age group.

school-age children entered school. There is no clear gender difference, but the percentage is slightly higher for boys, at 96.4 percent, and is 94.3 percent for girls. However, with regard to the percentage of children out of school, Cambodia has the second highest among all the countries (next to Indonesia), at 4.7 percent of primary school-age children. The rate is high for girls, at 5.7 percent for girls, and is 3.6 percent for boys. Third, the enrollment rate of secondary education in CLMV countries is significantly lower than that of ASEAN 6 countries. Although the figures are from 2008, Cambodia shows the lowest enrollment rate for secondary school among the CLMV countries, which is 38.3 percent. By gender, the proportion of women is only 36.7 percent, whereas it is 39.9 percent for men. Low levels of secondary school enrollment and low enrollment of girls are formidable challenges that lie ahead in improving the education outcomes, though the Royal Government of Cambodia is committed to its agenda of Education for All (EFA).

Table 3.2 presents indicators related to children in employment[8] in the CLMV and ASEAN countries. As the table shows, the child labor situation in the countries has improved considerably from 2001 to 2012. The decline in child labor is associated with economic growth and rising household income, which has fed job creation, and improved social protection for the population including the expansion of the conditional cash transfer program. In Cambodia, due to high economic growth and advancement in efforts to eliminate the worst forms of child labor, the percentage of children in employment (% of children ages 7–14) decreased significantly from 52.3 percent in 2001 to 11.5 percent in 2012. However, the percentage is still the highest among all the countries. In absolute

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[8] Children in employment refer to children involved in economic activity for at least one hour in the reference week of the survey.

numbers, it is estimated that over 313,000 children are still engaged in employment in

Cambodia (ILO 2010). The statistics indicate that 11 percent of children aged 7–14 years in

Cambodia combine work and study at the same time. With regard to employment status, the

percentage of children in wage employment[9] (% of children in employment, ages 7–14)

was 19.6 percent in 2012 in Cambodia, which is the second highest proportion, followed by

Philippines, where data are available. Finally, the percentage of self-employed children [10]

from ages of 7 to 14 decreased from 9.2 percent in 2009 to 3.3 percent in 2012 in Cambodia.

It is considered that most children in employment are engaged as unpaid family workers,

which are not reflected in the statistics.

3.4 Educational background and Child Labor Law in Cambodia

Figure 3.2 shows the educational structure with approximate starting age and

duration in Cambodia. The education system in Cambodia is divided into four levels: pre-

school education, primary education, secondary education (lower and upper), and higher

education. Six years of primary education and three years of lower secondary education

make up the country's basic education provision. After the completion of lower secondary

education, students have the option of continuing to upper secondary education or of

entering secondary-level vocational training programs offered by the Ministry of Labor and

Vocational Training (MOLVT). After completing upper secondary education, students can

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[9] Wage workers (also known as employees) are people who hold explicit (written or oral) or implicit employment contracts that provide basic remuneration that does not depend directly on the revenue of the unit for which they work.

[10] Self-employed workers are people whose remuneration depends directly on the profits derived from the goods and services they produce, with or without other employees, and include employers, own-account workers, and members of producer cooperatives.

enter either vocational training (which lasts for one to three years depending on the program) or the university (which offers two-year associate degree programs, four-year bachelor's degree programs, and seven-year medical programs).

In Cambodia, the Education Law establishes free basic education. Access to free, high-quality education is set out in the country's Constitution. Even though basic education is free, children need to pay school-related fees, such as building maintenance. Furthermore, education is not compulsory in Cambodia from grade nine. Thus, the percentage of children out of school (primary school age) is high and the enrollment rate of secondary schooling is low in Cambodia as the Table 3.1 shows. Other barriers to education include limited transportation to schools in remote areas, lack of drinking water and toilet facilities in some schools, language barriers, and an insufficient number of teachers. These barriers particularly affect ethnic minority children and children with disabilities.

Due to challenges in accessing basic education and the absence of a compulsory education requirement, children are vulnerable to involvement in the worst forms of child labor such as forced labor in the brick industry and in commercial sexual exploitation, sometimes as a result of human trafficking. The government has established laws and regulations related to child labor and ratified all key international conventions concerning child labor. For example, the government signed the Convention on the Rights of the Child in 1992 and ratified the ILO Minimum Age Convention, 1973 (No. 138) in 1999 and the ILO Worst Forms of Child Labor Convention, 1999 (No. 182) in 2005. Cambodia's Labor Law sets the allowable minimum age for wage employment at 15 years. However, due to gaps in Cambodia's legal framework, children are not adequately protected from child

labor. These gaps include the specification of a minimum age for work and prohibiting the commercial sexual exploitation of children. For example, the Labor Law's minimum age protections do not apply to household enterprises, which leaves children vulnerable to child labor in this occupation which are mainly home-based. Furthermore, laws do not prohibit the recruitment of children under age 18 into non-state armed groups. To fill this gap, the government made an advancement in efforts to eliminate child labor in 2017. However, more governmental actions are needed to advance the elimination of child labor, including providing sufficient resources for the enforcement of child labor laws to ensure that inspections are conducted throughout the country, especially in rural areas and in the informal sector (US Department of Labor 2018). Importantly, robust economic growth along with rising household income and good government policies on child labor could work effectively to discourage child labor.

3.5. Descriptive analysis

3.5.1 Data sets

This chapter mainly uses the Cambodia Labor Force and Child Labor Survey data (CLFS) and the Cambodia Socio-Economic Survey (CSES) data from the National Institute of Statistics under the auspices of the Ministry of Planning of the Royal Government of Cambodia for descriptive analyses. CLFS is a nationwide sample survey designed to collect data on the demographic and socio-economic characteristics of working children aged 5 to 17 years. The sample comprises 12,000 households from the 600 sampled villages. The aim of the survey is to provide information on child labor forces for research on the condition of

child labor in the various fields of social studies and economics. CSES data are also nationally representative household survey data, which I used for main analysis in Chapter 2. The survey comprises household demographic information, employment of all household members aged 5 years and older, education, healthcare, housing conditions including main source of lighting, assets, land, credit, income, and consumption. For descriptive analysis, I mainly use CLFS data for 2001 and 2012 and CSES data from 2004, 2009, 2014, and 2017. For the regression analysis, I use only CSES data from 2004, 2009, and 2014. CLFS data and CSES data from 2017 are not used for the regression analyses for following reasons. First, the CSES household survey is conducted every 5 years with a larger sample size beginning from 2004 and CSES 2017 contains a smaller sample. Second, CLFS data, unlike the CSES, do not capture all sources of household income or information related to households' main source of lighting (publicly provided electricity/city power, generator, battery, kerosene lamp, candle, and other), so I need both the CSES and CLFS. In this chapter, I restrict the samples to children aged 7 to 14 years, because most students have started schooling by age 7 and they start to enter into labor market after 15 since the minimum age for employment is 15 years old as set out in the Labor Law in Cambodia. The total number of children aged 7 to 14, households with children, and the number of villages in the surveys are reported in Table 3.3.

In addition to the CLFS and CSES data, I used Population Census data for 1998 and 2008 to construct one of the instrumental variables, population density at village level, which is to be discussed later in the section, 3.6.2.

3.5.2. Child labor and education

Figure 3.3 presents the proportion of children (7–14 years old) who were in the school system in the reference week and the proportion of children who engaged in economic activity even for one hour during the preceding 7 days as either an employee, a self-employed worker, or an unpaid family worker. The figure indicates that the situation for children is improving over the years and the proportion of children who reported going to school during the preceding 7 days increased from 86 percent in 2004 to 96 percent in 2017. Corresponding to this, the proportion of children who are engaged in economic activity decreased from 22 percent in 2004 to 8 percent in 2017. In 2009, the proportion of children engaged in economic activity increased to 34 percent. This may be attributed to the crop failure in 2008, which reduced household income and school attendance and increased child labor mainly as an unpaid family worker in the agriculture sector.

Table 3.4 shows the main sources of lighting in 2004, 2009, 2014, and 2017 in the sample households with children aged 7 to 14 years. In 2004, the main source of household lighting was kerosene lamps, followed by batteries and only 14 percent of households used publicly provided electricity as the main source. In 2009, this number was still low, at 24 percent, and the largest main source of household lighting was batteries, followed by kerosene lamps. Over the years, the percentage of households using publicly provided electricity or city power increased as main source of lighting increased from 14 percent in 2004 to 24 percent in 2009, 59 percent in 2014 and 78 percent in 2017. In particular, the coverage rate expanded significantly from 2014, thanks to several electrification programs.

CLFS 2001 includes information on three different types of questions that are reflected in three separate forms in the questionnaire. One of the questionnaires was answered by parents or guardians on children's activity and include questions regarding their perception on working children. Table 3.5 shows that the parents' main reason for letting children work are related to financial concerns. Parents need their children to work because they are poor and need the supplementary income from children to pay outstanding debt, to assist in the household business, to help start their own business, or to pay for school tuition. Other reasons include to gain experiences, and some are related to quality of education and infrastructure such as the education program being unsuitable or schools being too far. Thus, it is plausible to set household income as one of the underlying mechanisms to affect child labor and education.

The summary statistics of key households and children's characteristics, and the mean differences between households with access to electricity and households without access to electricity are provided in Table 3.6, by treatment group. At the household level, the number of children aged 7 to 14 years and the number of toddlers aged 0 to 6 years are larger in non-electrified houses. Regarding children's characteristics, the mean age of children is slightly higher in households with access to electricity, but the statistical difference disappeared in 2017. Further, a higher proportion of children in electrified houses are currently in the school system than those in non-electrified houses. Furthermore, households without access to electricity have a larger proportion of children who dropped out from the school system. In line with this, the educational years of children in electrified houses is higher than their counterparts in households without access to electricity.

Corresponding to this, the proportion of economically active children during the preceding 7 days is much higher among children in households without access to electricity than those in households with access to electricity. In particular, the proportion of working children increased significantly in 2009 due to crop failure in 2008 and nearly 40 percent of children were engaged in economic activity, mainly in agriculture as unpaid family workers. From 2014, this proportion decreased and 13 percent of children in households without access to electricity and 7 percent of children in households with access to electricity were engaged in any economic activities in 2017.

Regarding working children characteristics, nearly all the working children in households without access to electricity lived in rural areas. The proportion of working children living in households with access to electricity is also high in rural areas. In terms of employment status, nearly 90 percent of working children are unpaid family workers[11]. Based on electrification status, the proportion of children working as unpaid family worker is high among children in households without access to electricity except in 2017. It should be noted that the proportion of children in wage employment (employees[12]) increased over the years, from 4 percent in 2004 to 15 percent in 2017 and the average age of children engaged in wage employment is 13.4 years, although minimum age for work is stipulated as 15 years in Article 177 of the Labor Law in Cambodia. Based on electrification status, the proportion of children engaged in wage employment is high among children in households with access to electricity. The proportion of children working as an own-

[11] A person who works without pay in an economic enterprise operated by a related person living in the same household.
[12] A person who works for a public or private employer and receives remuneration in wages, salary, commission, tips, piece-rate or pay in kind.

85

account worker[13] (self-employed) decreased over the years and none are reported in 2014 and 2017. In terms of industries that children are engaged in, nearly 80 percent of children work in agriculture; followed by service sector and manufacturing sector. As Figure 3.4 shows, boys are more likely to be employed in agriculture than girls, and less in the service sector. In terms of employment status by each sector, the proportion of unpaid family workers is the highest among all the sectors: 89 percent in agriculture, 62 percent in manufacturing, and 82 percent in the service sector (Figure 3.5). The share of wage employment is the highest in manufacturing, at 35 percent. When electricity status is considered, the results show a different picture. Nearly 90 percent of working children households without access to electricity were engaged in agriculture, whereas for children in households with access to electricity, this percentage decreased and the percentage engaged in the service sector increased. With regard to weekly working hours, there is no statistical difference in households with access to electricity and households with no access to electricity in 2009 and 2017, but children in households with access to electricity spent more hours on work in 2004 and 2014, mainly due to extended business hours from electrification. Finally, children's average monthly salary from wage employment increased over the years, from 39 US dollar in 2004 to 148 [14]US dollar in 2017. Children in households with access to electricity earned more than those in households without access to electricity.

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[13] A person who operates his or her own economic enterprise or engages independently in a profession or trade and hires no employees.
[14] Average of 39 observations.

Overall, as Table 3.6 shows, most of the variables were significantly different from zero at the 1 percent level, indicating that the characteristics of children in households with access to electricity and households with no access to electricity are different. The proportion currently in the school system and educational attainment are higher among children in households with access to electricity compared to children in households without access to electricity across all years. Corresponding to this, the proportion of children engaged in economic activity is significantly higher among children in households without access to electricity, but overall, the proportion has decreased over the years. Regarding working children characteristics, nearly all of them lived in rural areas. In terms of industry and employment status, more than 80 percent of working children worked in agriculture as unpaid family workers. The proportion of working children in the service sector and in wage employment are higher among children in households with access to electricity than those in households with no access to electricity.

Finally, as discussed in the section 3.2.1, electrification may affect the individual's time-use pattern. Detailed information on the time use of each household member is available in the 2004 CSES data, collected from February 2004 to January 2005. I restricted the samples to children aged 7 to 14 years old and analyzed their time use pattern (sample size: 16,211). Table 3.7 provides the mean difference of children's time-use within 24 hours by electricity status. Furthermore, the pie chart of children's time-use over 24 hours is shown in Figure 3.6. As the table shows, except time for leisure, children's time use pattern for activities related to education, work, and household chores are statistically different from zero at the 1 percent level between children in households with access to

electricity and households without access to electricity. It is found that households with access to electricity spent 4.5 hours a day at school and doing homework, while children in households without access to electricity spent 2.9 hours. This difference in study time results in better school performance, and so children in electrified houses stay in school longer than those in households without access to electricity. With regard to activities related to work, children in households without access to electricity spent 1.1 hours for agricultural work including producing and tending rice and other crops and tending animals, while children in households with access to electricity spent only 0.2 hours a day. Time spent in wage employment was greater among children in households without access to electricity, while time spent as self-employed was greater among children in households with access to electricity. With regard to time for household chores including washing, cleaning, cooking, fetching water, collecting firewood and taking care of younger siblings, children in electrified houses spent 0.5 hours a day, while children in households without access to electricity spent 0.9 hours. In addition to children's time use by electricity status, the result of the test of mean difference of time use between children with working and non-working mothers is presented in Table 3.8. The results show that children with non-working mothers spend more time for schooling and less time for agriculture work at home. However, time spent for household chores is greater for children with working mothers. This may explain that the average number of toddlers of non-working mothers is higher than that of working mothers (0.67 for working mother and 0.78 for non-working mother), which result in larger burden for children with non-working mothers to do domestic chores. In summary, the results indicate that access to electricity and employment status of female

spouse appear to be related to children's time use pattern on activities related to education, work, and household chores.

3.6. Estimation strategy

To examine the impacts of electricity on child labor and education, I examine three possible channels: (1) household income, (2) female spouse employment, and (3) childhood participation in the labor market. In this chapter, I define "child laborer" as children aged 7–14 years engaged in any economic activity for one hour or more in the reference week. I evaluated the overall access to electricity across the country since there were multiple electrification projects implemented during the period 2004–2014. I obtained the household electrification status from the household questionnaire of the CSES survey data. I define treatment households as those that have access to publicly provided electricity or city power, while control households are those that did not obtain such connection and use a generator, battery, or kerosene lamp as their main source of lightning.

3.6.1 Household income

First, I estimate the impact of access to electricity on outcomes related to household income: (1) log of monthly total household income, (2) log of monthly non-farm income, (3) log of monthly farm income and (4) log of monthly other income. I restricted the samples to households with children aged 7–14 years. Let us assume that our outcomes, measured by Y_{ivt} and conditional on the treatment of household electrification ($Elec_{ivt}$), can be expressed by following equation:

$$Y_{hvt} = \alpha_1 + \beta_1 \text{Elec}_{hvt} + \pi_1 H_{hvt} + V_{vt} + \lambda + \theta t + \varepsilon_{hvt} \tag{1}$$

where Y_{hvtt} represents the outcome variable of household h in village v in time t, (1) log of monthly total household income, (2) log of monthly wage income in non-farm sector, (3) log of monthly agricultural income and (4) log of monthly other income. Elec_{hvt} is our variable of interest, measured by the coefficient (β), a dummy variable related to access to electricity, which takes a value of 1 if households use publicly provided electricity or city power as their main source of lighting, and 0 otherwise. H_{vt} is a vector of household-level characteristics including gender of household head (female headed=1, 0 otherwise), the number of household members with age 15–20, 21–30, 31–40, 41–50, and 51–58 years, the proportion of household members who are female, the proportion of household members who completed primary, secondary, and tertiary schooling, a binary variable on whether a household lives in an urban area, and finally, the size of irrigated land for production of rice and other crops (hectare). V_{vt} is a vector of village-level characteristics, including distance to the nearest bus stop, a dummy variable that captures whether there are large industrial enterprises (e.g., factory, company employing more than 10 persons, hotel or restaurant), and a dummy variable to capture whether there is infrastructure development projects (e.g., road development). District-level fixed effects are denoted as λ and year-fixed effects are denoted as θt. Finally, ε_{hvt} is an error term representing unobserved variables and standard errors are clustered at the village level.

3.6.2 Female spouse employment

Next, to examine the impact of access to electricity on employment of female

spouse (15–58 years) of monogamous head couples with children aged 7–14 years, the

following equation is estimated by probit model:

$$Y_{ihvt} = \alpha_2 + \beta_2 Elec_{hvt} + \delta_2 X_{ihvt} + \pi_2\ H_{hvt} + V_{vt} + \lambda + \theta_t + \varepsilon_{ihvt} \qquad (2)$$

where Y_{ihvt} represents outcome variables of individual i of household h in village v at time

t: (1) a binary variable for a female spouse who works as a paid employee, (2) a binary

variable for a female spouse who is self-employed and (3) a binary variable for a female

spouse who is employed as an unpaid family worker. $Elec_{hvt}$ is our interest variable, a

dummy variable related to access to electricity, which takes a value of 1 if households use

publicly provided electricity as their main source of lighting and 0 otherwise. X_{ivt} is a

vector of individual-level characteristics of the female spouse, including age, age squared,

and years of education. H_{vt} is a vector of household-level characteristics including the

number of toddlers aged 0-6, size of irrigated land for production of rice and other crops

(hectare), and a binary variable to capture whether a household lives in an urban area. V_{vt} is

vector of village-level characteristics, which are same as the specification (1). All the

specifications include district and year fixed effects. Finally, ε_{hvt} is an error term

representing unobserved variables and standard errors are clustered at the village level.

Estimation result using linear probability model is also reported in the appendix.

3.6.3 Child labor

Finally, I look at the relationship between household access to electricity and the incidence of child labor and children's educational attainment. The specification is same as (2), where Y_{ihvt} represents outcome variables of children aged 7–14 years, i of household h in village v at time t. The outcome variables related to child labor are: (1) a binary variable capturing whether a child is either an employee or is an own-account worker or unpaid family worker, and (2) weekly working hours. With regard to outcome variables related to education, I examine (3), a binary variable for whether a child is currently in school system, (4) a binary variable that captures whether a child dropped out from school (not in school system), and (5) children's years of education. $Elec_{hvt}$ is our interest variable, a dummy variable related to access to electricity, which takes a value of 1 if households use publicly provided electricity as their main source of lighting, and 0 otherwise. X_{ivt} is a vector of individual-level characteristics including gender (takes a value of 1 if a child is female), age, and age squared. H_{vt} is a vector of household-level characteristics, including years of education of household head, years of education of spouse, a binary variable for whether a household head is engaged in agriculture, household size, the number of toddlers aged 0–6 years, the size of irrigated land for rice production (hectare), and a dummy variable for whether a household lives in an urban area. V_{vt} is a vector of village-level characteristics, which are the same as the specification (1). All the specifications include district and year fixed effects. Finally, ε_{hvt} is an error term representing unobserved variables and standard errors are clustered at the village level.

3.6.4. Instrumental Variables

If electricity placement is not random and endogenously allocated, then the previous

estimates would be biased. As indicated in the Cambodia Energy Sector Strategy 2004, the

country's electrification strategy tends to prioritize areas with the best potential for

economic development and with higher income levels, suggesting that electricity projects

placement is not random. To cope with this endogeneity issue, I employ an instrumental

variables (IV) approach with fixed effects. The instruments I used in the chapter are same

as those in Chapter 2, (1) population density at village level, and (2) distance from the

center of each village to the nearest electricity substation.

3.6.5 Empirical results

The first channel I examine is electricity's impact on household income since one of

the main reasons for letting children work is to supplement household income. The second

channel I consider is the impact of electrification on female spouse labor market

participation. Finally, the third channel I examine is childhood participation in the labor

market to see if access to electricity reduces educational opportunities as a result of

increased employment opportunities for children.

First-stage regression

To see whether there are any obvious violations of the instrumental variable

approach, I first test whether the proposed two instruments are good predictors of the

endogenous variable, household access to electricity. I regress the two instruments, (1)

population density at village level and (2) distance from the center of each village to the

nearest electricity substation point, against household access to electricity and the first-stage regression results are presented in Table 3.9, 3.12, and 3.14. As the tables show, the two instrumental variables are statistically significant at the 1 percent level with high F-statistics that are greater than 20, which indicates that the instruments are strong. Additionally, I performed an instrument exogeneity test to check if the instruments are uncorrelated with the error term of the outcome equation by Hansen's J statistics. In all the specifications, the p-values are insignificant, indicating the null hypothesis cannot be rejected and the over-identification restriction is satisfied. Based on the results of these tests, the IV model is found to be robust.

Household income

First, estimation results from both OLS and 2SLS on household income: (1) log of monthly total household income[15], (2) log of monthly non-farm income, (3) log of monthly farm income, and (4) log of monthly other income are presented in Tables 3.10 and 3.11.

The estimation results of both OLS and 2SLS show that access to electricity had a positive effect on total household income and non-farm income. I also see that the coefficients of our preferred model, the IV estimation (2SLS) with fixed effects are substantially larger than the OLS estimates[16]. The results also show that there is a positive association between non-farm income and the educational level of household members.

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[15] There are 378 households with 0 or negative income values out of total 25,554 households, which is equivalent to 1.48% of all the samples. Thus, it is plausible to say that there is no selection bias problem by taking the log of household income instead of absolute values.

[16] One of the reasons that OLS estimates would be biased downward is the government's promotion of targeting poorer areas rather than more intensive expansions in developed areas to maintain their political support.

Furthermore, total household income and non-farm income have a statistically negative relationship with distance to bus stop, suggesting accessibility to the market impacts household income, especially non-farm income. Table 3.11 shows the estimation results for the impact of electrification on farm income and other income. The estimation result of 2SLS indicates that the effect is negative and statistically significant at the 5 percent level. This is because people may shift from farm to non-farm activities due to electrification. With regard to other income, which refers to non-labor income comprising remittances, pension, and social benefits, I do not find any statistically significant impact. Results suggest that access to electricity significantly increased the household income of households with children aged 7–14 years, mainly through increase in non-farm income.

Finally, the impact of household income on the incidence of child labor is estimated using OLS with district and year fixed effect. The result from the Appendix Table, A3.1 shows that the coefficient of log of total household income is negative and significant, which supports *H1: Increase of total household income decreases child labor*. However, the result should be treated with careful attention since I did not address endogeneity of household income in the specification.

Female spouse employment

Second, Table 3.13 presents the estimation results on the impact of household access to electricity on female spouse employment[17], (1) a binary variable that captures if

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[17] I also conducted regression analysis using samples who are female headed households with children. I find a similar impact of electricity; no statistical evidence that access to electricity increased their employment.

the female spouse is a paid employee (wage employment), (2) a binary variable that captures if the female spouse who is self-employed and (3) a binary variable that captures if the female spouse is an unpaid family worker. For adult labor markets, one of the accepted outcomes in the electricity literature is that, with access to electricity, there is an increase in female labor force participation (Dinkelman (2011), Grogan (2013) and Lipscomb et al. (2013)). One of the ways that increase in female labor force participation might impact children's educational attainment is that it would lead to changes in the household time allocation dynamics, because household chores may be re-distributed among household members including children. Our results show that access to electricity has a positive relationship with self-employment and a negative relationship with wage employment and unpaid family work, but none of these are significant. With regard to wage employment, it is found that there is a positive and statistically significant relationship with educational years. Educational years is not important for propensity to engage in self-employment and unpaid family work. Instead, distance to bus stop, which is a proxy for accessibility to the market, has a negative effect on employment. Finally, the estimation result using linear probability model is reported in appendix tables A3.2, which is consistent with the result using probit model. In summary, I find no evidence that access to electricity affects female employment, indicating that there are no changes in allocation of household chores among household members, which partly reject *H2*: *Access to electricity induces a female spouse to work outside, which results in the redistribution of household tasks and an increase in child labor*. This may mean that work engagement by the female spouse does not necessarily promote child labor.

Child labor and educational attainments

Finally, Tables 3.15 and 3.16 present the estimation results on the outcome

variables related to the incidence of child labor ((1) a binary variable capturing whether a

child is employed as an employee, an own-account worker, or an unpaid family worker

during the past 7 days and (2) weekly working hours) and the outcome variables related to

children's educational attainments ((3) a binary variable capturing whether a child is

currently in the school system, (4) a binary variable capturing whether a child drops out

from the school system, and (4) children's years of education). With regard to the effect on

child employment, our estimation results from both OLS and 2SLS suggest a strong

negative effect, indicating that household access to electricity significantly reduced the

incidence of child labor. In terms of working hours, there is negative relationship with

household access to electricity, but it became insignificant in the 2SLS estimation (column

(4) of Table 3.15). This is because more than 80 percent of working children are engaged in

agriculture, which is a seasonal job. Furthermore, it should be noted that there is a negative

association with the female dummy and household size. In particular, the number of

toddlers aged 0 to 5 years is positive and statistically significant on both outcomes.

With regard to educational attainment, the estimation results from Table 3.16

suggest a positive effect on the propensity that a child is in the school system and on

educational attainment. The propensity for dropping out from school is negatively impacted

by electricity. However, I do not find any statistically significant impact on educational

outcome in the 2SLS estimation. Thus, our estimation partly support *H3*: *Electrification*

97

decreases the incidence of child labor which leads to increase in educational attainment.
Parents' educational level seems to be more important—it has a positive relationship with children's school attendance and attainment and a negative relationship with the probability of dropping out of school. In addition, the number of toddlers (children under 5) in the households increases the probability of child labor and reduces children's educational attainments since a child may have to stay home instead of going to school to take care of a younger sibling.

3.7. Summary and conclusion

Lack of human capital and high incidence of child labor are one of the biggest challenges for Cambodia, one of the fastest growing economy in Southeast Asia. Considering the significant recent investment in electrical grid infrastructure, it is important to understand how access to electricity impacts households and the welfare of children. In this chapter, I examined the impacts of household access to electricity on children's educational attainments through three pathways: (1) household income, (2) employment of female spouse and (2) incidence of child labor. I provide substantial evidence suggesting that access to electricity increases total household income, especially through an increase in non-farm income. However, I do not find any evidence that access to electricity increases female labor force participation, implying there is no changes in labor allocation of female spouse among households with children. Finally, the results from 2SLS estimation show that electrification leads to a significant decrease in the probability of children being engaged in economic activity. Furthermore, the number of toddlers also significantly

affects children's propensity to work, indicating that policies or arrangements to provide childcare services are necessary, especially in rural areas. In terms of impact on educational attainment, I do not find any statistically significant impact of electricity. Instead, I find that parents' education levels have a positive impact on the children's school attendance and their educational attainment. While there are many other factors which increase children's educational attainment, I focus only on the factors affected by demand side of education in this chapter. On the supply side of education, the CSES village survey in 2004 and 2009 asked village leaders about the most important problem of primary school and lower-secondary school in the village. The top 3 problems reported are: "living standard of teachers is too low," "poor school building," and "not enough teachers." Thus, a comprehensive policy to improve the supply side of education, such as by increasing the salary of teachers and investment in school facilities together with investment in electrical grid infrastructure is key for human capital accumulation.

Chapter 4

Conclusion

4.1 Summary of major findings

In this dissertation, I provide empirical evidence towards a better understanding of the relationship between electrification and household welfare in Cambodia, one of the fastest growing economy in Southeast Asia (where ironically, child labor remain prevalent). The dissertation contains two chapters reporting the results of analytical studies. The objective of the first study, reported in Chapter 2, is to examine the causal effect of electrification in Cambodia on employment among the working-age population; and on household income growth. The second study examines the effects of electrification on children's welfare in terms of education and employment. To address potential endogeneity of electrification, I used two instrumental variables: (1) population density at village level; and (2) distance between center of village and nearest electricity substation point.

The first study examines the impacts of access to electricity on employment among the working age population and on various sources of household income, using data from the Cambodia Economic Survey series. The estimation results suggest that access to electricity increases the propensity of both females and males to work in wage employment in the formal sector. It also increases the propensity to work as self-employed in the non-farm sector. With regard to household income, this finding confirms our hypothesis that increased access to electricity contributes to total household income growth, largely

through increase in household nonfarm income. Furthermore, the effect of electrification on income growth is much stronger in urban areas than rural.

In the second analytical chapter, I restrict the samples to households with children aged 7- 14 years old, in order to explore the effects of electrification on child labor and education using the instrumental variable approach. There are three main findings. First, results of the descriptive analysis reveal that child labor is common in rural areas. In terms of employment status, more than 90 percent of working children are unpaid family workers, while the proportion of children engaged in wage employment is high among children in electrified houses. With regard to work in industry, nearly 80 percent of male children working in agriculture are more likely engaged in this sector than girls.

Second, the impacts of access to electricity on school attendance and children's years of education are examined through three possible channels: (1) household income; (2) female spouse employment; and (3) incidence of child labor. Estimation results show that access to electricity increases total household income, especially through increase in non-farm income. However, I find no evidence that access to electricity increases female labor force participation, which implies that female spouse engaged in work does not necessarily promote child labor when households gain access to electricity. Third, the estimation results indicate that electrification leads to a significant decrease in the probability that a child is engaged in economic activity. In terms of educational attainments including school attendance, propensity to drop out from school, and number of years completed in school, I do not find any statistically significant impact of electricity in the 2SLS estimation. Rather, I find that parents' education level has a positive impact on child's attendance in school

system and their educational years. It appears that children's educational outcomes is more strongly affected by parental schooling.

4.2 Policy implications

This dissertation explores issues related to Cambodia's two main development priorities (expansion of national electricity grid and promoting children's education) by examining how access to electricity impacts household welfare (employment of working-age population, household income growth, and children's education and child labor). The results of the first analysis indicate that in Cambodia, electrification facilitates a shift in household economic activities from agriculture to non-agriculture, which in turn contributes to household income growth. The findings of the second study suggests that electrification decreases the incidence of child labor, but I find no statistical evidence of the effect of electricity on educational outcomes of children, including school attendance, propensity to drop out from school, and years of education.

The findings of the two analytical chapters in this study have important policy implications. First, my results reveal that household access to electricity have a positive impact on household income through growth of nonfarm income (from wage employment and self-employment in non-farm sector). The results of the analysis of Economic Census data also shows an increase in the number of labor-intensive jobs that employ larger number of workers in wage employment in electrified villages. Thus, it is essential to expand access to grid electricity so as to promote formal sector jobs and make electricity affordable to them. Grid electricity is more reliable and less costly source of energy.

Second, with regard to impact on household income, there is heterogeneous effect between urban and rural areas. The effect of electricity on household income is much stronger in urban areas; whereas in rural areas the impact on total household income is positive, but not statistically significant (because households in rural areas rely on farm income, which is not affected by electrification). One likely reason for weak effect of electrification on total household income in rural areas is the high cost of electricity in rural areas (high because electricity utilities are operated by small private distributors, which sell to households at very high prices). Because of that high cost, households in rural areas use electricity for just one or two hours in the evening, mainly for household lighting, which does not contribute significantly to households' income generating activities (Han et al, 2020). Thus, it is essential to formulate policies to reduce the cost of electricity in rural areas so that households there can use electricity in income generation activities. The government would be well advised to accelerate the construction of rural energy infrastructure such as national grid extensions or mini-grid extensions to reach a larger segment of rural populations

Third, the findings of the second analysis suggest that electrification decreases the incidence of child labor, although electricity does not have any significant direct effect on educational outcomes such as school attendance, incidence of drop out, and years of schooling. Here I only analyzed the impact of electricity on children's education in terms of the demand side of education. Many other factors could increase children's educational attainment from the supply side of education, which is beyond the scope of this current study. CSES village surveys, for example, ask village leaders to identify the most important

103

problem related to primary school and lower-secondary school. The three most common

answers are: "The living standard of teachers is too low"; "Poor school buildings" and "Not

enough teachers." Related to poor school building, it is necessary for the government to

upgrade school quality by expanding electricity grid connections to schools to effectively

improve the supple side factors of education.

Fourth, the government has set in place laws and regulations related to child labor

and has ratified the resolutions of all key international conventions concerning child labor.

However, gaps still exist in Cambodia's legal framework so that children are not adequately

protected from child labor. For example, in the garment sector, the labor law stipulates that

factories can only employ children of age 15 and over. However, Human Rights Watch

(HRW) identified the illegal practice of child labor in at least 11 out of 73 factories in

Phnom Penh and nearby provinces. Since child labor is one of the main reasons for

dropping out from school, there is considerable urgency about this issue. For example, it is

important to raise awareness of contractors that they should not enter into contracts with

factories which employ children. Also, raising consumer awareness of the need to avoid

buying products from manufacturers that employ children is also of some urgency.

In conclusion, our analyses confirm a strong and positive effect of electrification on

household income growth through increase in non-farm income. The primary reason that

parents let their children work is because due to poverty, they rely on children's labor to

supplement household income. Thus, it appears that the development of the rural non-farm

sector is the most important strategy for eliminating child labor and promoting child

education. The rural non-farm sector creates jobs for adult laborers and in turn increases

household income. Development of the non-farm sector can be achieved through multiple electricity grid projects that can deliver low cost, affordable electricity to rural households. Overall, the findings reported here indicate that Cambodia's two developmental goals (expanding electricity and promoting children's education) are indeed related to the expansion of electricity, the promotion of child education and the discouragement of child labor. It is quite likely that for Cambodia, work towards the achievement of SDG 7, which aims to ensure access to affordable, reliable and modern energy to all by 2030, could be the best step towards the fostering of the human capital of the younger generation.

4.3 Direction for future research

The main finding of this dissertation is that household income growth has largely emanated from the growth of wage income and self-employment income. Both sectors are found to have been positively and significantly affected by electricity. Household income in turn has a positive impact on child schooling because schooling is a normal good; i.e., an increase in household income increases the demand for child schooling. With the recent COVID-19 pandemic, it would be insightful to explore the changes in the sources of household income inasmuch as the tourism sector, which has been a source of household wage income growth, has been severely affected. It is not a surprise if the incidence of poverty has gone up in Cambodia in more recent months. My hypothesis is that with the declining income from wages in the formal sector, many Cambodian households have reverted to agriculture and child labor has become even more prevalent. Furthermore, boys' education may have suffered disproportionately more than girls' because boys' labor

is needed in such as activities as tending draft animals and taking care of livestock as well as in weeding rice fields.

Another area worth exploring is how the supply side factor of education affects child schooling. The CSES data sets have shown that poor quality schooling facilities and less motivated teachers create a disincentive for parents in sending their children to school. This is a rationale behavior because poor quality schools and less motivated teachers do not create cognitive skills such as ability in reading and writing and in Math and Science, which are needed in the emerging job market. A student with poor quality education cannot get a good quality job which sends bad signal to Cambodian parents that child schooling is not a particularly profitable investment.

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Tables

Table 2.1. Access to Electricity and Economic Indicators in South East Asia

		GDP per capita PPP(constant international $)	Real GDP growth (%)	Poverty headcout ratio at national povery lines (%)		Share of agriculture in GDP (%)	Access to electricity (%) 2016		
		2017	2017	2006	2012	2017	Total	Urban	Rural
CLMV	**Cambodia**	**3,645**	**7.1**	**45.0**	**17.7**	**23.4**	**49.8**	**100.0**	**36.5**
	Myanmar	5,592	7.2	48.2 (2005)	32.1 (2015)	26.2	57.0	89.5	39.8
	Lao P.D.R	6,397	7	27.6 (2007)	23.2	16.2	87.1	97.4	80.3
	Vietnam	6,172	6.3	20.7 (2010)	13.5 (2014)	15.3	100.0	100.0	100.0
ASEAN 6	Indonesia	11,189	5.0	17.8	11.3 (2014)	13.1	97.6	100.0	94.8
	Malaysia	26,808	5.5	3.6 (2007)	0.6 (2014)	8.8	100.0	100.0	100.0
	Philippines	7,599	6.6	26.6	25.2	9.7	91.0	96.9	86.3
	Thailand	16,278	3.8	21.9	10.5	8.7	100.0	99.9	100.0
	Brunei	71,809	0	-	-	1.1	100.0	100.0	100.0
	Singapore	85,535	3.2	-	-	0.0	100.0	100.0	100.0

Source: World Development Indicators, Online (Accessed Janurary 11, 2019)
GDP Growth: OECD Economic Outlook for Southeast Asia, 2018

Table 2.2. Number of Households, Individuals, and Villages in the Cambodia Socio Economic Survey Data (CSES)

	2004	2009	2014	2017
Total number of households	14,983	11,971	12,095	3,840
Total number of individuals	74,719	57,105	53,968	16,909
Total number of villages	900	720	1,008	384

Table 2.3 Main Sources of Lighting in Cambodia, 2004-2017

	2004							
	Total	%	Phnom Penh	%	Urban	%	Rural	%
Publicly-provided electricity	2,424	16%	1,215	87%	821	39%	310	3%
Generator	1,035	7%	134	10%	249	12%	647	6%
Battery	3,627	24%	19	1%	228	11%	3,411	30%
Kersosene lamp	7,715	51%	19	1%	782	37%	6,968	61%
Other (Candle, solar, none)	182	1%	8	1%	19	1%	153	1%
Total households	**14,983**		**1,395**	**9%**	**2,099**	**14%**	**11,489**	**77%**
	2009							
	Total	%	Phnom Penh	%	Urban	%	Rural	%
Publicly-provided electricity	3,210	27%	1,097	99%	1,010	76%	1,111	10%
Generator	204	2%	4	0%	14	1%	201	2%
Battery	4,609	39%	2	0%	134	10%	4,623	40%
Kersosene lamp	3,702	31%	4	0%	168	13%	3,337	29%
Other (Candle, solar, none)	246	2%	6	1%	5	0%	247	2%
Total households	**11,971**		**1,113**	**9%**	**1,331**	**11%**	**9,519**	**80%**
	2014							
	Total	%	Phnom Penh	%	Urban	%	Rural	%
Publicly-provided electricity	7,377	61%	1,991	99%	1,734	91%	3,674	45%
Generator	92	1%	2	0%	5	0%	97	1%
Battery	3,450	29%	1	0%	97	5%	3,391	41%
Kersosene lamp	819	7%	4	0%	39	2%	692	8%
Other (Candle, solar, none)	354	3%	4	0%	21	1%	340	4%
Total households	**12,092**		**2,002**	17%	**1,896**	16%	**8,194**	68%
	2017							
	Total	%	Phnom Penh	%	Urban	%	Rural	%
Publicly-provided electricity	3,140	82%	787	100%	763	97%	1,590	70%
Generator	6	0%	1	0%		0%	5	0%
Battery	375	10%		0%	16	2%	359	16%
Kersosene lamp	41	1%		0%	3	0%	38	2%
Other (Candle, solar, none)	278	7%	2	0%	8	1%	268	12%
Total households	**3,840**		**790**	21%	**790**	21%	**2,260**	59%

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) various years

115

Table 2.4 Main Sources of Lighting in Targeted Provinces in Cambodia, 2004– 2017

			2004																				
	Phnom Penh	%	Banteay Meanchey	%	Battambang	%	Kampong Cham	%	Kampong Speu	%	Kampong Thom	%	Kampot	%	Kandal	%	Siermup	%	Sihanoukville	%	Takeo	%
Publicly-provided electricity	1,215	87%	47	7%	127	16%	91	5%	18	3%	33	5%	41	7%	104	10%	91	12%	89	41%	29	3%
Generator	134	10%	116	18%	90	11%	82	5%	9	1%	21	3%	21	4%	102	10%	36	5%	40	19%	64	8%
Battery	19	1%	52	8%	111	14%	582	35%	186	30%	118	20%	110	20%	444	43%	66	9%	5	2%	339	41%
Kersosene lamp	19	1%	420	64%	485	59%	914	55%	408	65%	422	70%	389	69%	384	37%	570	75%	82	38%	405	48%
Other (Candle, solar, none)	8	1%	19	3%	5	1%	1	0%	2	0%	9	1%	1	0%	2	0%	-	0%	-	0%	-	0%
Total households	1,395		654		818		1,670		623		603		562		1,036		763		216		837	
			2009																				
	Phnom Penh	%	Banteay Meanchey	%	Battambang	%	Kampong Cham	%	Kampong Speu	%	Kampong Thom	%	Kampot	%	Kandal	%	Siermup	%	Sihanoukville	%	Takeo	%
Publicly-provided electricity	1,097	99%	138	26%	288	39%	190	14%	58	12%	64	14%	39	9%	322	34%	125	21%	63	46%	106	18%
Generator	4	0%	20	4%	10	1%	26	2%	5	1%	3	1%	9	2%	35	4%	7	1%	7	5%	5	1%
Battery	2	0%	170	31%	170	23%	701	53%	272	54%	185	41%	192	47%	395	42%	159	27%	12	9%	312	52%
Kersosene lamp	4	0%	208	39%	253	34%	387	29%	161	32%	199	44%	165	40%	185	20%	287	49%	51	37%	167	28%
Other (Candle, solar, none)	6	1%	4	1%	18	2%	24	2%	4	1%	3	1%	7	2%	6	1%	8	1%	4	3%	12	2%
Total households	1,113		540		739		1,328		500		454		412		943		586		137		602	
			2014																				
	Phnom Penh	%	Banteay Meanchey	%	Battambang	%	Kampong Cham	%	Kampong Speu	%	Kampong Thom	%	Kampot	%	Kandal	%	Siermup	%	Sihanoukville	%	Takeo	%
Publicly-provided electricity	1,991	99%	638	79%	571	59%	846	52%	544	42%	277	38%	185	39%	851	87%	445	45%	131	79%	635	72%
Generator	2	0%	14	2%	1	0%	8	0%	6	0%	-	0%	4	1%	18	2%	1	0%	1	1%	2	0%
Battery	1	0%	109	13%	328	34%	594	37%	646	49%	338	46%	227	48%	79	8%	396	40%	7	4%	171	19%
Kersosene lamp	4	0%	46	6%	45	5%	94	6%	60	5%	73	10%	34	7%	26	3%	129	13%	22	13%	49	6%
Other (Candle, solar, none)	4	0%	5	1%	25	3%	79	5%	53	4%	50	7%	25	5%	5	1%	23	2%	5	3%	24	3%
Total households	2,002		812		970		1,621		1,309		738		475		979		994		166		881	
			2017																				
	Phnom Penh	%	Banteay Meanchey	%	Battambang	%	Kampong Cham	%	Kampong Speu	%	Kampong Thom	%	Kampot	%	Kandal	%	Siermup	%	Sihanoukville	%	Takeo	%
Publicly-provided electricity	787	100%	142	89%	224	93%	318	88%	264	83%	67	52%	70	70%	227	95%	156	71%	70	100%	234	94%
Generator	1	0%	2	1%	-	0%	1	0%	-	0%	-	0%	-	0%	-	0%	-	0%	-	0%	-	0%
Battery	-	0%	6	4%	11	5%	28	8%	36	11%	35	27%	20	20%	12	5%	38	17%	-	0%	7	3%
Kersosene lamp	-	0%	6	4%	-	0%	3	1%	4	1%	5	4%	1	1%	1	0%	9	4%	-	0%	1	0%
Other (Candle, solar, none)	2	0%	4	3%	5	2%	10	3%	16	5%	23	18%	9	9%	-	0%	17	8%	-	0%	8	3%
Total households	790		160		240		360		320		130		100		240		220		70		250	

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) various years

Table 2.5 Household Time Use Pattern in Cambodia, 2004

	2004				
	HH With electricity	N	HH Without electricity	N	p-value
Time Use (24 hours)					
Time to work as employed	2.0	7,748	1.4	33,761	0.00
Time to work as employed (male)	2.7	3,622	1.7	15,810	0.00
Time to work as employed (female)	1.5	4,126	1.1	17,951	0.00
Time to work as employed (urban)	1.8	2,549	1.5	3,616	0.00
Time to work as employed (rural)	1.4	850	1.4	29,579	0.62
Own business work	2.2	7,748	1.0	33,761	0.00
Own business work (male)	2.1	3,622	1.0	15,810	0.00
Own business work (female)	2.2	4,126	1.0	17,951	0.00
Own business work (urban)	2.4	2,549	1.3	3,616	0.00
Own business work (rural)	2.5	850	0.9	29,579	0.00
Agricultural work	0.2	7,748	1.9	33,761	0.00
Agricultural work (male)	0.2	3,622	2.3	15,810	0.00
Agricultural work (female)	0.1	4,126	1.6	17,951	0.00
Agricultural work (urban)	0.2	2,549	1.5	3,616	0.00
Agricultural work (rural)	0.8	850	2.0	29,579	0.00
Household chores	1.7	7,748	2.2	33,761	0.00
Household chores (male)	0.5	3,622	0.9	15,810	0.00
Household chores (female)	2.8	4,126	3.4	17,951	0.00
Household chores (urban)	1.8	2,549	2.1	3,616	0.00
Household chores (rural)	1.9	850	2.3	29,579	0.00
Leisure	2.9	7,748	2.7	33,761	0.00
Leisure (male)	3.1	3,622	2.9	15,810	0.00
Leisure (female)	2.7	4,126	2.5	17,951	0.00
Leisure (urban)	2.7	2,549	2.7	3,616	0.23
Leisure (rural)	2.7	850	2.7	29,579	0.57

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) 2004

Table 2.6. Test of Mean Difference between Households with Access to Electricity and Households without Electricity

	2004			2009			2014			2017		
	With electricity	Without electricity	p-value	With electricity	Without electricity	p-value	With electricity	Without electricity	With electricity	Without electricity	p-value	
Outcome variables												
Proportion to work as wage employment	0.3	0.1	0.00	0.3	0.2	0.00	0.4	0.3	0.3	0.2	0.00	
Proportion to work as self-employment in agriculture	0.3	0.9	0.00	0.4	1.0	0.00	0.6	1.0	0.6	1.0	0.00	
Proportion to work as self-employment in non-farm sector	0.6	0.3	0.00	0.6	0.2	0.00	0.4	0.2	0.4	0.1	0.00	
Proportion to work as unpaid family worker	0.2	0.4	0.00	0.1	0.2	0.00	0.0	0.1	0.0	0.0	0.00	
Total monthly household income (USD)	476.2	150.7	0.00	665.4	354.4	0.04	689.9	469.0	729.2	490.1	0.00	
Total monthly farm income (USD)	15.8	82.2	0.00	351.4	36.6	0.03	91.2	185.1	75.7	147.8	0.00	
Total monthly non-farm income (USD)	409.7	60.6	0.00	715.3	86.9	0.00	553.0	188.5	615.6	303.8	0.00	
Explanatory valuables and other												
Household level												
Proportion of female-headed	0.2	0.2	0.00	0.2	0.2	0.00	0.2	0.2	0.2	0.2	0.01	
Number of household members who are												
Between 15-20 years old	0.9	0.7	0.00	0.8	0.7	0.01	0.6	0.6	0.4	0.5	0.15	
Between 21-30 years old	0.9	0.8	0.00	1.1	0.9	0.00	0.9	0.8	0.8	0.7	0.02	
Between 31-40 years old	0.7	0.7	0.21	1.2	1.4	0.36	0.6	0.6	0.7	0.6	0.00	
Between 41-50 years old	0.6	0.5	0.00	0.6	0.5	0.00	0.6	0.5	0.5	0.4	0.00	
Between 51-58 years old	0.4	0.3	0.00	0.4	0.3	0.00	0.4	0.3	0.4	0.4	0.22	
Ratio of household member with												
Primary schooling	0.6	0.8	0.00	0.5	0.8	0.00	0.6	0.7	0.7	0.9	0.00	
Secondary schooling	0.5	0.2	0.00	0.5	0.3	0.00	0.5	0.3	0.5	0.3	0.00	
Tertiary schooling	0.1	0.0	0.00	0.2	0.0	0.00	0.2	0.0	0.2	0.0	0.00	
Female	0.5	0.5	0.58	0.5	0.5	0.00	0.5	0.5	0.6	0.6	0.83	
Area of irrigated parcel land (ha)	0.2	2.8	0.00	0.2	0.4	0.00	0.3	0.5	0.2	0.4	0.00	
Individual level												
Wheter worked during the past 7 days	0.8	0.8	0.00	0.8	0.9	0.00	0.8	0.9	0.8	0.9	0.00	
Weekly hours of work of hh head	47.1	39.9	0.00	50.2	49.9	0.42	50.9	49.5	46.0	41.0	0.00	
Weekly hours of work of spouse	45.9	35.2	0.00	48.1	41.8	0.00	46.8	42.5	43.9	34.5	0.00	
Village level												
Distance to bus stop (km)	8.7	22.3	0.0	7.1	20.9	0.0	8.9	22.9	8.0	20.8	0.00	
whether there are large industrial enterprises	0.8	0.3	0.0	0.7	0.4	0.0	0.7	0.3	0.2	0.1	0.12	
Whether there is infrastructure development projects	0.3	0.2	0.0	0.4	0.2	0.0	0.2	0.2	0.3	0.2	0.44	

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) various years

Table 2.7: First Stage Regression for Electrification and Employment

VARIABLES	Household access to electricity
Instruments	
1. Population density	.0169328***
	(.0050143)
2. Distance between village and a nearest electricity substation point	-.0613282***
	(.0175047)
Other control variables	
Female (1=yes)	.011272***
	(..0029233)
Age	.0009712
	(.0011546)
Age squared	3.23e-06
	(.000016)
Married (1=yes)	-.004814
	(.0055779)
Years of education	.0108167***
	(.0007125)
Urban (1=yes)	.1599959***
	(.038751)
Number of toddlers	-.005731
	(.004007)
Size of irrigated land	-.0012859**
	(.0005907)
Distance_bus_stop	-.0002977
	(.0004068)
Village_factory (1=yes)	.0934118***
	(.0191573)
Village_Infrastructure (1=yes)	.013907
	(.0184744)
Proportion_Female_Emp	-.1062934**
	(.0432739)
Proportion_Male_Emp	.1347996**
	(.0651443)
Mean_Earnings	.0002156*
	(.0001146)
Observations	95,654
Joint significance of all IVs	F=19.93
Hansen J statistics	1.784
	Chi-sq(1) P-val = 0.1816

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.8. Impact of Electrification on Wage Employment (Linear Probability model)

	OLS	2SLS	2SLS	2SLS
	Dependent variable: Wage employment			
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	0.0312***	0.306***	0.208**	0.408***
	(0.00885)	(0.113)	(0.104)	(0.153)
Individual level				
Female (1=yes)	-0.0968***	-0.0990***		
	(0.00465)	(0.00519)		
Age	0.0309***	0.0302***	0.0224***	0.0358***
	(0.00131)	(0.00147)	(0.00162)	(0.00231)
Age_squared	-0.000457***	-0.000452***	-0.000372***	-0.000512***
	(1.78e-05)	(1.97e-05)	(2.17e-05)	(3.06e-05)
Married (1=yes)	-0.119***	-0.117***	-0.161***	-0.0653***
	(0.00642)	(0.00696)	(0.00771)	(0.0123)
Years of education	0.00385***	0.000788	-0.000246	0.000351
	(0.000579)	(0.00136)	(0.00134)	(0.00186)
Household level				
Urban (1=yes)	0.0342**	-0.0187	-0.0280	-0.0125
	(0.0174)	(0.0326)	(0.0292)	(0.0464)
Number of toddlers	-0.00350	-0.00167	-0.0146***	0.00596
	(0.00316)	(0.00364)	(0.00411)	(0.00524)
Size of irrigated land	-0.00134***	-0.00104***	-0.00108***	-0.000831
	(0.000357)	(0.000373)	(0.000339)	(0.000534)
Village level				
Distance_bus_stop	-2.59e-05	7.78e-05	-0.000292	0.000163
	(0.000175)	(0.000206)	(0.000196)	(0.000267)
Village_factory (1=yes)	0.00905	-0.0186	-0.0118	-0.0228
	(0.00832)	(0.0150)	(0.0145)	(0.0199)
Village_Infrastructure (1=yes)	-0.00962	-0.00841	0.00167	-0.0171
	(0.00784)	(0.00989)	(0.00949)	(0.0135)
Proportion_Female_Emp	0.115***	0.132***		
	(0.0197)	(0.0268)		
Proportion_Male_Emp	0.331***	0.304***	0.240***	0.502***
	(0.0276)	(0.0383)	(0.0332)	(0.0443)
Mean_Earnings	6.66e-05	-1.21e-06	-1.02e-05	4.88e-05
	(4.64e-05)	(5.65e-05)	(5.46e-05)	0.502***
Observations	104,013	95,654	50,405	45,249
R-squared	0.135	-0.010	0.028	-0.057
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.9. Impact of Electrification on Self-employment in Non-farm Sector (Linear Probability model)

	Dependent variable: Self- employment in Non-farm sector			
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	0.115***	0.487***	0.479***	0.486***
	(0.0128)	(0.158)	(0.160)	(0.170)
Individual level				
Female (1=yes)	0.0147***	0.00869**		
	(0.00319)	(0.00372)		
Age	0.000810	0.000213	0.00112	-0.000938
	(0.00123)	(0.00132)	(0.00159)	(0.00190)
Age_squared	-1.32e-07	1.95e-06	-1.39e-05	2.21e-05
	(1.71e-05)	(1.84e-05)	(2.18e-05)	(2.57e-05)
Married (1=yes)	0.0273***	0.0266***	0.0226***	0.0286***
	(0.00637)	(0.00687)	(0.00744)	(0.0108)
Years of education	0.00976***	0.00498***	0.00437**	0.00583***
	(0.000669)	(0.00186)	(0.00198)	(0.00201)
Household level				
Urban (1=yes)	0.134***	0.0711*	0.0813*	0.0595
	(0.0303)	(0.0425)	(0.0452)	(0.0444)
Number of toddlers	0.0108**	0.0167***	0.0169***	0.0159***
	(0.00427)	(0.00455)	(0.00499)	(0.00540)
Size of irrigated land	-0.000756*	-8.70e-05	-0.000214	1.19e-05
	(0.000452)	(0.000582)	(0.000655)	(0.000576)
Village level				
Distance_bus_stop	-0.000356	-0.000138	-0.000207	-0.000286
	(0.000243)	(0.000300)	(0.000302)	(0.000305)
Vilage_factory (1=yes)	0.0339***	-0.00388	-0.00458	-0.00170
	(0.0124)	(0.0214)	(0.0219)	(0.0223)
Village_Infrastructure (1=yes)	0.0194	0.0245*	0.0243*	0.0290*
	(0.0123)	(0.0140)	(0.0142)	(0.0150)
Proportion_Female_Emp	0.0513*	0.0930**		
	(0.0288)	(0.0375)		
Proportion_Male_Emp	-0.133***	-0.168***	-0.106**	-0.121**
	(0.0454)	(0.0561)	(0.0512)	(0.0521)
Mean_Earnings	0.000133**	3.90e-05	7.27e-05	1.71e-05
	(6.36e-05)	(8.10e-05)	(7.52e-05)	(9.17e-05)
Observations	104,013	95,654	50,405	45,249
R-squared	0.135	-0.010	-0.023	-0.022
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.10. Impact of Electrification on Self-employment in Farm Sector *(Linear Probability model)*

	Dependent variable: Self- employment in Farm Sector			
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	-0.141***	-0.688***	-0.718***	-0.717***
	(0.0147)	(0.190)	(0.201)	(0.213)
Individual level				
Female (1=yes)	-0.0732***	-0.0630***		
	(0.00574)	(0.00650)		
Age	0.0329***	0.0339***	0.0372***	0.0277***
	(0.00146)	(0.00169)	(0.00216)	(0.00246)
Age_squared	-0.000326***	-0.000329***	-0.000368***	-0.000266***
	(2.06e-05)	(2.37e-05)	(3.01e-05)	(3.35e-05)
Married (1=yes)	0.111***	0.112***	0.0575***	0.202***
	(0.00746)	(0.00846)	(0.00991)	(0.0143)
Years of education	-0.0157***	-0.00901***	-0.00504**	-0.0109***
	(0.000770)	(0.00223)	(0.00248)	(0.00252)
Household level				
Urban (1=yes)	-0.172***	-0.0756	-0.0659	-0.0857
	(0.0291)	(0.0487)	(0.0518)	(0.0568)
Number of toddlers	-0.00783*	-0.0146***	-0.0255***	-0.00943
	(0.00466)	(0.00542)	(0.00631)	(0.00679)
Size of irrigated land	0.00148***	0.000715	0.000741	0.000664
	(0.000498)	(0.000652)	(0.000884)	(0.000631)
Village level				
Distance_bus_stop	0.000230	-4.40e-05	-0.000699*	6.99e-05
	(0.000294)	(0.000352)	(0.000375)	(0.000404)
Village_factory (1=yes)	-0.0425***	0.0121	0.0247	0.00423
	(0.0143)	(0.0257)	(0.0278)	(0.0284)
Village_Infrastructure (1=yes)	-0.0107	-0.0187	-0.00305	-0.0231
	(0.0139)	(0.0172)	(0.0186)	(0.0196)
Proportion_Female_Emp	0.308***	0.258***		
	(0.0327)	(0.0450)		
Proportion_Male_Emp	0.127**	0.171**	0.309***	0.317***
	(0.0494)	(0.0670)	(0.0655)	(0.0671)
Mean_Earnings	-0.000365***	-0.000230**	-0.000171*	-0.000222**
	(8.03e-05)	(9.21e-05)	(0.000104)	(0.000106)
Observations	104,013	95,654	50,405	45,249
R-squared	0.246	0.051	0.006	0.069
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.11. Impact of Electrification on Unpaid Family Worker (Linear Probability model)

	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	-0.0325***	-0.243***	-0.213**	-0.230***
	(0.00565)	(0.0777)	(0.107)	(0.0739)
Individual level				
Female (1=yes)	0.0664***	0.0663***		
	(0.00402)	(0.00432)		
Age	-0.0179***	-0.0178***	-0.0142***	-0.0194***
	(0.000900)	(0.000975)	(0.00122)	(0.00137)
Age_squared	0.000183***	0.000185***	0.000150***	0.000205***
	(1.16e-05)	(1.27e-05)	(1.61e-05)	(1.74e-05)
Married (1=yes)	-0.0249***	-0.0292***	0.0307***	-0.110***
	(0.00401)	(0.00442)	(0.00576)	(0.00718)
Years of education	-0.000939***	0.00144	0.00147	-0.000162
	(0.000308)	(0.000934)	(0.00132)	(0.000923)
Household level				
Urban (1=yes)	-0.0241**	0.0246	0.0221	0.0298
	(0.0106)	(0.0198)	(0.0279)	(0.0186)
Number of toddlers	-0.0135***	-0.0142***	-0.00983***	-0.0104***
	(0.00178)	(0.00212)	(0.00293)	(0.00250)
Size of irrigated land	0.00101***	0.000668**	0.00102*	0.000396
	(0.000323)	(0.000322)	(0.000605)	(0.000302)
Village level				
Distance_bus_stop	0.000335***	0.000196	0.00101***	-2.12e-05
	(0.000114)	(0.000163)	(0.000233)	(0.000141)
Village_factory (1=yes)	-0.00262	0.0199*	0.00889	0.0267***
	(0.00523)	(0.0102)	(0.0134)	(0.0102)
Village_Infrastructure (1=yes)	0.00763	0.0109	3.23e-05	0.00996
	(0.00531)	(0.00682)	(0.00953)	(0.00653)
Proportion_Female_Emp	-0.267***	-0.286***		
	(0.0150)	(0.0195)		
Proportion_Male_Emp	-0.280***	-0.257***	-0.375***	-0.454***
	(0.0211)	(0.0287)	(0.0374)	(0.0254)
Mean_Earnings	5.04e-06	7.03e-05	-8.58e-06	8.48e-05**
	(2.60e-05)	(4.48e-05)	(5.10e-05)	(4.21e-05)
Observations	104,013	95,654	50,405	45,249
R-squared	0.250	0.044	-0.005	0.115
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2.12: First Stage Regression for Electrification and Household Income

VARIABLES	Household access to electricity
Instruments	
1. Population density	.0188878***
	(.0051109)
2. Distance between village and a nearest electricity substation point	-.0519789***
	(.0179813)
Other control variables	
Female_headed (1=yes)	.0002973
	(.0095227)
Age_15_20	-.0030114
	(.0034578)
Age_21_30	-.0017894
	(.0036864)
Age_31_40	-.0064175***
	(.001111)
Age_41_50	-.001116
	(.0048176)
Age_51_58	.0080025***
	(.0022002)
Proportion_Female	.0091979
	(.023679)
Primary_schooling	-.0004007
	(.007498)
Secondary_schooling	.1417514***
	(.0129986)
Tertiary_schooling	.2382369***
	(.0241783)
Urban (1=yes)	.1562152***
	(.0406762)
Size of irrigated land	-.0014879**
	(.0006485)
Distance_bus_stop	-.0003293
	(.0003954)
Village_factory(1=yes)	.1021166 ***
	(.0194198)
Village_ Infrastructure (1=yes)	.01499
	(.0185896)
Proportion_Female_Emp	-.0927467**
	(.0447449)
Proportion_Male_Emp	.156996**
	(.0636943)
Observations	26,714
Joint significance of all IVs	F=19.93
Hansen J statistic	0.124
	(Chi-sq(1) P-val = 0.7246)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.13. Impact of Electrification on Log of Total Monthly Household Income

	All	All	Urban	Rural
		Dependent variable: Log of Total Monthly Income		
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES				
Electricity(1=yes)	0.213***	0.392	1.159**	0.0551
	(0.0325)	(0.369)	(0.475)	(0.393)
Household level				
Female_headed (1=yes)	-0.170***	-0.179***	-0.202***	-0.0884**
	(0.0262)	(0.0279)	(0.0405)	(0.0390)
Age_15_20	0.194***	0.195***	0.111**	0.182***
	(0.0291)	(0.0311)	(0.0467)	(0.0322)
Age_21_30	0.181***	0.179***	0.177***	0.272***
	(0.0113)	(0.0121)	(0.0306)	(0.0254)
Age_31_40	0.0160**	0.0167***	0.0176***	0.250***
	(0.00642)	(0.00646)	(0.00472)	(0.0539)
Age_41_50	0.103***	0.0977***	0.134***	0.265***
	(0.0160)	(0.0169)	(0.0270)	(0.0376)
Age_51_58	-0.00414	-0.00601	0.00633	0.276***
	(0.00792)	(0.00822)	(0.00791)	(0.0328)
Proportion_Female	-0.00753	0.00670	0.219*	0.0227
	(0.0705)	(0.0751)	(0.121)	(0.0793)
Primary_schooling	0.141***	0.147***	0.0818*	0.156***
	(0.0202)	(0.0206)	(0.0435)	(0.0222)
Secondary_schooling	0.371***	0.346***	0.112	0.405***
	(0.0319)	(0.0634)	(0.0903)	(0.0665)
Tertiary_schooling	0.770***	0.720***	0.634***	0.703***
	(0.0552)	(0.106)	(0.105)	(0.150)
Urban (1=yes)	0.109*	0.0947		
	(0.0567)	(0.0921)		
Size of irrigated land	0.00244*	0.00285**	-0.000964	0.00287**
	(0.00127)	(0.00143)	(0.00414)	(0.00143)
Village level				
Distance_bus_stop	4.02e-05	0.000135	0.000502	0.000189
	(0.000548)	(0.000610)	(0.00223)	(0.000593)
Village_factory (1=yes)	0.0335	0.00515	0.146	0.0336
	(0.0307)	(0.0530)	(0.0902)	(0.0556)
Village_Infrastructure (1=yes)	0.0178	0.0180	-0.0299	0.00421
	(0.0325)	(0.0350)	(0.0573)	(0.0401)
Proportion_Female_Emp	0.172***	0.180***	0.562***	0.0537
	(0.0778)	(0.0876)	(0.155)	(0.100)
Proportion_Male_Emp	0.169	0.126	0.0333	0.210
	(0.112)	(0.132)	(0.208)	(0.149)
Observations	29,085	26,714	6,117	20,597
R-squared	0.316	0.091	0.099	0.121
District fived effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses   *** p<0.01, ** p<0.05, * p<0.1

Table 2.14. Impact of Electrification on Log of Non-Farm Income

	All	All	Urban	Rural
Dependent variable: Log of Non-farm Income				
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES				
Electricity(1=yes)	0.243***	1.228**	1.433*	1.191***
	(0.0347)	(0.479)	(0.800)	(0.437)
Household level				
Female_headed (1=yes)	-0.148***	-0.160***	-0.215***	-0.123**
	(0.0330)	(0.0374)	(0.0497)	(0.0483)
Age_15_20	0.172***	0.175***	0.0860**	0.218***
	(0.0314)	(0.0355)	(0.0393)	(0.0215)
Age_21_30	0.249***	0.239***	0.211***	0.253***
	(0.0210)	(0.0226)	(0.0437)	(0.0234)
Age_31_40	0.156***	0.140***	0.200***	0.151***
	(0.0358)	(0.0320)	(0.0406)	(0.0418)
Age_41_50	0.137***	0.122***	0.207***	0.122***
	(0.0252)	(0.0261)	(0.0284)	(0.0340)
Age_51_58	-0.00858*	-0.0158**	0.00709	0.0976***
	(0.00503)	(0.00652)	(0.00914)	(0.0325)
Proportion_Female	0.202**	0.221**	0.270**	0.197
	(0.0859)	(0.0985)	(0.128)	(0.124)
Primary_schooling	0.0555**	0.0705**	0.00354	0.113***
	(0.0252)	(0.0334)	(0.0474)	(0.0411)
Secondary_schooling	0.363***	0.253***	0.0588	0.343***
	(0.0387)	(0.0789)	(0.109)	(0.0803)
Tertiary_schooling	0.613***	0.405***	0.481***	0.266
	(0.0571)	(0.116)	(0.118)	(0.164)
Urban (1=yes)	0.181***	0.0157		
	(0.0673)	(0.119)		
Size of irrigated land	-0.00349	-0.000729	-0.00279	-0.000440
	(0.00252)	(0.00285)	(0.00977)	(0.00275)
Village level				
Distance_bus_stop	-0.00287***	-0.00186	-0.00102	-0.00184
	(0.000973)	(0.00116)	(0.00246)	(0.00123)
Village_factory (1=yes)	0.0393	-0.0951	0.108	-0.104
	(0.0353)	(0.0702)	(0.122)	(0.0671)
Village_Infrastructure (1=yes)	0.0172	-0.000370	-0.0468	0.00184
	(0.0341)	(0.0403)	(0.0635)	(0.0508)
Proportion_Female_Emp	0.320***	0.357***	0.464***	0.274**
	(0.0933)	(0.111)	(0.177)	(0.136)
Proportion_Male_Emp	0.0960	-0.0643	0.0741	-0.0759
	(0.136)	(0.176)	(0.248)	(0.210)
Observations	17,113	15,495	5,324	10,171
R-squared	0.378	0.003	0.067	-0.016
District fived effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses   *** p<0.01, ** p<0.05, * p<0.1

Table 2.15. Impact of Electrification on Log of Farm Income

	All	All	Urban	Rural
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES				
Electricity(1=yes)	-0.313***	-1.920***	-1.229	-2.246***
	(0.0468)	(0.597)	(0.858)	(0.717)
Household level				
Female_headed (1=yes)	-0.322***	-0.328***	-0.265**	-0.283***
	(0.0322)	(0.0400)	(0.119)	(0.0439)
Age_15_20	0.126***	0.116***	0.0383	0.126***
	(0.0258)	(0.0257)	(0.0334)	(0.0278)
Age_21_30	0.0985***	0.0919***	0.0968**	0.148***
	(0.0127)	(0.0147)	(0.0459)	(0.0200)
Age_31_40	0.0859***	0.0765***	0.0721***	0.207***
	(0.00333)	(0.00545)	(0.00820)	(0.0291)
Age_41_50	0.164***	0.171***	0.110	0.252***
	(0.0188)	(0.0207)	(0.0676)	(0.0289)
Age_51_58	0.185***	0.228***	0.215***	0.295***
	(0.0213)	(0.0283)	(0.0821)	(0.0368)
Proportion_Female	-0.0870	-0.105	0.0225	-0.0753
	(0.0933)	(0.106)	(0.326)	(0.115)
Primary_schooling	0.0952***	0.107***	0.156*	0.0968***
	(0.0222)	(0.0272)	(0.0920)	(0.0295)
Secondary_schooling	0.0392	0.263***	0.113	0.296***
	(0.0405)	(0.0927)	(0.194)	(0.105)
Tertiary_schooling	-0.0465	0.506**	0.171	0.594**
	(0.122)	(0.236)	(0.568)	(0.260)
Urban (1=yes)	-0.391***	-0.167		
	(0.116)	(0.153)		
Size of irrigated land	0.0102***	0.00813***	0.00562	0.00771***
	(0.00217)	(0.00197)	(0.00560)	(0.00207)
Village level				
Distance_bus_stop	0.00203**	0.00110	0.00372	0.00107
	(0.000809)	(0.000918)	(0.00612)	(0.00100)
Village_factory (1=yes)	-0.0548	0.116	-0.214	0.158*
	(0.0391)	(0.0787)	(0.235)	(0.0918)
Village_Infrastructure (1=yes)	0.0172	-0.0193	0.0760	-0.0378
	(0.0341)	(0.0529)	(0.157)	(0.0604)
Proportion_Female_Emp	0.156	-0.0402	0.658	-0.117
	(0.101)	(0.150)	(0.423)	(0.171)
Proportion_Male_Emp	-0.151	0.111	-0.546	0.182
	(0.139)	(0.213)	(0.596)	(0.244)
Observations	22,928	21,534	2,206	19,327
R-squared	0.217	-0.084	0.168	-0.244
District fived effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses   *** p<0.01, ** p<0.05, * p<0.1

Table 2.16. Impact of Electrification on Log of Other Income

	All	All	Urban	Rural
	OLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES				
Electricity(1=yes)	0.232**	-0.760	-1.095	-0.240
	(0.102)	(0.861)	(1.297)	(0.922)
Household level				
Female_headed (1=yes)	0.557***	0.561***	0.184	0.614***
	(0.0911)	(0.0962)	(0.133)	(0.112)
Age_15_20	0.0244	0.0186	0.126**	0.00346
	(0.0347)	(0.0371)	(0.0630)	(0.0415)
Age_21_30	0.00628	0.00429	0.0959	-0.00645
	(0.0310)	(0.0324)	(0.0654)	(0.0393)
Age_31_40	0.0182	0.0586	0.0880	0.0329
	(0.0614)	(0.0663)	(0.0991)	(0.0768)
Age_41_50	0.263***	0.287***	0.0331	0.311***
	(0.0490)	(0.0548)	(0.101)	(0.0612)
Age_51_58	0.345***	0.405***	0.204*	0.409***
	(0.0488)	(0.0629)	(0.104)	(0.0696)
Proportion_Female	-0.199	-0.199	0.471	-0.323
	(0.238)	(0.251)	(0.464)	(0.278)
Primary_schooling	0.117**	0.126**	-0.0142	0.144**
	(0.0535)	(0.0609)	(0.133)	(0.0655)
Secondary_schooling	0.505***	0.678***	0.708**	0.581***
	(0.103)	(0.181)	(0.309)	(0.189)
Tertiary_schooling	0.908***	1.163***	1.678***	0.746**
	(0.170)	(0.288)	(0.370)	(0.349)
Urban (1=yes)	0.163	0.229		
	(0.172)	(0.232)		
Size of irrigated land	0.00995*	0.00794	-0.000151	0.0119*
	(0.00539)	(0.00628)	(0.0127)	(0.00642)
Village level				
Distance_bus_stop	-0.000793	-0.00153	-0.000490	-0.00126
	(0.00202)	(0.00209)	(0.0157)	(0.00208)
Village_factory (1=yes)	-0.143	-0.0443	0.494	-0.152
	(0.107)	(0.164)	(0.397)	(0.168)
Village_Infrastructure (1=yes)	0.0598	0.0606	0.0251	0.105
	(0.0341)	(0.0403)	(0.236)	(0.134)
Proportion_Female_Emp	0441	0.485 (0.298)	-0.0260	0.409
	(0.278)	0.0152	(0.604)	(0.332)
Proportion_Male_Emp	0.0951	(0.356)	-0.562	-0.0158
	(0.341)		(0.805)	(0.388)
Observations	8,074	7,583	1,593	5,990
R-squared	0.292	0.013	0.015	0.047
District fived effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.1 Children in Education in South East Asia

		Net enrollment rate (% of primary school age children) in			Children out of school (% of primary school age) in 2014			School enrollment, secondary (% net) in 2014		
		All	Girls	Boys	All	Girls	Boys	All	Girls	Boys
CLMV	**Cambodia**	**95.3**	**94.3**	**96.4**	**4.7**	**5.7**	**3.6**	**38.3** (2008)	**36.7** (2008)	**39.9** (2008)
	Myanmar	96.1	88 (2010)	90 (2010)	3.9	-	-	48.7	49.0	48.5
	Lao P.D.R	96.5	95.4	97.7	3.4	4.6	2.3	52.3	51.1	53.5
	Vietnam	100 (2013)	-	-	0.0	-	-	-	-	-
ASEAN 6	Indonesia	93.2	92.6	93.7	6.8	7.4	6.3	75.2	74.9	75.5
	Malaysia	99.9	99.8	100.0	0.1	0.2	0.0	74.7	77.5	71.9
	Philippines	96 (2015)	96 (2015)	95 (2015)	2.6	1.7	3.4	66.4	72.1	61.0
	Thailand	98 (2009)	98 (2009)	98 (2009)	1.8 (2009)	2 (2009)	1.5 (2009)	78.8	82.5	75.3
	Brunei	96.6	-	-	0.2	-	-	87.4	88.8	86.2
	Singapore	-	-	-	-	-	-	-	-	-

Source: World Development Indicators, Online (Accessed August 5th, 2020)

Table 3.2 Children in Employment in South East Asia

	Country	Children in employment, total (%)				Children in wage employmen	Children in self-emplyed, total (%)	
		2001	2006	2009	2012	2012	2009	2012
CLMV	**Cambodia**	**52.3**	**48.9**(2004)	**34.5**	**11.5**	**19.6**	**9.2**	**3.3**
	Myanmar	-	-	-	-	-	-	-
	Lao P.D.R	-	18.6	11.4(2010)	-	3.6(2010)	16.4(2010)	-
	Vietnam	-	21.3	-	10.9	7.5	-	8.2
ASEAN 6	Indonesia	8.9(2000)	-	6.6	3.7(2010)	15.6(2010)	2.4(2010)	-
	Malaysia	-	-	-	-	-	-	-
	Philippines	13.3	-	-	9.0(2011)	20.4(2011)	-	4.8(2011)
	Thailand	-	15.1	-	-	-	-	-
	Brunei	-	-	-	-	-	-	-
	Singapore	-	-	-	-	-	-	-

Source: World Development Indicators, Online (Accessed February 3, 2020)

Table 3.3. Number of Children, Households with Children, and Villages in the Cambodia

Socio-Economic Survey (CSES) and Cambodia Labor Force and Child Labor Survey

(CLFS) data

	2004	2009	2012	2014	2017
Total number of children (7-14 years old)	16,407	10,373	8,529	8,345	2,554
Total number of households with children	9,081	6,318	5,283	5,535	1,719
Total number of villages	860	713	600	997	373

Note: CSES (2004, 2009, 2014 and 2017), CLFS (2012)

Table 3.4. Main Sources of Lighting in Cambodian households, 2004-2017

	2004		2009		2014		2017	
	Total	%	Total	%	Total	%	Total	%
Publicly-provided electricity	1,306	14%	1,547	24%	3,254	59%	1,349	78%
Generator	624	7%	121	2%	48	1%	3	0%
Battery	2,271	25%	2,578	41%	1,701	31%	202	12%
Kersosene lamp	4,772	53%	1,927	31%	372	7%	21	1%
Other (Candle, solar, none)	107	1%	145	2%	160	3%	144	8%
Total households	**9,080**		**6,318**		**5,535**		**1,719**	

Source: Author's calculations from the Cambodia Socio Economic Survey data from various years

Table 3.5. Parents' Perception on the Main Reason to Allow Children to Work in

Cambodia

Category	Number	%
Poor family	2,921	24%
To supplement household income	2,389	19%
To pay outstanding debt	1,658	13%
To assist/help in household enterprise	1,390	11%
To pay schooling	867	7%
To start own business	742	6%
To gain experience	1,208	10%
Education program is not suitable	408	3%
School institutions are too far	215	2%
Others	551	4%
Total number of households	12,349	100%

Source: Cambodia Child Labor Survey 2001

Table 3.6. Mean Difference between Children Living in Households with and without Access to Electricity in Cambodia

	CSES 2004			CSES 2009			CSES 2014			CSES 2017		
	With electricity	Without electricity	p-value	With electricity	Without electricity	p-value	With electricity	Without electricity	p-value	With electricity	Without electricity	p-value
Characteristics of children (7-14)												
Age	10.8	10.6	0.0	10.8	10.5	0.0	10.6	10.5	0.0	10.5	10.5	0.8
Proportion who are curently in school system	0.95	0.85	0.0	0.94	0.86	0.0	0.94	0.86	0.0	0.97	0.95	0.0
Proportion of drop out	0.02	0.03	0.0	0.03	0.05	0.0	0.03	0.05	0.0	0.03	0.05	0.1
Educational years	3.7	2.6	0.0	4.3	3.1	0.0	4.6	4.5	0.0	3.7	3.1	0.0
Proportion who engaged in economic activity	0.08	0.24	0.0	0.1	0.4	0.0	0.06	0.15	0.0	0.07	0.13	0.0
Characteristics of working children (7-14)												
Proportion of children living in rural areas	1.00	1.00	-	0.63	0.98	0.0	0.74	0.97	0.0	1.00	1.00	-
Employment status												
Unpaid family worker	0.93	0.91	0.4	0.76	0.86	0.0	0.81	0.86	0.1	0.80	0.86	0.3
Wage employment	0.06	0.04	0.4	0.12	0.05	0.0	0.19	0.14	0.1	0.20	0.14	0.3
Self-employment	0.01	0.04	0.0	0.12	0.09	0.1	0.00	0.00	-	0.00	0.00	-
Proportion of employment in:												
Agriculture sector	0.28	0.85	0.0	0.49	0.88	0.0	0.65	0.88	0.0	0.65	0.91	0.0
Manufacturing sector	0.07	0.02	0.0	0.06	0.03	0.0	0.12	0.04	0.0	0.02	0.01	0.2
Service sector	0.64	0.12	0.0	0.45	0.09	0.0	0.23	0.07	0.0	0.28	0.08	0.0
Weekly hours of work	22.5	24.9	0.0	26.0	25.3	0.5	31.4	28.8	0.0	23.1	24.9	0.5

Source: Author's calculations from the Cambodia Socio Economic Survey (CSES) data from various years

Table 3.7 Mean Difference of Time Use between Children Living at Home with Access to

Electricity and Those without Electricity in Cambodia

	2004				
	With electricity	N	Without electricity	N	p-value
24 hours					
Go to schol (also homework)	4.5	2,115	2.9	14,096	0.00
Agriculture work	0.2	2,115	1.1	14,096	0.00
Work as wage employed	0.1	2,115	0.2	14,096	0.01
Work as self-employed	0.25	2,115	0.15	14,096	0.00
Household chores	0.5	2,115	0.9	14,096	0.00
Leisure	4.3	2,115	4.4	14,096	0.47
Sleep	10.1	2,115	10.5	14,096	0.00

Source: Author's calculations from the Cambodia Socio Economic Survey data in 2004

135

Table 3.8 Mean Difference of Time Use between Children with Working Mothers and

Non-Working Mothers in Cambodia

	2004				
	Household with working mother	N	Household with NOT working mother	N	p-value
24 hours					
Go to schol (also homework)	3.0	11,683	3.3	4,525	0.00
Agriculture work	1.0	11,683	0.8	4,525	0.02
Work as wage employed	0.19	11,683	0.23	4,525	0.02
Work as self-employed	0.17	11,683	0.16	4,525	0.00
Household chores	0.86	11,683	0.90	4,525	0.25
Leisure	4.4	11,683	4.3	4,525	0.08
Sleep	10.5	11,683	10.4	4,525	0.00

Source: Author's calculations from the Cambodia Socio Economic Survey data in 2004

136

Table 3.9: First Stage Regressions for Electrification and Household Income

VARIABLES	Household access to electricity
Instruments	
1. Population density	.0207533***
	(.0062262)
2. Distance between village and	-.0591538***
the nearest substation point (km)	(.0198223)
Other control variables	
Female_head (1=yes)	-.0042161
	(.0127052)
Age_15_20	-.010387*
	(.0055511)
Age_21_30	.0003719
	(.0061746)
Age_31_40	.0083728*
	(.0049982)
Age_41_50	.0066926
	(.0070089)
Age_51_60	.0164765*
	(.0108519)
Proportion_female	.0459885
	(.0312361)
Primary_schooling	-.0089812
	(.0073692)
Secondary_schooling	.0985283***
	(.0156407)
Tertiary_schooling	.2751656 ***
	(.0426156)
Size of irrigated land	-.0008564**
	(.0004275)
Urban (1=yes)	.1552761***
	(.0534586)
Distance_bus_stop	.0003585
	(.0004346)
Village_factory (1=yes)	.0733303 ***
	(.0198556)
Village_Infrastracture (1=yes)	.0093113
	(.0209674)
Observations	10,975
Joint significance of all IVs	F=23.43
Hansen J statistics	0.462
	Chi-sq(1) P-val = 0.4966

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.10. Estimation Results on Household Income (1)

VARIABLES	OLS (1) Total_income	2SLS (2) Total_income	OLS (3) Nonfarm_income	2SLS (4) Nonfarm_income
Electricity (1=yes)	0.230***	1.664**	0.150***	1.167*
	(0.0784)	(0.829)	(0.0571)	(0.676)
Household level				
Female_head (1=yes)	0.0972	0.102	-0.164***	-0.146**
	(0.0757)	(0.0790)	(0.0545)	(0.0609)
Age_15_20	0.281***	0.315***	0.192***	0.215***
	(0.0267)	(0.0319)	(0.0246)	(0.0335)
Age_21_30	0.377***	0.373***	0.270***	0.260***
	(0.0353)	(0.0361)	(0.0273)	(0.0288)
Age_31_40	0.205***	0.183***	0.131***	0.118***
	(0.0647)	(0.0591)	(0.0312)	(0.0284)
Age_41_50	0.166***	0.145***	0.108***	0.0913**
	(0.0565)	(0.0556)	(0.0370)	(0.0382)
Age_51_60	0.0563	0.0281	0.0715	0.0470
	(0.0568)	(0.0601)	(0.0448)	(0.0505)
Proportion_Female	-0.0351	-0.0180	0.179	0.144
	(0.183)	(0.197)	(0.151)	(0.171)
Primary_schooling	0.0472	0.0752	0.0968**	0.118**
	(0.0581)	(0.0662)	(0.0484)	(0.0573)
Secondary_schooling	0.367***	0.210	0.359***	0.270***
	(0.0943)	(0.140)	(0.0691)	(0.0920)
Tertiary_schooling	0.828***	0.390	0.578***	0.252
	(0.163)	(0.312)	(0.142)	(0.247)
Urban (1=yes)	0.317**	0.0596	0.208*	0.0452
	(0.132)	(0.203)	(0.116)	(0.171)
Size of irrigated land	0.00214	0.00381	-0.000310	0.00126
	(0.00270)	(0.00300)	(0.00276)	(0.00294)
Village level				
Distance_bus_stop	-0.00389**	-0.00366**	-0.00322**	-0.00288*
	(0.00151)	(0.00162)	(0.00132)	(0.00151)
Village_factory (1=yes)	0.0126	-0.158	0.0342	-0.0994
	(0.0688)	(0.116)	(0.0510)	(0.0978)
Village_Infrastracture (1=yes)	0.0636	0.0543	0.0161	0.000815
	(0.0736)	(0.0822)	(0.0561)	(0.0631)
Observations	8,935	8,395	6,136	5,789
R-squared	0.284	-0.013	0.369	-0.015
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.11. Estimation Results on Household Income (2)

	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)
VARIABLES	Farm_income	Farm_income	Other_income	Other_income
Electricity (1=yes)	-0.210***	-2.807**	0.383**	-0.418
	(0.0512)	(1.184)	(0.157)	(1.288)
Individual level				
Female_head (1=yes)	-0.243***	-0.248***	0.833***	0.816***
	(0.0456)	(0.0679)	(0.145)	(0.155)
Age_15_20	0.151***	0.117***	-0.0448	-0.0517
	(0.0179)	(0.0308)	(0.0528)	(0.0558)
Age_21_30	0.135***	0.129***	0.0815	0.0722
	(0.0172)	(0.0259)	(0.0561)	(0.0572)
Age_31_40	0.156***	0.189***	0.136	0.150
	(0.0139)	(0.0312)	(0.0974)	(0.109)
Age_41_50	0.178***	0.213***	0.458***	0.463***
	(0.0226)	(0.0390)	(0.0935)	(0.100)
Age_51_60	0.220***	0.332***	0.502***	0.518***
	(0.0288)	(0.0608)	(0.101)	(0.115)
Proportion_Female	-0.119	-0.0765	-0.205	-0.0908
	(0.120)	(0.155)	(0.365)	(0.391)
Primary_schooling	0.0891***	0.0810**	0.0654	0.0423
	(0.0266)	(0.0379)	(0.102)	(0.105)
Secondary_schooling	0.0976*	0.383***	0.368**	0.439**
	(0.0512)	(0.145)	(0.151)	(0.214)
Tertiary_schooling	0.126	0.946**	0.316	0.570
	(0.129)	(0.397)	(0.304)	(0.399)
Urban (1=yes)	-0.206*	0.103	0.370	0.287
	(0.116)	(0.226)	(0.261)	(0.324)
Size of irrigated land	0.00570***	0.00312	0.0116*	0.0124*
	(0.00176)	(0.00212)	(0.00609)	(0.00635)
Village level				
Distance_bus_stop	0.000759	0.00131	-0.00200	-0.00195
	(0.000758)	(0.00123)	(0.00288)	(0.00294)
Village_factory (1=yes)	-0.0250	0.217	-0.0966	-0.0463
	(0.0411)	(0.139)	(0.142)	(0.223)
Village_Infrastracture (1=yes)	-0.0416	-0.0291	0.231	0.239
	(0.0450)	(0.0751)	(0.152)	(0.152)
Observations	11,685	10,975	3,375	3,209
R-squared	0.206	-0.573	0.340	0.039
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.12: First Stage Regressions for Electrification and Female Spouse Employment

VARIABLES	Household access to electricity
Instruments	
1. Population density	.0229107***
	(.0082849)
2. Distance between village and	-.0600286***
the nearest substation point (km)	(.0241777)
Other control variables	
Age	.0011486
	(.0058338)
Age_squared	.0000192
	(.0000714)
Years of education	.0128029***
	(.0016844)
Number of toddlers	.0033635
	(.0080832)
Size of irrigated land	-.0001091
	(.0011315)
Urban (1=yes)	.183162***
	(.057484)
Distance_bus_stop	-.0004764
	(.0007043)
Vilage_factory (1=yes)	.0865801***
	(.0246689)
Village_Infrastracture (1=yes)	.0274016
	(.0254021)
Observations	5,058
Joint significance of all IVs	F=23.782
Hansen J statistics	0.079
	Chi-sq(1) P-val = 0.7788

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.13. Estimation Results on Female Spouse Employment in Cambodia (Probit model)

VARIABLES	Probit (1) Paid_employee	IV_Probit (2) Paid_employee	Probit (3) Self_employed	IV_Probit (4) Self_employed	Probit (5) Unpaid	IV_Probit (6) Unpaid
Electricity (1=yes)	0.0347	-0.573	0.0524	0.120	-0.269**	-0.631
	(0.0702)	(0.555)	(0.0612)	(0.445)	(0.110)	(0.663)
Individual level						
age	0.0609**	0.0570*	0.0132	0.0287	-0.00485	-0.0272
	(0.0284)	(0.0306)	(0.0220)	(0.0222)	(0.0339)	(0.0326)
age_squared	-0.000974***	-0.000915**	-0.000131	-0.000331	0.000123	0.000429
	(0.000356)	(0.000381)	(0.000270)	(0.000272)	(0.000414)	(0.000400)
Years of education	0.0312***	0.0403***	-0.00811	-0.00952	-0.00609	-1.27e-06
	(0.00688)	(0.0107)	(0.00504)	(0.00823)	(0.00752)	(0.0119)
Household level						
Urban (1=yes)	0.135	0.325*	-0.134	-0.164	-0.233	-0.108
	(0.133)	(0.189)	(0.124)	(0.151)	(0.225)	(0.239)
Number of toddlers	-0.00257	0.00151	-0.0988***	-0.102***	0.00212	0.0171
	(0.0363)	(0.0365)	(0.0275)	(0.0279)	(0.0357)	(0.0422)
Size of irrigated land	-0.0251	-0.0212	0.00507	0.00565	-0.000182	0.00217
	(0.0208)	(0.0144)	(0.00503)	(0.00462)	(0.00503)	(0.00505)
Village level						
Distance_bus_stop	0.000483	-0.000502	-0.00366**	-0.00335**	0.00805***	0.00877***
	(0.00196)	(0.00189)	(0.00157)	(0.00148)	(0.00241)	(0.00217)
Village_factory (1=yes)	0.0285	0.122	-0.0281	-0.0610	-0.0611	-0.00643
	(0.0763)	(0.0824)	(0.0655)	(0.0635)	(0.0985)	(0.0951)
Village_Infrastructure (1=yes)	-0.00219	-0.0111	0.0904	0.0741	0.000853	0.0692
	(0.0739)	(0.0677)	(0.0654)	(0.0535)	(0.105)	(0.0809)
Observations	4,759	4,537	5,205	4,964	4,061	3,857
R-squared		0.3859		0.3960		0.379
District fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.14: First Stage Regressions for Electrification and Child Labor

VARIABLES	Household access to electricity
Instruments	
1. Population density	.0153778***
	(.0053664)
2. Distance between village and	-.0491986***
the nearest substation point (km)	(.0172622)
Other control variables	
Female (1=yes)	.0069297
	(.0050194)
Age	.0089471
	(.0095554)
Age_squared	-.0003471
	(.0004471)
Houshold_head_education	.0070989 ***
	(.0012059)
Houshold_spouse_education	.006229***
	(.001441)
Head_agri	-.0561411***
	(.0111016)
HH_size	.0017022
	(.0022596)
Number of toddlers	-.0039259
	(.004461)
Urban (1=yes)	.1294799 **
	(.0565675)
Size of irrigated land	-.000052
	(.0001244)
Distance_bus_stop	.0004056
	(.0003291)
Vilage_factory (1=yes)	.0701801 ***
	(.0174364)
Village_Infrastracture (1=yes)	.005025
	(.0179854)
Observations	17,295
Joint significance of all IVs	F=19.93
Hansen J statistics	0.475
	Chi-sq(1) P-val = 0.4908

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.15. Estimation Results on Child Labor

VARIABLES	Probit (1) Employed	IV_Probit (2) Employed	OLS (3) Work_hours	2SLS (4) Work_hours
Electricity (1=yes)	-0.324***	-1.737***	-1.454***	-0.352
	(0.0680)	(0.454)	(0.451)	(5.543)
Individual level				
Female (1=yes)	-0.0689***	-0.0592**	-0.650***	-0.582***
	(0.0214)	(0.0237)	(0.192)	(0.201)
age	1.007***	0.970***	-0.289	-0.548
	(0.0759)	(0.0666)	(0.459)	(0.467)
age_squared	-0.0323***	-0.0307***	0.119***	0.131***
	(0.00334)	(0.00300)	(0.0223)	(0.0227)
Household level				
Houshold_head_education	-0.00544	0.00452	-0.0924***	-0.0917*
	(0.00432)	(0.00463)	(0.0341)	(0.0540)
Household_spouse_education	-0.0189***	-0.00945*	-0.0383	-0.0535
	(0.00524)	(0.00566)	(0.0412)	(0.0548)
Head_agriculture	0.126***	0.0263	1.105***	1.189***
	(0.0376)	(0.0421)	(0.283)	(0.426)
Household size	-0.0304***	-0.0297***	-0.205***	-0.239***
	(0.00850)	(0.00736)	(0.0749)	(0.0722)
Number of toddlers	0.0795***	0.0741***	0.739***	0.777***
	(0.0179)	(0.0164)	(0.154)	(0.159)
Size of irrigated land	-0.00118	-0.00159	-0.00255	-0.00219
	(0.000932)	(0.00107)	(0.00375)	(0.00404)
Urban (1=yes)	-0.328**	0.0385	-2.146*	-0.922
	(0.144)	(0.128)	(1.255)	(1.296)
Village level				
Distance_bus_stop	-0.000146	-0.000444	-0.00118	-0.00319
	(0.00120)	(0.000611)	(0.00857)	(0.00944)
Village_factory (1=yes)	0.0196	0.123***	-0.887**	-0.748
	(0.0554)	(0.0432)	(0.422)	(0.595)
Village_Infrastructure (1=yes)	0.116**	0.100***	0.627	0.404
	(0.0556)	(0.0316)	(0.430)	(0.438)
Observations	20,750	19,115	18,594	17,295
R-squared		0.378	0.213	0.148
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.16. Estimation Results on Children's Education

VARIABLES	Probit (1) School	IV_Probit (2) School	Probit (3) Drop	IV_Probit (4) Drop	OLS (5) Educ_years	2SLS (6) Educ_years
Electricity (1=yes)	0.185***	0.861	-0.187***	-0.782	-0.0260	0.795
	(0.0679)	(0.755)	(0.0673)	(0.782)	(0.0389)	(0.585)
Female (1=yes)	-0.113***	-0.0963**	0.117***	0.102***	0.0972***	0.100***
	(0.0372)	(0.0391)	(0.0367)	(0.0387)	(0.0191)	(0.0200)
age	0.607***	0.631***	-0.514***	-0.540***	0.787***	0.811***
	(0.107)	(0.107)	(0.104)	(0.105)	(0.0521)	(0.0527)
age_squared	-0.0389***	-0.0400***	0.0348***	0.0359***	-0.00341	-0.00427*
	(0.00475)	(0.00482)	(0.00463)	(0.00471)	(0.00238)	(0.00242)
Houshold_head_education	0.0275***	0.0268***	-0.0259***	-0.0257***	0.0426***	0.0378***
	(0.00712)	(0.00795)	(0.00703)	(0.00792)	(0.00419)	(0.00648)
Household_spouse_education	0.0416***	0.0325***	-0.0379***	-0.0301***	0.0404***	0.0336***
	(0.00828)	(0.00987)	(0.00816)	(0.00980)	(0.00449)	(0.00588)
Head_agri	-0.0692	-0.0360	0.0699	0.0428	-0.0730***	-0.0182
	(0.0503)	(0.0681)	(0.0498)	(0.0691)	(0.0276)	(0.0461)
Household size	-0.00543	9.38e-05	0.000495	-0.00516	-0.00330	-0.00267
	(0.0125)	(0.0122)	(0.0123)	(0.0120)	(0.00750)	(0.00782)
Number of toddlers	-0.0290	-0.0291	0.0315	0.0332	-0.103***	-0.0993***
	(0.0279)	(0.0281)	(0.0275)	(0.0276)	(0.0174)	(0.0184)
Size of irrigated land	0.00364	0.00296	-0.00333	-0.00249	0.000718**	0.000828*
	(0.00260)	(0.00272)	(0.00254)	(0.00266)	(0.000350)	(0.000443)
Urban (1=yes)	-0.169	-0.316	0.176	0.303	0.0897	-0.0578
	(0.149)	(0.196)	(0.145)	(0.201)	(0.0941)	(0.133)
Distance_bus_stop	-0.00150	-0.00135	0.00148	0.00139	-0.00133*	-0.00123
	(0.00100)	(0.00103)	(0.000990)	(0.00102)	(0.000745)	(0.000884)
Village_factory (1=yes)	0.0217	-0.0471	-0.0103	0.0497	0.101**	0.0202
	(0.0502)	(0.0727)	(0.0492)	(0.0726)	(0.0400)	(0.0616)
Village_Infrastructure (1=yes)	-0.00985	-0.0269	0.0133	0.0282	0.00947	-0.00554
	(0.0484)	(0.0522)	(0.0475)	(0.0518)	(0.0398)	(0.0439)
Observations	18,318	17.059	19,678	18,270	16,589	15,470
R-squared		0.3784		0.375	0.699	0.626
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.1 Monthly Household Income in Cambodia, All Households (USD PPP)

Monthly household income	2004	%	2009	%	2014	%	2017	%
All households								
1. **Wage work**								
1.a) Agriculture	20	9%	33	8%	68	11%	27	4%
1.b) Mining	0	0%	0	0%	1	0%	1	0%
1.c) Manufacturing								
Garment	2	1%	2	0%	8	1%	78	11%
Food	0	0%	1	0%	3	0%	5	1%
Wood	1	1%	2	1%	5	1%	5	1%
Metal	0	0%	1	0%	3	0%	8	1%
Other	0	0%	1	0%	2	0%	5	1%
1. d) Service								
Construction	5	2%	9	2%	26	4%	50	7%
Retail	6	3%	6	1%	18	3%	12	2%
Government	23	11%	21	5%	47	7%	65	9%
Transport	4	2%	9	2%	27	4%	37	5%
Business service	1	0%	5	1%	14	2%	65	9%
Other	1	0%	5	1%	7	1%	27	4%
Industry unspecified	20	9%	13	3%	37	6%	8	1%
Total income from wage work (1)	**84**	**39%**	**109**	**26%**	**266**	**41%**	**393**	**57%**
2. **Self-employmet**								
2a) Agriculture								
Crop income	23	11%	115	27%	50	8%	33	5%
Animal raising	20	9%	5	1%	4	1%	11	2%
Fishing	9	4%	9	2%	12	2%	7	1%
Forestry & hunting	9	4%	14	3%	26	4%	11	2%
Total income from self-employment, agriculture (2)	**61**	**28%**	**143**	**34%**	**91**	**14%**	**61**	**9%**
2b) Non-agriculture								
Manufacturing	4	2%	13	3%	18	3%	13	2%
Service								
Retail	39	18%	79	19%	134	21%	132	19%
Transport	8	4%	51	12%	33	5%	28	4%
Business service	1	1%	2	0%	11	2%	9	1%
Other	6	3%	19	4%	14	2%	20	3%
Total income from self-employment, non-agriculture (3)	**58**	**27%**	**162**	**38%**	**210**	**33%**	**202**	**30%**
3. Income from other sources								
Remittance (abroad)	5	2%	3	1%	10	2%	12	2%
Remittance (domestic)	3	1%	3	1%	43	7%	12	2%
Other	4	2%	3	1%	20	3%	5	1%
Income from other sources (4)	**12**	**6%**	**9**	**2%**	**74**	**11%**	**29**	**4%**
Total household income from wage work & self-employment (1)+(2)+(3)+(4)	**215**	**100%**	**423**	**100%**	**640**	**100%**	**686**	**100%**

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) for various years

Appendix Table A2.2. Monthly Household Income in Phnom Penh, 2014–2017 (USD PPP)

Monthly household income	2004	%	2009	%	2014	%	2017	%
Phnom Penh								
1. Wage work								
1.a) Agriculture	1	0%	3	0%	10	1%	1	0%
1.b) Mining	0	0%	0	0%	0	0%	1	0%
1.c) Manufacturing								
Garment	10	2%	8	1%	18	2%	107	13%
Food	0	0%	1	0%	2	0%	1	0%
Wood	4	1%	3	0%	4	0%	3	0%
Metal	1	0%	4	0%	6	1%	11	1%
Other	1	0%	23	3%	30	3%	8	1%
1. d) Service								
Construction	20	4%	22	3%	26	3%	36	4%
Retail	32	6%	26	3%	48	5%	21	3%
Government	130	24%	113	15%	156	16%	125	15%
Transport	20	4%	41	5%	73	7%	75	9%
Business service	4	1%	34	5%	55	6%	189	23%
Other	4	1%	23	3%	100	10%	54	7%
Industry unspecified	49	23%	45	11%	0	0%	1	0%
Total income from wage work (1)	**277**	**51%**	**346**	**45%**	**530**	**54%**	**634**	**77%**
2. **Self-employmet**								
2a) Agriculture								
Crop income	1	0%	3	0%	10	1%	0	0%
Animal raising	1	0%	2	0%	1	0%	0	0%
Fishing	1	0%	2	0%	(0)	0%	2	0%
Forestry & hunting	0	0%	0	0%	1	0%	0	0%
Total income from self-employment, agriculture (2)	**4**	**1%**	**7**	**1%**	**11**	**1%**	**2**	**0%**
2b) Non-agriculture								
Manufacturing	18	3%	31	4%	16	2%	7	1%
Service								
Retail	146	27%	213	28%	273	28%	91	11%
Transport	22	4%	76	10%	64	7%	43	5%
Business service	8	1%	10	1%	29	3%	4	1%
Other	22	4%	55	7%	29	3%	23	3%
Total income from self-employment, non-agriculture (3)	**216**	**40%**	**385**	**50%**	**411**	**42%**	**169**	**20%**
3. Income from other sources								
Remittance (abroad)	18	3%	11	1%	8	1%	2	0%
Remittance (domestic)	8	1%	6	1%	9	1%	10	1%
Other	17	3%	7	1%	11	1%	9	1%
Income from other sources (4)	**44**	**8%**	**24**	**3%**	**28**	**4%**	**22**	**3%**
Total household income from wage work & self-employment (1)+(2)+(3)+(4)	**540**	100%	**763**	100%	**980**	100%	**827**	100%

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) for various years

Appendix Table A2.3. Monthly Household Income in Urban Areas except Phnom Penh, 2014–2017 (USD PPP)

Monthly household income	2004	%	2009	%	2014	%	2017	%
Urban area without Phnom Penh								
1. Wage work								
1.a) Agriculture	16	5%	18	4%	48	6%	14	2%
1.b) Mining	0	0%	1	0%	0	0%	0	0%
1.c) Manufacturing								
Garment	1	0%	5	1%	10	1%	49	6%
Food	1	0%	3	1%	3	0%	5	1%
Wood	2	1%	2	0%	5	1%	3	0%
Metal	1	0%	1	0%	4	1%	8	1%
Other	0	0%	13	3%	3	0%	5	1%
1. d) Service								
Construction	6	2%	13	3%	34	4%	55	7%
Retail	10	3%	10	2%	23	3%	15	2%
Government	36	11%	49	10%	58	8%	98	12%
Transport	9	3%	18	4%	38	5%	46	6%
Business service	1	0%	12	2%	18	2%	66	8%
Other	1	0%	18	4%	9	1%	34	4%
Industry unspecified	7	3%	0	0%	33	5%	3	0%
Total income from total wage work (1)	**90**	**27%**	**163**	**35%**	**287**	**38%**	**400**	**50%**
2. Self-employmet								
2a) Agriculture								
Crop income	17	5%	13	3%	20	3%	22	3%
Animal raising	13	4%	4	1%	4	1%	4	0%
Fishing	13	4%	2	1%	8	1%	2	0%
Forestry & hunting	7	2%	5	1%	15	2%	4	1%
Total income from self-employment, agriculture (2)	**49**	**15%**	**25**	**5%**	**46**	**6%**	**32**	**4%**
2b) Non-agriculture								
Manufacturing	11	3%	16	3%	21	3%	18	2%
Service								
Retail	122	37%	117	25%	235	31%	216	27%
Transport	23	7%	112	24%	67	9%	54	7%
Business service	5	1%	3	1%	25	3%	21	3%
Other	5	2%	13	3%	27	4%	20	2%
Total income from self-employment, non-agriculture (3)	**166**	**51%**	**262**	**56%**	**376**	**49%**	**329**	**41%**
3. Income from other sources								
Remittance (abroad)	8	2%	7	1%	11	1%	16	2%
Remittance (domestic)	3	1%	7	2%	24	3%	13	2%
Other	7	2%	5	1%	18	2%	8	1%
Income from other sources (4)	**23**	**7%**	**19**	**4%**	**53**	**8%**	**37**	**5%**
Total household income from wage work & self-employment (1)+(2)+(3)+(4)	**329**	**100%**	**469**	**100%**	**762**	**100%**	**798**	**100%**

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) for various years

Appendix Table A2.4. Monthly Household Income in Rural Areas, 2004–2017 (USD PPP)

Monthly household income	2004	%	2009	%	2014	%	2017	%
Rural areas								
1. **Wage work**								
1.a) Agriculture	23	17%	38	11%	87	16%	41	7%
1.b) Mining	0	0%	0	0%	1	0%	1	0%
1.c) Manufacturing								
Garment	1	1%	1	0%	5	1%	77	13%
Food	0	0%	1	0%	3	1%	7	1%
Wood	1	0%	2	1%	5	1%	6	1%
Metal	0	0%	0	0%	1	0%	7	1%
Other	0	0%	7	2%	2	0%	4	1%
1. d) Service								
Construction	3	2%	6	2%	25	5%	53	9%
Retail	2	2%	3	1%	9	2%	8	1%
Government	8	5%	7	2%	15	3%	32	5%
Transport	2	1%	4	1%	13	2%	21	3%
Business service	0	0%	1	0%	4	1%	21	4%
Other	0	0%	1	0%	3	1%	16	3%
Industry unspecified	3	1%	0	0%	22	3%	13	2%
Total income from total wage work (1)	**44**	**31%**	**73**	**22%**	**194**	**37%**	**306**	**51%**
2. **Self-employmet**								
2a) Agriculture								
Crop income	26	19%	142	42%	67	13%	49	8%
Animal raising	24	17%	5	2%	4	1%	17	3%
Fishing	9	7%	11	3%	16	3%	10	2%
Forestry & hunting	10	7%	17	5%	34	7%	16	3%
Total income from self-employment, agriculture (2)	**70**	**50%**	**175**	**52%**	**122**	**23%**	**92**	**15%**
2b) Non-agriculture		0						
Manufacturing	1	0%	10	3%	17	3%	14	2%
Service								
Retail	11	8%	41	12%	76	14%	117	20%
Transport	4	3%	16	5%	17	3%	14	2%
Business service	0	0%	0	0%	4	1%	6	1%
Other	4	3%	15	4%	8	1%	19	3%
Total income from self-employment, non-agriculture (3)	**19**	**14%**	**84**	**25%**	**122**	**23%**	**170**	**28%**
3. Income from other sources								
Remittance (abroad)	3	2%	2	1%	11	2%	14	2%
Remittance (domestic)	2	2%	2	1%	56	11%	12	2%
Other	2	1%	2	0%	23	4%	2	0%
Income from other sources (4)	**7**	**5%**	**6**	**2%**	**90**	**17%**	**28**	**5%**
Total household income from wage work & self-employment (1)+(2)+(3)+(4)	**139**	100%	**337**	100%	**527**	100%	**597**	100%

Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) for various years

Appendix Table A2.5 Exclusion Restriction

	Employment				Income			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Wage_emp	Self_nonfarm	Self_farm	Unpaid	Total_inc	Non_farm	Farm_inc	Other_inc
ln_pop_densit	0.00169	.0060657	-0.00655	-0.00510*	-0.0112	0.0330*	-0.0402	0.0178
	(0.00355)	(.0045493)	(0.00660)	(0.00283)	(0.0128)	(0.0182)	(0.0247)	(0.0400)
ln_distance	-0.0502***	0.00593	0.0535**	0.0323***	0.0363	0.0516	0.0884	-0.0334
	(0.0127)	(0.00473)	(0.0214)	(0.0115)	(0.0465)	(0.0580)	(0.0737)	(0.184)
Observations	46,176	46,176	46,176	46,176	13,370	5,622	5,263	3,609
R-squared	0.116	0.098	0.228	0.246	0.309	0.363	0.189	0.356

Note: The dependent variables are (1) whether an individual is employed as a wage earner (paid employee), (2) self-employed in non-farm sector, (3) self-employed in farm sector, (4) unpaid family worker, (5) log of total monthly household income, (6) log of monthly income in non-farm sector , (7) log of monthly income in farm sector and (8) log of monthly other income. The sample is limited to observations before the village had electricity. All errors are clustered at village level. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.6. Impact of Electrification on Wage Employment (Probit model)

	Probit	IV_Probit	IV_Probit	IV_Probit
	Dummy dependent variable: Wage employment			
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	0.120***	0.757***	0.402**	1.073***
	(0.0262)	(0.133)	(0.189)	(0.191)
Individual level				
Female (1=yes)	-0.334***	-0.335***		
	(0.0132)	(0.00922)		
Age	0.110***	0.107***	0.0996***	0.117***
	(0.00389)	(0.00273)	(0.00384)	(0.00413)
Age_squared	-0.00161***	-0.00159***	-0.00163***	-0.00163***
	(5.39e-05)	(3.78e-05)	(5.44e-05)	(5.56e-05)
Married (1=yes)	-0.372***	-0.369***	-0.570***	-0.191***
	(0.0172)	(0.0123)	(0.0156)	(0.0216)
Years of education	0.0129***	0.00713***	0.00256	0.00657***
	(0.00162)	(0.00165)	(0.00238)	(0.00241)
Household level				
Urban (1=yes)	0.111**	-0.0308	-0.0182	-0.0559
	(0.0494)	(0.0375)	(0.0557)	(0.0527)
Number of toddlers	-0.00958	-0.00623	-0.0498***	0.0144*
	(0.00938)	(0.00603)	(0.00862)	(0.00874)
Size of irrigated land	-0.00703***	-0.00653***	-0.00947***	-0.00441***
	(0.00244)	(0.000918)	(0.00160)	(0.00115)
Village level				
Distance_bus_stop	-0.000917*	-0.000754***	-0.00216***	-0.000371
	(0.000534)	(0.000273)	(0.000407)	(0.000378)
Village_factory (1=yes)	0.0273	-0.0304*	-0.00290	-0.0399
	(0.0248)	(0.0172)	(0.0246)	(0.0244)
Village_Infrastructure (1=yes)	-0.0385*	-0.0435***	-0.00218	-0.0666***
	(0.0226)	(0.0122)	(0.0173)	(0.0174)
Proportion_Female_Emp	0.550***	0.566***		
	(0.0582)	(0.0322)		
Proportion_Male_Emp	1.120***	1.081***	1.034***	1.709***
	(0.0827)	(0.0467)	(0.0598)	(0.0601)
Mean_Earnings	0.000129	-5.33e-05	-3.36e-05	8.93e-05
	(0.000132)	(6.96e-05)	(9.49e-05)	(0.000104)
Observations	112,433	102,873	54,150	48,602
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.7 Impact of Electrification on Self-employment in Non-farm Sector (Probit model)

	Probit	IV_Probit	IV_Probit	IV_Probit
		Dummy dependent variable: Self-employment in non-farm sector		
	(1)	(2)	(3)	(4)
VARIABLES		All	Female	Male
Electricity (1=yes)	0.356***	1.563***	1.618***	1.499***
	(0.0374)	(0.130)	(0.179)	(0.188)
Individual level				
Female (1=yes)	0.0352***	0.0195**		
	(0.00833)	(0.00887)		
Age	0.000106	-0.000784	0.00199	-0.00338
	(0.00332)	(0.00256)	(0.00344)	(0.00395)
Age_squared	2.33e-05	2.06e-05	-2.66e-05	6.96e-05
	(4.60e-05)	(3.50e-05)	(4.73e-05)	(5.29e-05)
Married (1=yes)	0.0710***	0.0682***	0.0609***	0.0654***
	(0.0167)	(0.0120)	(0.0148)	(0.0214)
Years of education	0.0259***	0.0131***	0.0110***	0.0158***
	(0.00175)	(0.00161)	(0.00223)	(0.00237)
Household level				
Urban (1=yes)	0.332***	0.0913**	0.0917*	0.0735
	(0.0783)	(0.0369)	(0.0527)	(0.0521)
Number of toddlers	0.0374***	0.0563***	0.0555***	0.0558***
	(0.0115)	(0.00580)	(0.00795)	(0.00854)
Size of irrigated land	-0.00218	0.000287	0.000378	0.000314
	(0.00132)	(0.000692)	(0.00103)	(0.000938)
Village level				
Distance_bus_stop	-0.000830	-0.000248	-0.000519	-0.000484
	(0.000733)	(0.000254)	(0.000342)	(0.000375)
Village_factory (1=yes)	0.0781**	-0.0180	-0.0274	-8.69e-05
	(0.0353)	(0.0167)	(0.0232)	(0.0239)
Village_Infrastructure (1=yes)	0.0774**	0.0716***	0.0725***	0.0911***
	(0.0335)	(0.0118)	(0.0161)	(0.0170)
Proportion_Female_Emp	0.251***	0.375***		
	(0.0836)	(0.0307)		
Proportion_Male_Emp	-0.475***	-0.554***	-0.324***	-0.359***
	(0.128)	(0.0446)	(0.0554)	(0.0573)
Mean_Earnings	0.000328*	3.11e-05	0.000135	1.32e-05
	(0.000177)	(6.98e-05)	(9.30e-05)	(0.000103)
Observations	112,183	102,704	54,167	48,437
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.8 Impact of Electrification on Self-employment in Farm sector (Probit model)

	Probit	IV_Probit	IV_Probit	IV_Probit
	Dummy dependent variable: Self-employment in farm sector			
	(1)	(2)	(3)	(4)
VARIABLES	All		Female	Male
Electricity (1=yes)	-0.00887	-0.407***	-0.308*	-0.560***
	(0.0217)	(0.120)	(0.166)	(0.176)
Individual level				
Female (1=yes)	-0.115***	-0.116***		
	(0.0117)	(0.00818)		
Age	-0.00534	-0.00346	-0.0101***	0.00524
	(0.00353)	(0.00236)	(0.00316)	(0.00367)
Age_squared	0.000127***	0.000111***	0.000179***	1.70e-05
	(4.70e-05)	(3.22e-05)	(4.34e-05)	(4.91e-05)
Married (1=yes)	0.0567***	0.0559***	0.0245*	0.0739***
	(0.0153)	(0.0110)	(0.0136)	(0.0199)
Years of education	-0.00297**	-0.000247	-0.00216	0.00355
	(0.00137)	(0.00149)	(0.00207)	(0.00220)
Household level				
Urban (1=yes)	-0.0607	0.0342	-0.00775	0.0603
	(0.0459)	(0.0345)	(0.0493)	(0.0492)
Number of toddlers	-0.00285	-0.00235	-0.00942	-0.00218
	(0.00838)	(0.00533)	(0.00729)	(0.00791)
Size of irrigated land	0.00118	0.000964	0.00229**	0.000110
	(0.000791)	(0.000617)	(0.000937)	(0.000835)
Village level				
Distance_bus_stop	-9.68e-05	-0.000212	-0.00174***	0.000533
	(0.000456)	(0.000224)	(0.000308)	(0.000326)
Village_factory (1=yes)	-0.00507	0.0258*	0.0183	0.0454**
	(0.0204)	(0.0155)	(0.0214)	(0.0223)
Village_Infrastructure (1=yes)	0.0281	0.0327***	0.0508***	0.0435***
	(0.0205)	(0.0109)	(0.0148)	(0.0158)
Proportion_Female_Emp	0.513***	0.505***		
	(0.0499)	(0.0281)		
Proportion_Male_Emp	-0.181**	-0.173***	0.251***	-0.0525
	(0.0710)	(0.0411)	(0.0508)	(0.0530)
Mean_Earnings	-0.000322***	-0.000231***	-0.000157*	-0.000169*
	(0.000125)	(6.44e-05)	(8.52e-05)	(9.63e-05)
Observations	112,524	102,964	54,286	48,678
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.9 Impact of Electrification on Unpaid Family Worker (Probit model)

	Probit	IV_Probit	IV_Probit	IV_Probit
	(1)	(2)	(3)	(4)
VARIABLES		All	Female	Male
Electricity (1=yes)	-0.138***	-1.385***	-1.662***	-1.543***
	(0.0262)	(0.178)	(0.239)	(0.296)
Individual level				
Female (1=yes)	0.447***	0.446***		
	(0.0172)	(0.0116)		
Age	-0.0713***	-0.0704***	-0.0599***	-0.0471***
	(0.00419)	(0.00329)	(0.00428)	(0.00598)
Age_squared	0.000637***	0.000641***	0.000604***	0.000113
	(5.85e-05)	(4.63e-05)	(5.97e-05)	(8.94e-05)
Married (1=yes)	-0.134***	-0.155***	0.213***	-0.715***
	(0.0195)	(0.0153)	(0.0188)	(0.0298)
Years of education	-0.00216	0.00991***	0.0155***	0.00327
	(0.00159)	(0.00217)	(0.00292)	(0.00363)
Household level				
Urban (1=yes)	-0.188***	0.144***	0.286***	0.215**
	(0.0619)	(0.0532)	(0.0735)	(0.0860)
Number of toddlers	-0.0739***	-0.0759***	-0.0489***	-0.0786***
	(0.00941)	(0.00756)	(0.00988)	(0.0129)
Size of irrigated land	0.00297***	0.000812	-0.000351	0.000247
	(0.000865)	(0.000726)	(0.00107)	(0.00110)
Village level				
Distance_bus_stop	0.000758*	0.000180	0.00266***	-0.000902*
	(0.000450)	(0.000300)	(0.000390)	(0.000499)
Village_factory (1=yes)	0.000846	0.117***	0.0860***	0.177***
	(0.0237)	(0.0220)	(0.0295)	(0.0357)
Village_Infrastructure (1=yes)	0.0311	0.0625***	0.0148	0.0782***
	(0.0243)	(0.0152)	(0.0201)	(0.0248)
Proportion_Female_Emp	-1.351***	-1.430***		
	(0.0643)	(0.0392)		
Proportion_Male_Emp	-1.313***	-1.211***	-1.468***	-2.708***
	(0.0906)	(0.0565)	(0.0678)	(0.0840)
Mean_Earnings	0.000156	0.000471***	-0.000275*	0.000570***
	(0.000170)	(0.000107)	(0.000150)	(0.000175)
Observations	112,141	102,581	53,825	48,443
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.10 Impact of Electrification on Wage Employment using Panel Data

VARIABLES	Dummy dependent variable: Wage employment		
	(1) All	(2) Female	(3) Male
Electricity (1=yes)	0.104***	0.0470	0.140***
	(0.0380)	(0.0358)	(0.0450)
Individual level			
Female (1=yes)	-0.111***		
	(0.0144)		
Age	0.0482***	0.0407***	0.0510***
	(0.00423)	(0.00441)	(0.00653)
Age_squared	-0.000687***	-0.000627***	-0.000699***
	(5.76e-05)	(6.08e-05)	(8.54e-05)
Married (1=yes)	-0.137***	-0.203***	-0.0514*
	(0.0232)	(0.0253)	(0.0302)
Years of education	0.00610***	0.00219	0.00696***
	(0.00178)	(0.00219)	(0.00235)
Household level			
Urban (1=yes)	0.0881	0.0504	0.0557
	(0.0864)	(0.0823)	(0.110)
Number of toddlers	-0.00350	-0.0307**	0.0119
	(0.00908)	(0.0123)	(0.0140)
Size of irrigated land	-0.000967	-0.000663	-0.000160
	(0.00186)	(0.00222)	(0.00241)
Village level			
Distance_bus_stop	-0.000118	0.000128	-0.000802
	(0.000823)	(0.000881)	(0.00111)
Village_factory (1=yes)	-0.0532	0.0818	-0.181**
	(0.0771)	(0.0740)	(0.0865)
Village_Infrastructure (1=yes)	-0.0399	0.0418	-0.0718
	(0.0423)	(0.0453)	(0.0469)
Constant	-0.353***	-0.288***	-0.378***
	(0.0942)	(0.0943)	(0.134)
Observations	10,567	5,492	5,075
R-squared	0.198	0.215	0.254
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.11. Impact of Electrification on Self-employment in Non-farm Sector

using Panel Data

	Dummy dependent variable: Self-employment in non-farm sector		
	(1)	(2)	(3)
VARIABLES	All	Female	Male
Electricity (1=yes)	0.172***	0.171***	0.162***
	(0.0475)	(0.0512)	(0.0496)
Individual level			
Female (1=yes)	-0.00570		
	(0.0106)		
age	-0.00887**	-0.00714	-0.00863
	(0.00369)	(0.00451)	(0.00575)
age_squared	0.000123**	9.56e-05	0.000131*
	(5.19e-05)	(6.26e-05)	(7.83e-05)
Married (1=yes)	0.0556***	0.0567**	0.0362
	(0.0194)	(0.0225)	(0.0309)
years of education	0.00205	0.00227	0.00138
	(0.00196)	(0.00233)	(0.00240)
Household level			
Urban (1=yes)	0.357***	0.380***	0.320***
	(0.0768)	(0.0938)	(0.0763)
Number of toddlers	-0.000882	-0.00469	0.00135
	(0.0128)	(0.0135)	(0.0169)
Size of irrigated land	-0.000505	-0.00123	0.000100
	(0.00264)	(0.00296)	(0.00292)
Village level			
Distance_bus_stop	0.00379***	0.00343***	0.00411***
	(0.00111)	(0.00130)	(0.000968)
vil_factory (1=yes)	-0.0794	-0.119	-0.0407
	(0.0849)	(0.0932)	(0.0822)
Village_Infrastructure (1=yes)	0.0950	0.0774	0.103
	(0.0729)	(0.0820)	(0.0714)
Constant	0.712***	0.745***	0.652***
	(0.0745)	(0.0893)	(0.102)
Observations	10,567	5,492	5,075
R-squared	0.279	0.268	0.320
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.12. Impact of Electrification on Self-employment in Farm Sector

using Panel data

	Dummy dependent variable: Self-employment in farm sector		
	(1)	(2)	(3)
VARIABLES	All	Female	Male
Electricity (1=yes)	-0.105**	-0.154***	-0.0553
	(0.0448)	(0.0523)	(0.0543)
Individual level			
Female (1=yes)	-0.0419**		
	(0.0168)		
age	0.0410***	0.0441***	0.0331***
	(0.00436)	(0.00555)	(0.00665)
age_squared	-0.000446***	-0.000483***	-0.000360***
	(6.16e-05)	(7.56e-05)	(9.19e-05)
Married (1=yes)	0.0749***	0.0410	0.150***
	(0.0209)	(0.0262)	(0.0351)
years of education	-0.0105***	-0.00836***	-0.0122***
	(0.00188)	(0.00219)	(0.00233)
Household level			
Urban (1=yes)	-0.248***	-0.277***	-0.254**
	(0.0852)	(0.0932)	(0.126)
Number of toddlers	0.0152	0.0115	0.0118
	(0.0128)	(0.0134)	(0.0179)
Size of irrigated land	0.00463	0.00646*	0.00277
	(0.00378)	(0.00377)	(0.00430)
Village level			
Distance_bus_stop	-0.00541***	-0.00585***	-0.00449***
	(0.000927)	(0.00119)	(0.00133)
Village_factory (1=yes)	0.153**	0.136	0.153
	(0.0697)	(0.0870)	(0.0987)
Village_Infrastructure (1=yes)	-0.0809	-0.0591	-0.122**
	(0.0537)	(0.0648)	(0.0556)
Constant	-1.032***	-1.115***	-0.928***
	(0.0800)	(0.116)	(0.110)
Observations	10,567	5,492	5,075
R-squared	0.360	0.362	0.410
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.13 Impact of Electrification on Unpaid Family Worker using Panel

Data

	(1)	(2)	(3)
	Dummy dependent variable: Unpaid family worker		
VARIABLES	All	Female	Male
Electricity (1=yes)	-0.00611	-0.00278	-0.00499
	(0.0239)	(0.0284)	(0.0243)
Individual level			
Female (1=yes)	0.0505***		
	(0.0101)		
Age	-0.0166***	-0.0146***	0.000175***
	(0.00242)	(0.00332)	(4.27e-05)
Age_squared	0.000192***	0.000179***	-0.0715***
	(3.23e-05)	(4.49e-05)	(0.0181)
Married (1=yes)	-0.0158	0.0225	-0.000496
	(0.0115)	(0.0159)	(0.00104)
Years of education	-0.000735	-0.000620	0.0343
	(0.000818)	(0.00117)	(0.0504)
Household level			
Urban (1=yes)	-0.0190	-0.0715	-0.0148**
	(0.0620)	(0.0854)	(0.00607)
Number of toddlers	-0.0184***	-0.0127	-0.000949
	(0.00654)	(0.00829)	(0.00145)
Size of irrigated land	-0.00187*	-0.00333***	0.000426
	(0.00111)	(0.00119)	(0.000486)
Village level			
Distance_bus_stop	0.00179**	-0.0342	0.000426
	(0.000766)	(0.0811)	(0.000486)
Village_factory (1=yes)	0.00442	0.00390	0.0477
	(0.0573)	(0.0690)	(0.0477)
Village_Infrastructure (1=yes)	0.0163	0.465***	0.0288
	(0.0530)	(0.0810)	(0.0436)
Constant	0.432***	-0.00278	0.396***
	(0.0643)	(0.0284)	(0.0763)
Observations	10,567	5,492	5,075
R-squared	0.224	0.280	0.238
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix Table A2.14 Impact of Electrification on log of monthly total household income using panel data

VARIABLES	Dependent variable: Log of total monthly income		
	(1) All	(2) Urban	(3) Rural
Electricity(1=yes)	0.352***	0.413**	0.179
	(0.120)	(0.158)	(0.159)
Household level			
Female-headed (1=yes)	-0.379***	-0.342***	-0.369***
	(0.0573)	(0.0731)	(0.0807)
Age_15_20	0.00335	0.00904*	0.0124
	(0.00490)	(0.00486)	(0.00824)
Age_21_30	0.0213	0.0159	0.134***
	(0.0179)	(0.0153)	(0.0293)
Age_31_40	0.00890**	0.00888***	0.0764**
	(0.00414)	(0.00317)	(0.0328)
Age_41_50	0.0181**	0.0191**	0.0176
	(0.00722)	(0.00880)	(0.0244)
Age_51_60	0.00222	0.00302	0.00953
	(0.00424)	(0.00381)	(0.0329)
Proportion_Female	-0.259	-0.134	-0.238
	(0.200)	(0.269)	(0.252)
Primary_schooling	0.0114**	-0.00149	0.0122*
	(0.00515)	(0.00307)	(0.00677)
Secondary_schooling	-0.0767*	-0.0861	-0.0153
	(0.0407)	(0.0603)	(0.0348)
Tertiary_schooling	0.120*	0.0255	0.419**
	(0.0652)	(0.0559)	(0.165)
Urban (1=yes)	0.480***	0.496***	0.709***
	(0.107)	(0.131)	(0.211)
Size of irrigated land	0.976***		
	(0.237)		
Village level			
Distance_bus_stop	-0.00589*	0.00244	-0.00561***
	(0.00318)	(0.0207)	(0.00133)
Village_factory (1=yes)	-0.313	-0.766***	-0.384
	(0.258)	(0.272)	(0.282)
Village_Infrastructure (1=yes)	0.394*	0.117	1.251***
	(0.201)	(0.210)	(0.238)
Constant	5.372***	6.318***	4.736***
	(0.285)	(0.320)	(0.252)
Observations	10,205	7,086	3,119
R-squared	0.374	0.311	0.392
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.15 Impact of Electrification on log of Non-farm Income using Panel Data

	(1)	(2)	(3)
	Dependent variable: Log of monthly non-farm income		
VARIABLES	All	Urban	Rural
Electricity(1=yes)	0.345	0.280**	0.389*
	(0.253)	(0.131)	(0.199)
Household level			
Female-headed (1=yes)	-0.0916	-0.161**	0.106
	(0.0765)	(0.0783)	(0.202)
Age_15_20	-1.13e-05	0.00507	-0.0246
	(0.00489)	(0.00453)	(0.0186)
Age_21_30	0.0100	0.00961	0.0171
	(0.0129)	(0.0120)	(0.0537)
Age_31_40	0.0275*	0.0264*	0.0215
	(0.0149)	(0.0141)	(0.0294)
Age_41_50	0.0299***	0.0299***	0.0135
	(0.00797)	(0.00792)	(0.0450)
Age_51_60	0.00710	0.00728	0.0620
	(0.00707)	(0.00835)	(0.0610)
Proportion_Female	-0.307	0.0537	-1.150***
	(0.211)	(0.241)	(0.365)
Primary_schooling	0.00770	-0.0928**	0.00741
	(0.00883)	(0.0387)	(0.00838)
Secondary_schooling	-0.0496	-0.0723	0.0499
	(0.0421)	(0.0596)	(0.0629)
Tertiary_schooling	0.208***	0.120	0.541***
	(0.0747)	(0.0827)	(0.176)
Urban (1=yes)	0.604***	0.636***	0.358
	(0.130)	(0.144)	(0.545)
Size of irrigated land	0.659***		
	(0.237)		
Distance_bus_stop	-0.0105*	0.00504	-0.0146***
	(0.00586)	(0.0252)	(0.00430)
Village level			
Village_factory (1=yes)	-0.193	-0.291	-0.752
	(0.268)	(0.253)	(0.585)
Village_Infrastructure (1=yes)	0.0531	-0.0217	0.761**
	(0.205)	(0.243)	(0.295)
Constant	5.303***	5.634***	5.441***
	(0.386)	(0.302)	(0.436)
Observations	7,159	5,716	1,443
R-squared	0.372	0.267	0.474
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.16 Impact of Electrification on log of Farm Income using Panel Data

	Dependent variable: Log of monthly farm income		
	(1)	(2)	(3)
VARIABLES	All	Urban	Rural
Electricity(1=yes)	-0.142	-0.0588	-0.154
	(0.169)	(0.234)	(0.166)
Household level			
Female_headed (1=yes)	-0.340***	-0.213	-0.352**
	(0.113)	(0.250)	(0.135)
Age_15_20	0.0121	-0.0130	0.0293***
	(0.0137)	(0.0105)	(0.00709)
Age_21_30	-0.0462	-0.0790***	0.0712
	(0.0433)	(0.0183)	(0.0474)
Age_31_40	0.0753***	0.0641***	0.0695
	(0.00442)	(0.00474)	(0.0497)
Age_41_50	0.0333*	0.0868	0.0167
	(0.0199)	(0.0637)	(0.0214)
Age_51_58	0.000795	0.0112	-0.0714
	(0.0169)	(0.0153)	(0.0618)
Proportion_Female	-0.383	-0.760*	0.268
	(0.295)	(0.440)	(0.381)
Primary_schooling	0.0170**	0.00462	0.0240***
	(0.00854)	(0.00454)	(0.00750)
Secondary_schooling	-0.0518	-0.0426	-0.0117
	(0.0698)	(0.200)	(0.0574)
Tertiary_schooling	0.182	0.193	0.227
	(0.113)	(0.131)	(0.194)
Urban (1=yes)	0.106	-0.150	0.300
	(0.242)	(0.348)	(0.345)
Size of irrigated land	-0.280		
	(0.429)		
Village level			
Distance_bus_stop	-0.00730	0.272**	-0.0146***
	(0.00466)	(0.108)	(0.00430)
Village_factory (1=yes)	-0.300	0.514	-0.752
	(0.423)	(0.445)	(0.585)
Village_Infrastructure (1=yes)	0.364	1.410***	0.761**
	(0.231)	(0.462)	(0.295)
Constant	4.510***	2.391***	5.441***
	(0.519)	(0.500)	(0.436)
Observations	4,466	1,771	1,443
R-squared	0.372	0.267	0.474
Village fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.17 Village level Effect of Electrification on Employment

VARIABLES	2SLS (1) Wage_Emp	2SLS (2) Self_Nonfarm	2SLS (3) Self_farm	2SLS (4) Unpaid
Village_Electricity (1=yes)	0.285***	0.228*	-0.373**	-0.312***
	(0.103)	(0.126)	(0.161)	(0.0920)
Individual level				
Female (1=yes)	-0.0685***	0.0104***	-0.106***	0.0924***
	(0.00545)	(0.00347)	(0.00756)	(0.00590)
age	0.0236***	0.00179	0.0336***	-0.0217***
	(0.00163)	(0.00137)	(0.00189)	(0.00134)
Age_sqaured	-0.000359***	-1.74e-05	-0.000324***	0.000218***
	(2.23e-05)	(1.90e-05)	(2.66e-05)	(1.76e-05)
Mariied (1=yes)	-0.115***	0.0216***	0.132***	-0.0384***
	(0.00800)	(0.00744)	(0.0101)	(0.00643)
Years of education	0.00193***	0.00951***	-0.0144***	-0.000199
	(0.000727)	(0.000815)	(0.00103)	(0.000569)
Household level				
Urban (1=yes)	0.0207	0.00917	-0.0908	0.0532
	(0.0545)	(0.0580)	(0.0741)	(0.0375)
Number of toddlers	0.00374	0.0116**	-0.00944	-0.0209***
	(0.00391)	(0.00488)	(0.00595)	(0.00280)
Size of irrigated land	-0.000763**	-0.000440	0.000963	0.000171
	(0.000326)	(0.000536)	(0.000598)	(0.000333)
Village level				
Distance_bus_stop	-8.62e-05	-0.000676**	4.45e-05	0.000464**
	(0.000238)	(0.000272)	(0.000350)	(0.000236)
Village_factory (1=yes)	-0.0204	0.00497	-0.00173	0.0261*
	(0.0152)	(0.0181)	(0.0238)	(0.0133)
Village_Infrastructure (1=yes)	-0.0392**	0.0116	0.0155	0.0395**
	(0.0177)	(0.0219)	(0.0285)	(0.0153)
Observations	60,217	60,217	60,217	60,217
R-squared	0.005	-0.010	0.099	0.026
District fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A2.18 Firm Characteristics between Village with Access to Electricity and without Electricity

	2011				2014			
	Village without access to electricity		Village with access to electricity		Village without access to electricity		Village with access to electricity	
Number of total establishments	23,330	28%	59,414	72%	896	9%	9,558	91%
No of formal firms	327	1%	2,748	5%	205	23%	4,803	50%
No of informal firms	23,003	99%	56,666	95%	691	77%	4,755	50%
No of firms in manufacturing sector	3,867	17%	4,430	7%	126	14%	2,983	31%
No of firms in service sector	19,461	83%	54,978	93%	770	86%	6,574	69%
No of female-owned businesses	13,477	58%	41,836	70%	382	43%	2,216	23%
Average number of total workers	2.8	-	3.7	-	86.0	-	205.0	-
No of female workers	1.7	-	2.4	-	61.1	-	144.0	-
No of male workers	1.1	-	1.3	-	24.9	-	61.0	-
Operating years	5.8	-	7.0	-	5.8	-	11.4	-
Daily Business hours	10.8	-	10.4	-	10.8	-	10.4	-
Daily sales in USD	24.2	-	54.9	-	848	-	1,442	-
Manugacturing	17.8	-	51.2	-	6,769	-	4,297	-
Service	25.5	-	52.9	-	267	-	648	-

Source: Author's calculation from Cambodia Economic Census Data 2011, 2014

Appendix Table A2.19 Village level Effect of Electrification on Household Income

VARIABLES	2SLS (1) Total_Income	2SLS (2) Nonfarm_Income	2SLS (3) Farm_Income
Village_Electricity (1=yes)	0.265	0.657	-0.502***
	(0.293)	(0.414)	(0.0864)
Household level			
Female_headed (1=yes)	-0.272***	0.0990**	-0.353***
	(0.0324)	(0.0445)	(0.0351)
Age_15_20	0.0544	0.0593***	0.143***
	(0.0396)	(0.0224)	(0.0186)
Age_21_30	0.165***	0.135***	0.126***
	(0.0282)	(0.0277)	(0.0225)
Age_31_40	0.0235**	0.177***	0.142***
	(0.0114)	(0.0443)	(0.0176)
Age_41_50	0.198***	0.222***	0.152***
	(0.0232)	(0.0359)	(0.0287)
Age_51_58	0.195***	0.0880**	0.201***
	(0.0256)	(0.0359)	(0.0541)
Proportion_Female	0.0823	-0.111	-0.290***
	(0.0666)	(0.127)	(0.0907)
Primary_schooling	0.136***	0.0806**	0.131***
	(0.0229)	(0.0322)	(0.0290)
Secondary_schooling	0.394***	0.591***	0.184***
	(0.0337)	(0.0559)	(0.0584)
Tertiary_schooling	0.783***	0.830***	-0.204
	(0.0769)	(0.132)	(0.214)
Urban (1=yes)	-0.0976	0.217	
	(0.113)	(0.156)	
Size of irrigated land	0.00336***	0.00222	0.00573***
	(0.00130)	(0.00243)	(0.00155)
Village level			
Distance_bus_stop	5.11e-05	-0.00176	0.00276**
	(0.000583)	(0.00138)	(0.00136)
Village_factory (1=yes)	0.0133	-0.0624	-0.0729
	(0.0418)	(0.0689)	(0.0677)
Village_Infrastructure (1=yes)	0.0105	-0.0909	0.0235
	(0.0525)	(0.0790)	(0.0691)
Observations	58,187	22,287	24,758
R-squared	0.088	0.047	0.151
District fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A3.1 Impact of log of Total Income on Child Labor

	OLS
	(1)
VARIABLES	Child_Labor
Log_Total_Income	-0.00531*
(endogenous)	(0.00304)
Individual level	
Female (1=yes)	-0.0180***
	(0.00678)
Age	0.0203
	(0.0166)
Age_squared	0.00199**
	(0.000790)
Household level	
Houshold_head_education	-0.00138
	(0.00126)
Household_spouse_education	-0.00468***
	(0.00144)
Head_agriculture	0.0270***
	(0.00964)
Household_size	-0.00643**
	(0.00253)
Urban (1=yes)	-0.0808**
	(0.0333)
Number of toddlers	0.0154***
	(0.00548)
Size of irrigated land	-0.000919*
	(0.000524)
Village level	
Distance_bus_stop	-4.57e-05
	(0.000342)
Village_factory (1=yes)	-0.00823
	(0.0158)
Village_Infrastructure (1=yes)	0.0235
	(0.0159)
Observations	12,457
R-squared	0.239
District fixed effect	Yes
Year fixed effect	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix Table A3.2 Estimation Results on Female Spouse Employment (Linear probability model)

	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Wage_employed	Wage_employed	Self_employed	Self_employed	Unpaid	Unpaid
Electricity (1=yes)	-0.00668	-0.190	0.0135	0.0152	-0.0110	0.00343
	(0.0152)	(0.164)	(0.0213)	(0.236)	(0.0131)	(0.153)
Individual level						
age	0.00723	0.00769	0.00668	0.0104	-0.00137	-0.00370
	(0.00491)	(0.00504)	(0.00753)	(0.00766)	(0.00482)	(0.00498)
age_squared	-0.000124**	-0.000124**	-7.59e-05	-0.000124	2.39e-05	5.42e-05
	(5.92e-05)	(6.09e-05)	(9.20e-05)	(9.33e-05)	(5.90e-05)	(5.95e-05)
Years of education	0.00521***	0.00772***	-0.00201	-0.00205	-0.000533	-0.000871
	(0.00139)	(0.00254)	(0.00171)	(0.00356)	(0.00103)	(0.00232)
Household level						
Urban (1=yes)	0.0284	0.0800*	-0.0171	-0.0243	-0.0461	-0.0478
	(0.0301)	(0.0450)	(0.0452)	(0.0702)	(0.0321)	(0.0473)
Number of toddlers	0.00292	0.00379	-0.0357***	-0.0369***	0.00170	0.00303
	(0.00693)	(0.00713)	(0.00958)	(0.00977)	(0.00479)	(0.00490)
Size of irrigated land	-0.00178**	-0.00173*	0.00268	0.00249	-0.000178	0.000483
	(0.000873)	(0.000905)	(0.00178)	(0.00192)	(0.00155)	(0.00172)
Village level						
Distance_bus_stop	4.06e-05	-0.000249	-0.00147***	-0.00149**	0.000985**	0.000978*
	(0.000358)	(0.000460)	(0.000553)	(0.000665)	(0.000430)	(0.000521)
Village_factory (1=yes)	0.00860	0.0305	-0.0179	-0.0232	-0.00193	-0.00240
	(0.0147)	(0.0229)	(0.0220)	(0.0321)	(0.0128)	(0.0186)
Village_Infrastructure (1=yes)	-0.00242	0.000215	0.0201	0.0168	0.0153	0.0191
	(0.0142)	(0.0157)	(0.0225)	(0.0228)	(0.0144)	(0.0145)
Observations	5,265	5,058	5,265	5,058	5,265	5,058
R-squared	0.115	-0.033	0.149	0.009	0.233	0.006
District fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figures

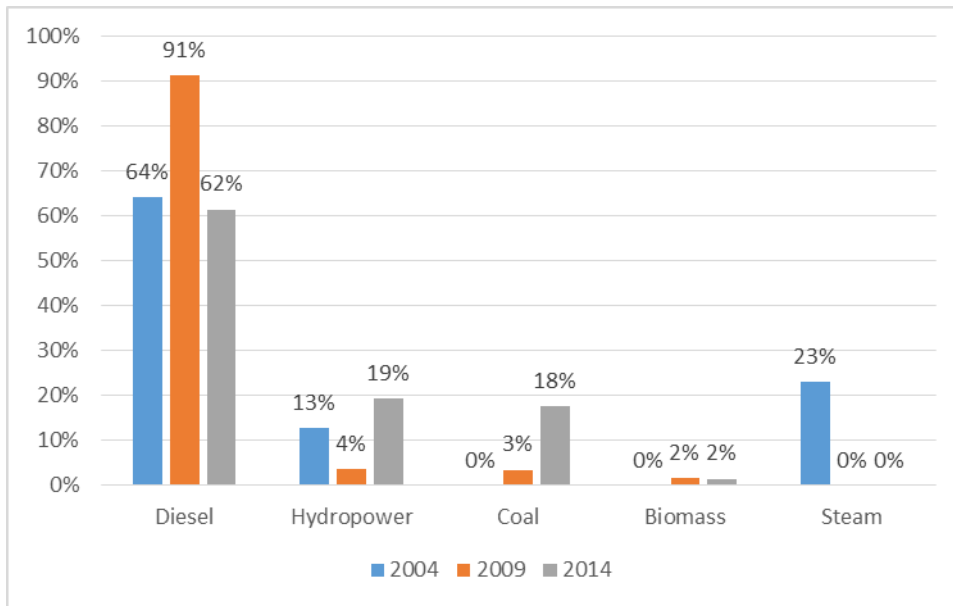*Figure 2.1. Conceptual Framework: Expected Outcomes of Electrification*
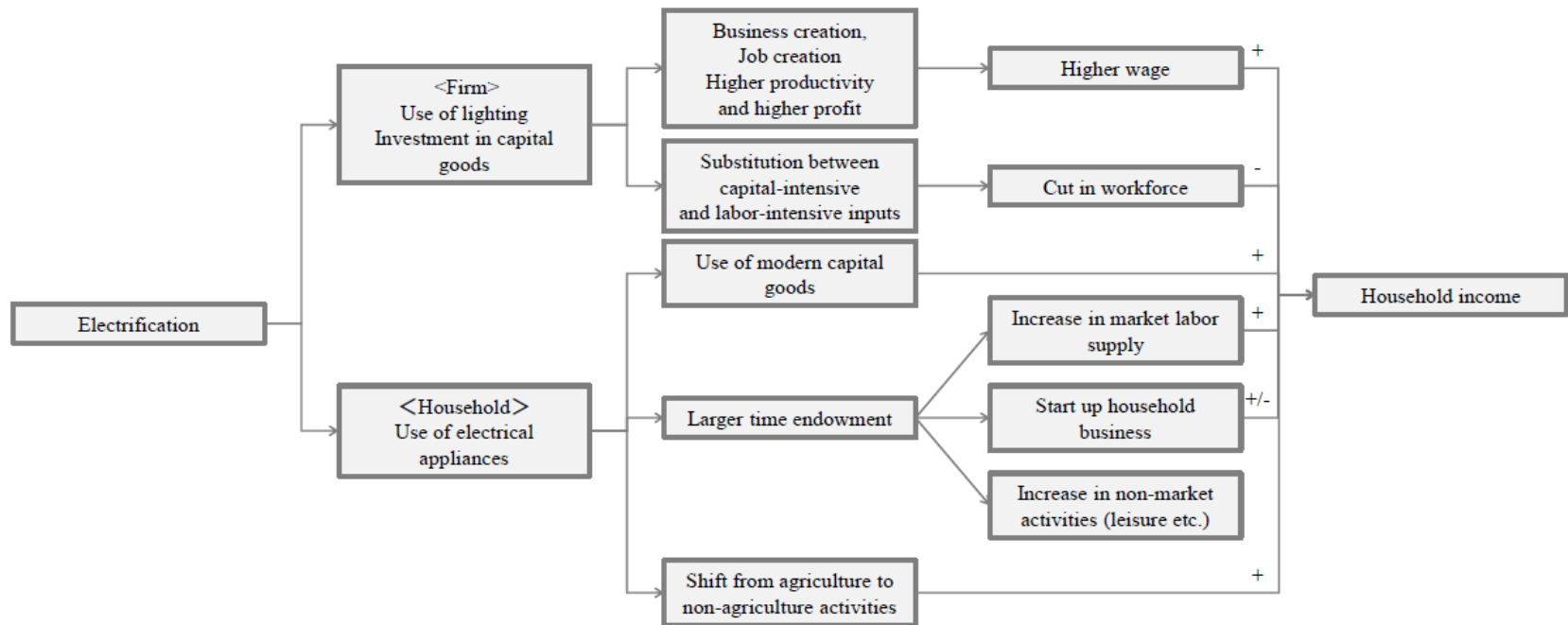
*Figure 2.2. Generation and Import of Energy in Cambodia, 2004-2018*
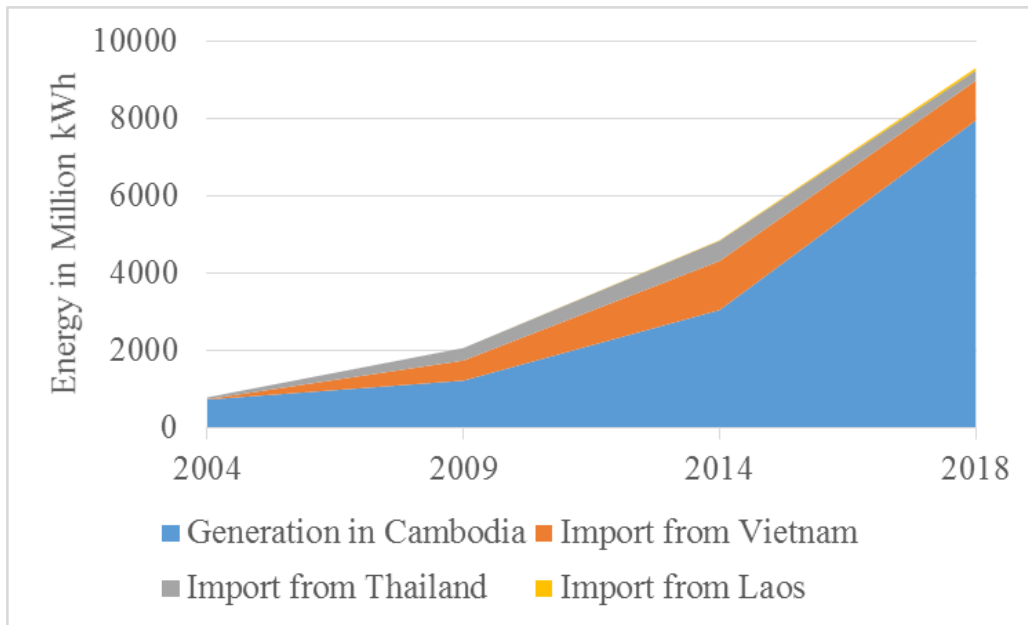
Note: Graph drawn using data from Electricity Authority of Cambodia (EAC) Annual

Report, various issues

Figure 2.3. Main Sources of Power in Cambodia, 2004 - 2014

Note: Graph drawn using data from Electricity Authority of Cambodia (EAC) Annual

Report, various issues

Figure 2.4. Gross Domestic Product (GDP) Annual Growth (%) and the Percentage of

Population with Access to Electricity, 1994-2018
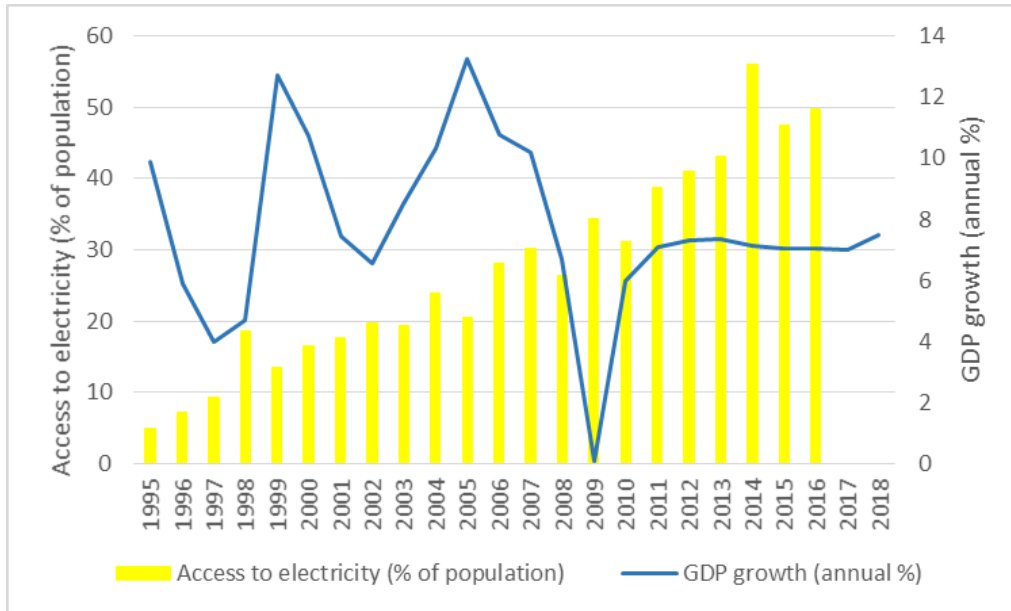
Note: Graph drawn using data from World Development Indicators, various issues

Figure 2.5. Percentage of Population with Access to Electricity and Sectoral Share of

Gross Domestic Product in Asia, 2016

Panel A: Agriculture
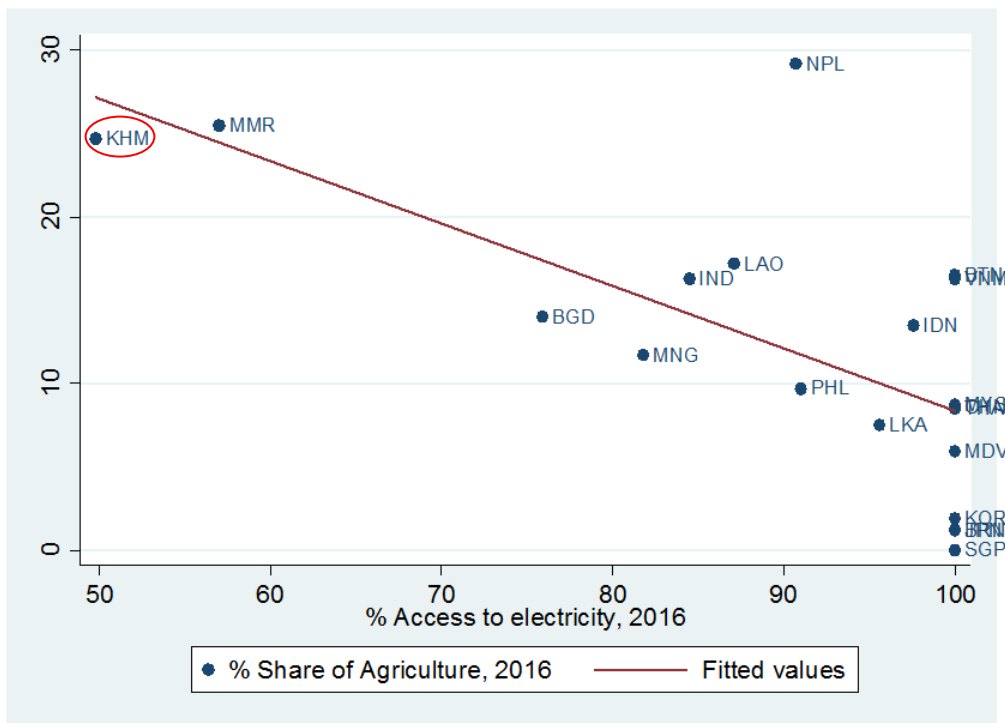
Note: Graph drawn using data from World Development Indicators

Panel B: Industry
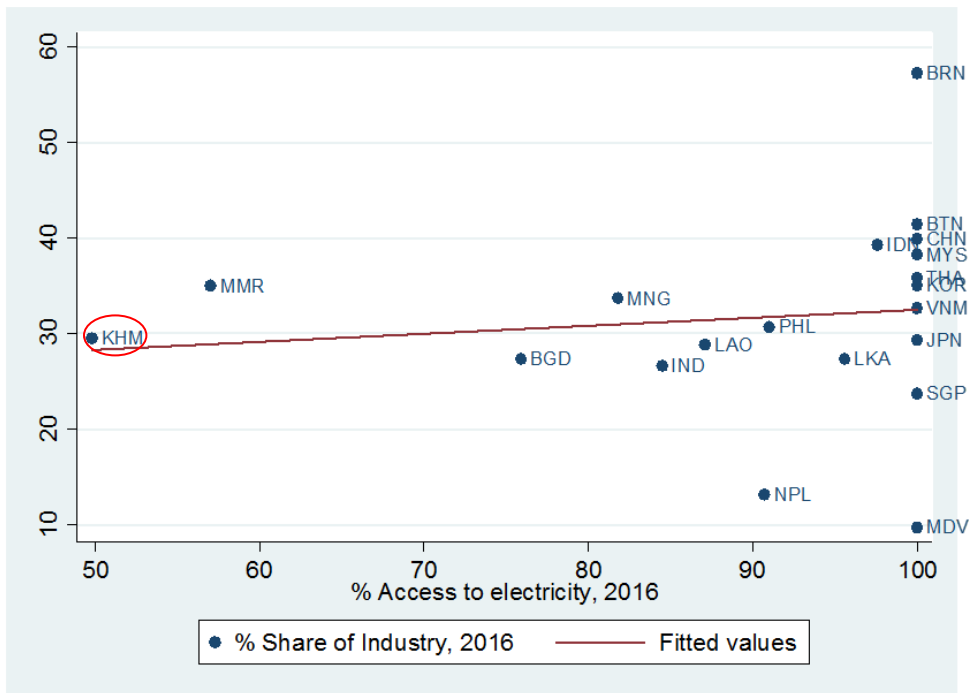
Note: Graph drawn using data from World Development Indicators

Panel C: Service
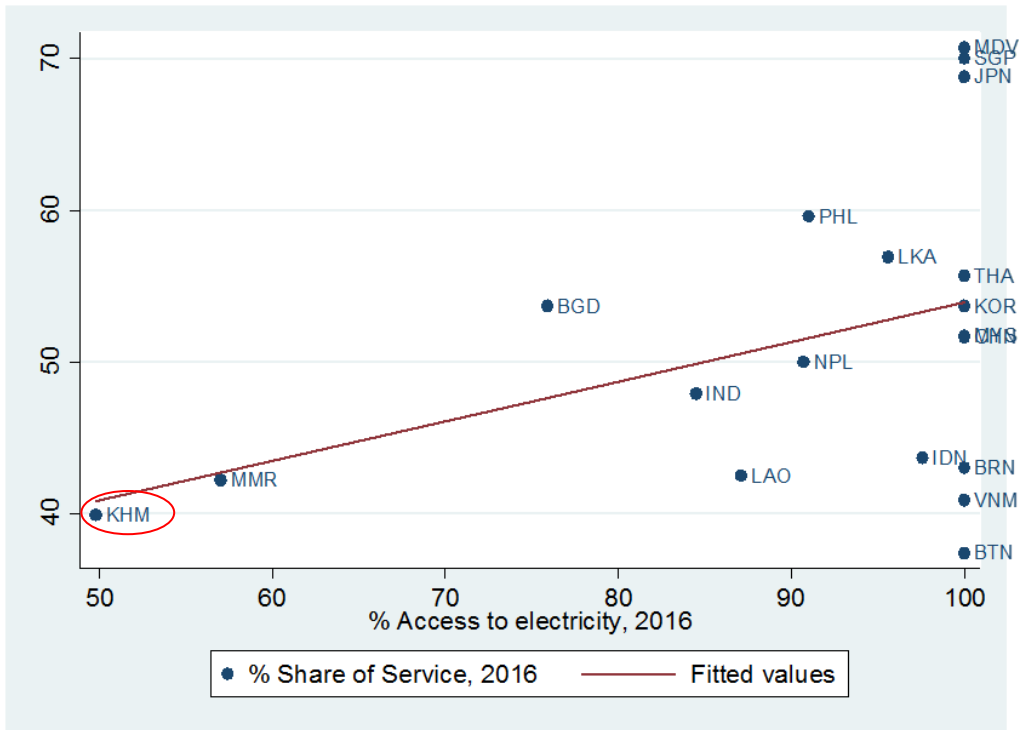
Note: Graph drawn using data from World Development Indicators

Figure 2.6. Map of Electricity Project Areas in Cambodia
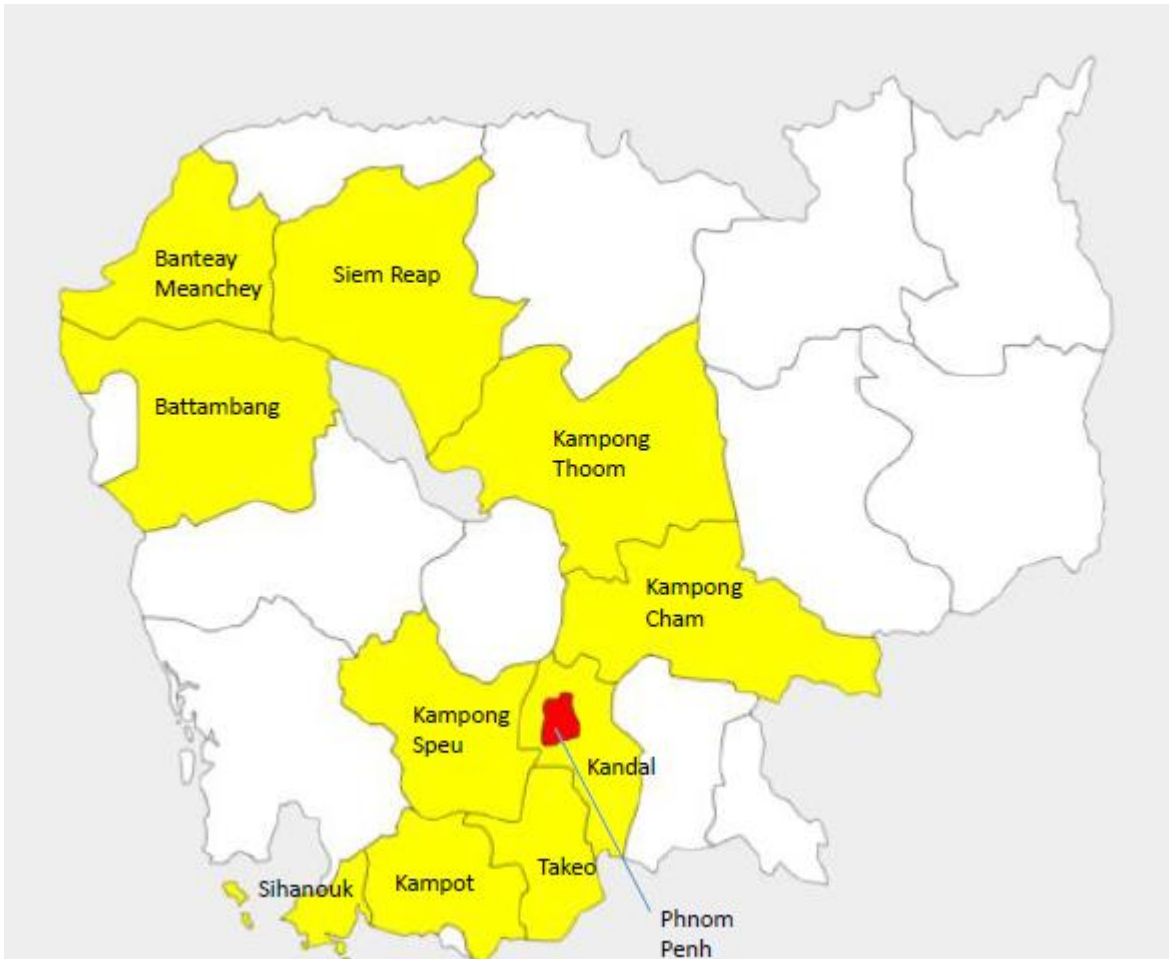
Figure 2.7. Monthly Household Income in USD PPP in Cambodia, 2004 - 2017
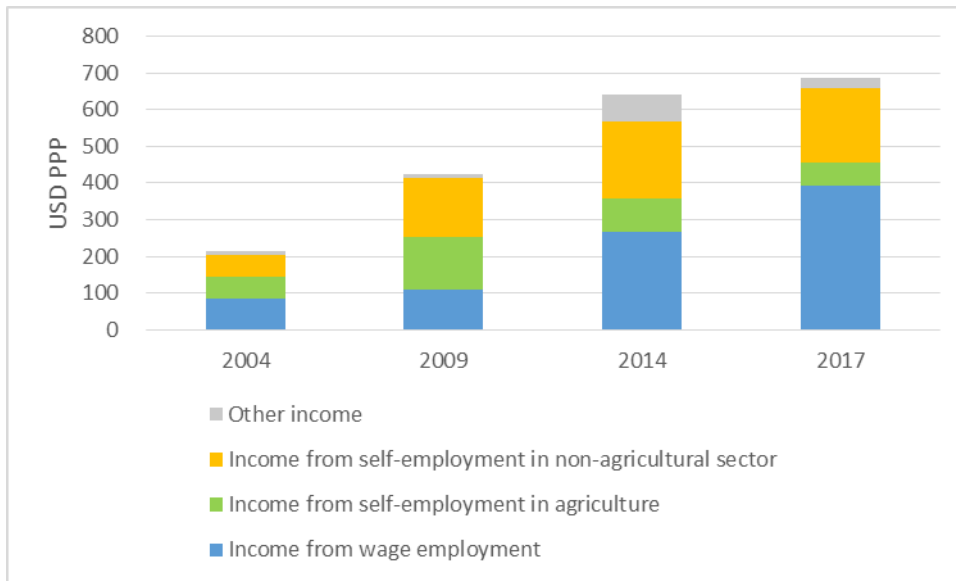
Source: Author's calculations, using data from the Cambodia Socio-Economic Survey

(CSES) for various years

Figure 2.8. Monthly Household Income in Phnom Penh and Urban and Rural areas

(USD PPP)
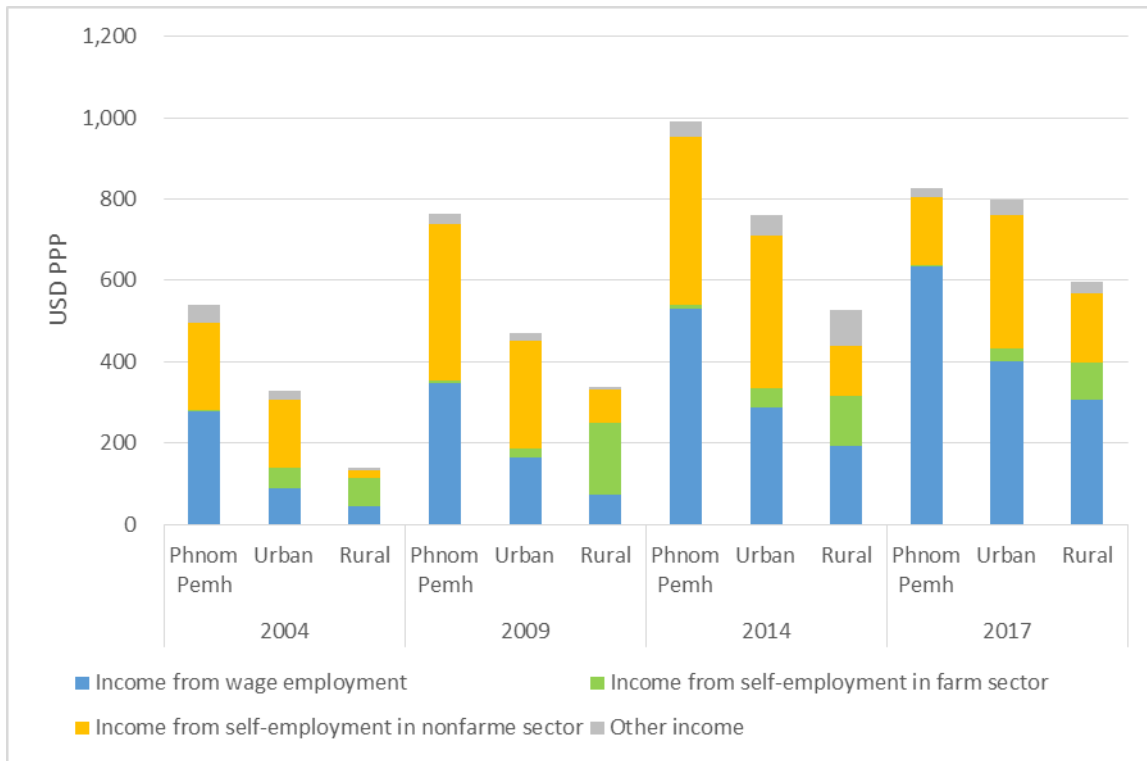
Source: Author's calculations from the Cambodia Socio-Economic Survey (CSES) various

years

Figure 2.9. Cambodia's Exports by Sector in Manufacturing, 1997-2015
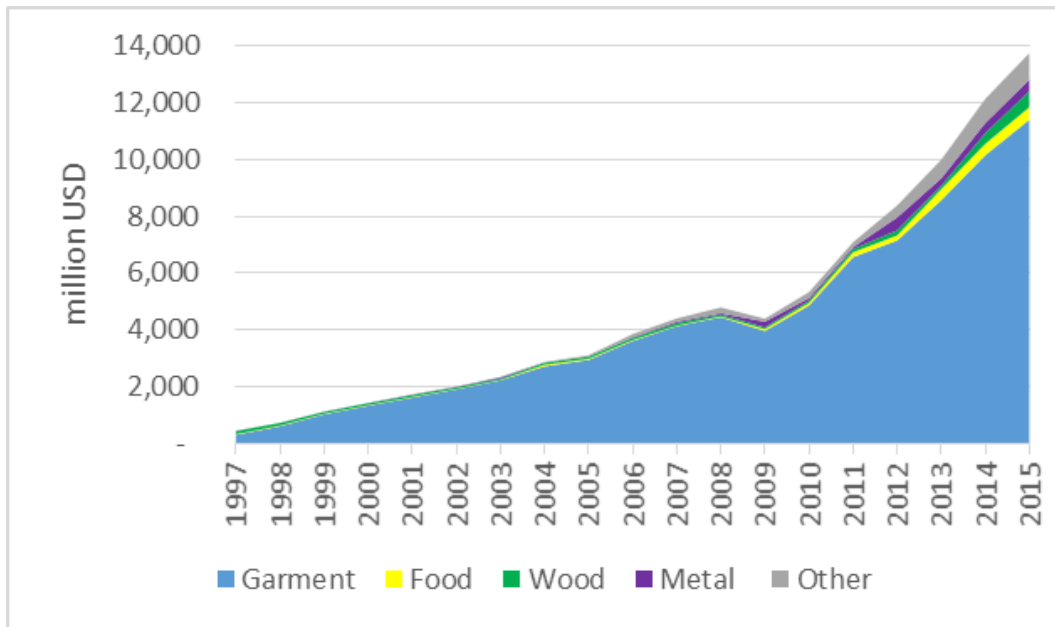
Source: Author's calculation using data from UN COMTRADE

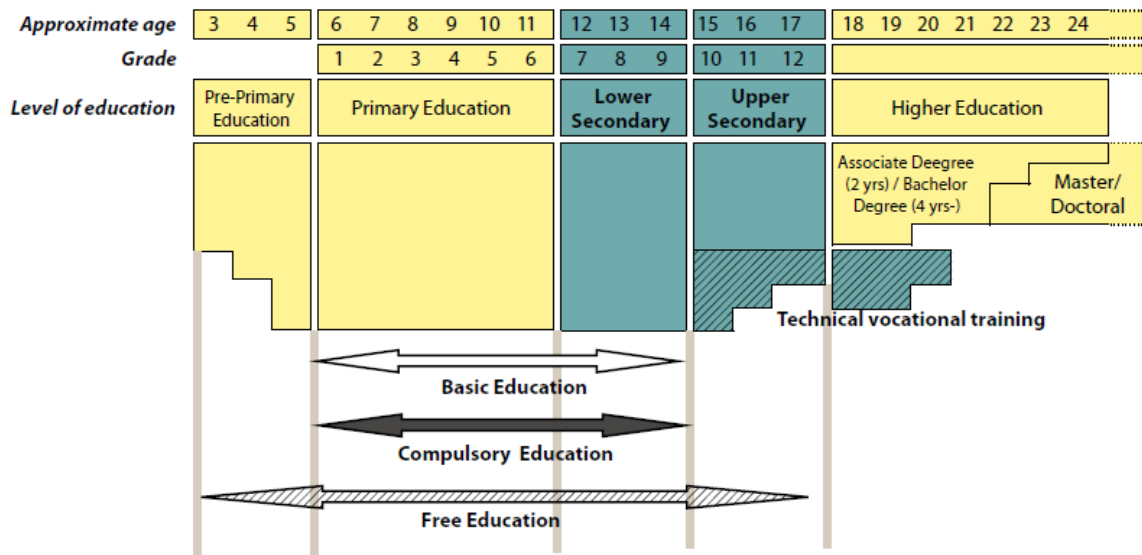**Figure 2.10 Electricity Network and Electricity Substation Points in Cambodia**

Source: Open Development Cambodia (ODC)

**Figure 3.1. Conceptual Framework of How Electrification Affects Child Education**
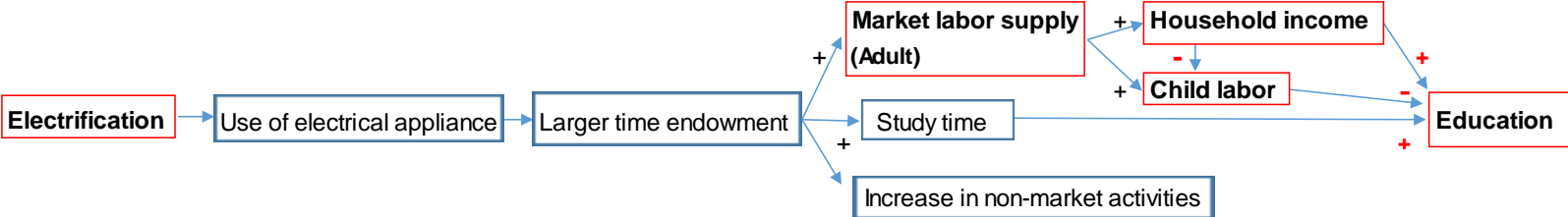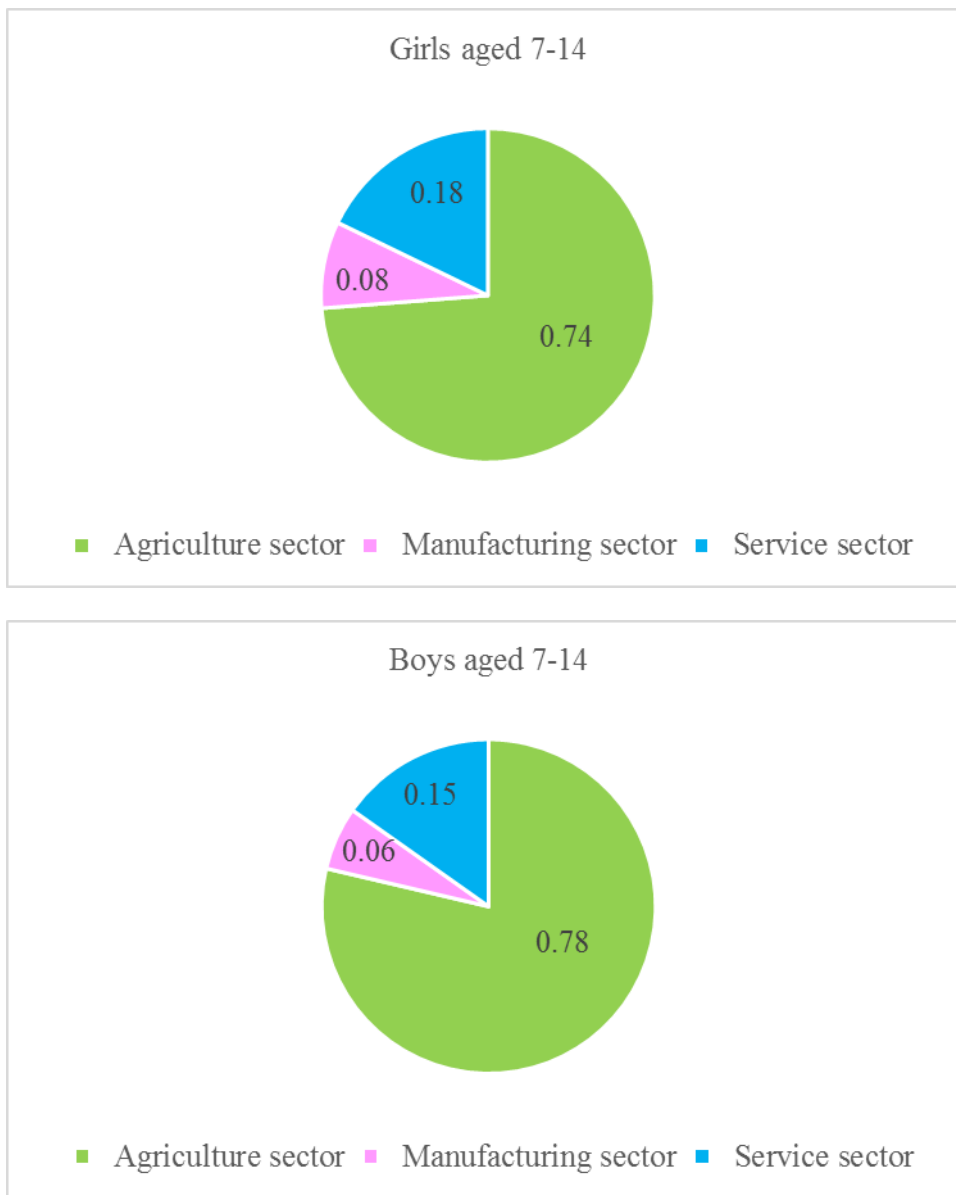
Figure 3.2. Education Structure in Cambodia

Approximate age	3 4 5	6 7 8 9 10 11	12 13 14	15 16 17	18 19 20 21 22 23 24
Grade		1 2 3 4 5 6	7 8 9	10 11 12	
Level of education	Pre-Primary Education	Primary Education	Lower Secondary	Upper Secondary	Higher Education

Associate Deegree (2 yrs) / Bachelor Degree (4 yrs-)   Master/ Doctoral

Technical vocational training

Basic Education

Compulsory Education

Free Education

Source: UNESCO (2008)

179

Figure 3.3. Proportion of Children who go to School / Engage in Economic Activities in Cambodia
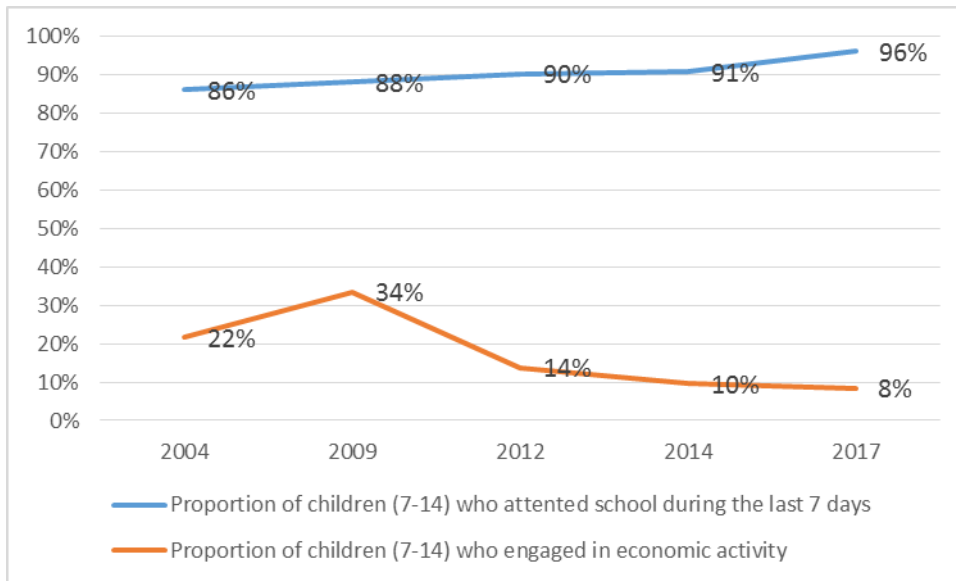
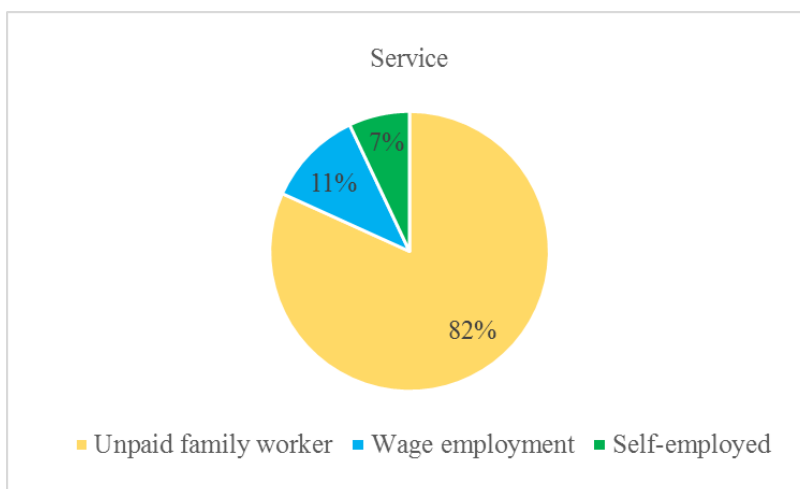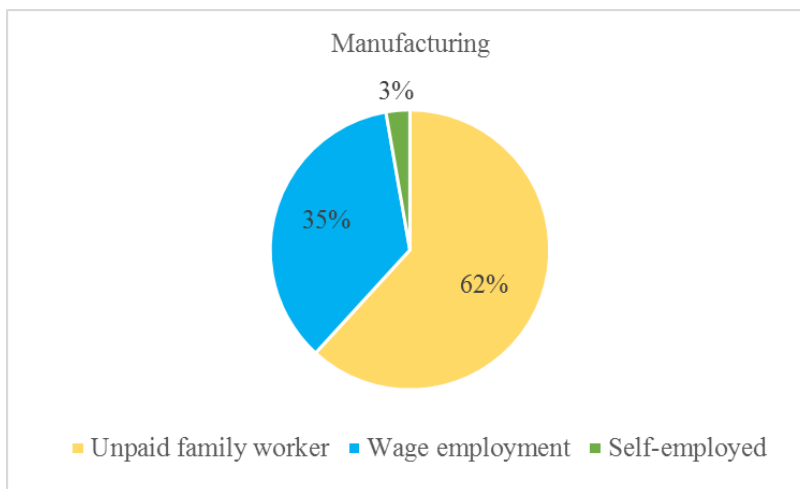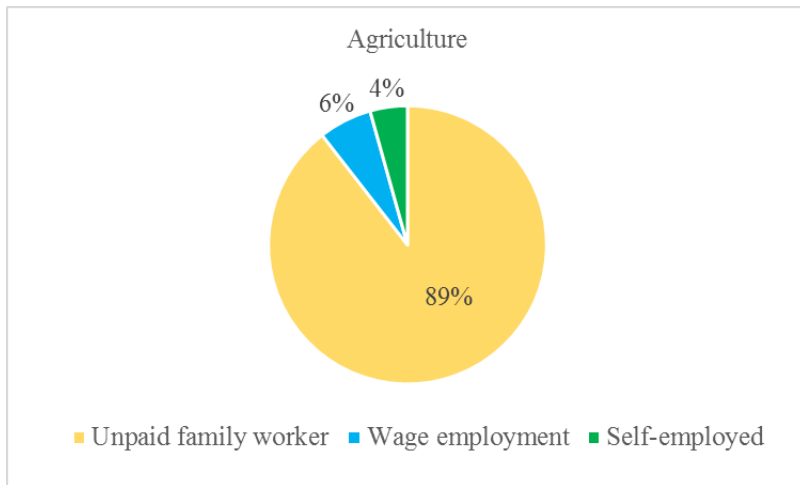Source: Author's calculations from the Cambodia Socio Economic Survey data from various years and CLFS (2012)

Figure 3.4. Industry Share of Children in Employment by Gender in Cambodia

Girls aged 7-14

- Agriculture sector ▪ Manufacturing sector ▪ Service sector

0.18
0.08
0.74

Boys aged 7-14

- Agriculture sector ▪ Manufacturing sector ▪ Service sector

0.15
0.06
0.78

Source: Author's calculations from the Cambodia Socio Economic Survey (CSES) data from various years

Figure 3.5. Employment Status by Sector in Cambodia

Agriculture

- 6% Wage employment
- 4% Self-employed
- 89% Unpaid family worker

Unpaid family worker ■ Wage employment ■ Self-employed

Manufacturing

- 3% Self-employed
- 35% Wage employment
- 62% Unpaid family worker

Unpaid family worker ■ Wage employment ■ Self-employed

Service

- 7% Self-employed
- 11% Wage employment
- 82% Unpaid family worker

Unpaid family worker ■ Wage employment ■ Self-employed
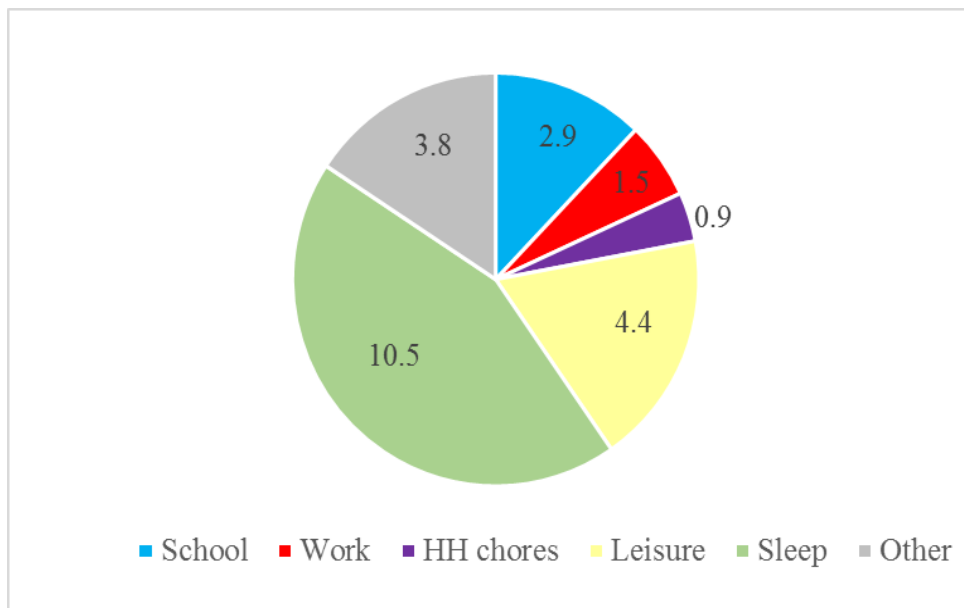
Figure 3.6. Children's Time Use by Electricity Status in Cambodia

1) Children in electrified houses
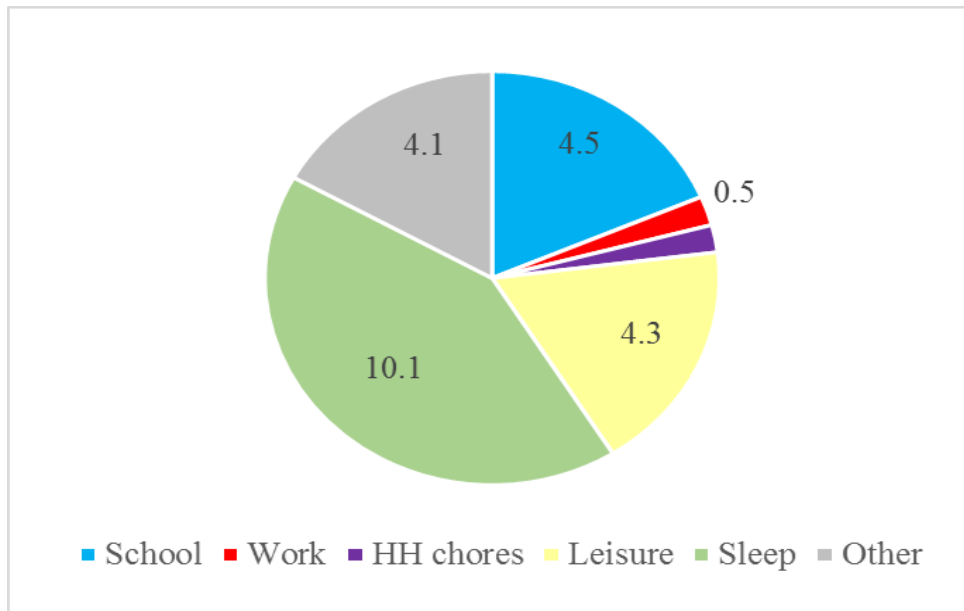
2) Children in non-electrified houses

Source: Author's calculation from Cambodia Socio Economic Survey (CSES) 2004