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Theresa Pieper, Thanh Tung Nguyen, and Matin Qaim

Access to Electricity and Gendered Labor Allocation: Insights from Ethiopia

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Zentrum für Entwicklungsforschung (ZEF)
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Genscherallee 3
D – 53113 Bonn
Germany
Phone: +49-228-73-1861
Fax: +49-228-73-1869
E-Mail: zef@uni-bonn.de
www.zef.de

The authors:

Theresa Pieper, Center for Development Research (ZEF), University of Bonn, Germany. Contact: theresa.pieper@uni-bonn.de
Thanh Tung Nguyen Center for Development Research (ZEF), University of Bonn, Germany. Contact: tnguyen3@uni-bonn.de
Matin Qaim, Center for Development Research (ZEF), and Institute for Food and Resource Economics, University of Bonn, Germany. Contact: mqaim@uni-bonn.de

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Abstract

Electrification typically promotes economic development and enhances household wellbeing. However, how electrification affects the economic activities of different demographic groups is not yet sufficiently understood. Focusing only on aggregate household-level outcomes may overlook unequal effects on different individuals, which may potentially result in intra-household inequities. Here, we use panel data from Ethiopia to analyze the implications for different groups of individuals. Specifically, we analyze how electrification is associated with labor time allocation of male and female adults, children, and elderly household members. For adults, we find that electrification is positively associated with off-farm working hours and negatively associated with time spent on own farming activities and unpaid housework such as firewood and water fetching. For working-age women, the positive association with the time spent on off-farm activities is particularly large. For children, most of the associations are not statistically significant, even though electrification seems to increase boy's time allocation to own farming activities, possibly substituting for some of the reduced adult time spent on farming. Differentiating between sources of electricity, we find that the effects are typically larger for grid than for off-grid solar electricity. Our results suggest that electrification is economically beneficial and can promote more gender-equitable labor outcomes.

Keywords: Grid electrification, Solar off-grid electrification, Household labor allocation, Gender, Ethiopia

JEL Codes: D13, J16, J22, Q40, Q42

1. Introduction

Electrification often plays a critical role in improving labor productivity and promoting economic growth (IEA, 2024a). Despite these benefits, access to electricity remains limited in many low- and middle-income countries. Globally, around 700 million people are still without electricity, most of them residing in sub-Saharan Africa (IEA, 2024b). Accordingly, providing universal, reliable, sustainable, and affordable access to electricity is a central objective of the United Nations' Sustainable Development Goal 7 (UN, 2024). Electrification is also assumed to play an important role in the structural transformation of rural areas by promoting a shift from farm to non-farm work (Gibson and Olivia, 2010; Chhay and Yamazaki, 2021). However, the benefits of electricity may not be equally shared by all individuals and groups. For instance, it remains unclear how electrification may influence gender disparities in labor outcomes. In this article, we analyze the implications of electrification for different groups of male and female individuals.

A number of studies examine the gendered effects of electrification on the labor allocation of working-age individuals, yet the results remain inconclusive. On the one hand, van de Walle et al. (2015) find that in India electrification leads to an increase in men's labor supply, particularly through higher participation in casual wage labor, while it has no significant effect on women's labor supply. Similarly, Salmon and Tanguy (2016) find that in Nigeria electrification does not result in increased income-generating work hours for women, due to intra-household bargaining dynamics that prioritize their husbands' work time. On the other hand, studies in South Africa and Nicaragua show that electrification enhances the likelihood of female employment without affecting male employment (Dinkelman, 2011; Grogan and Sadanand, 2013). Also in Guatemala, electrification increases the amount of time women spend on income-generating work (Grogan, 2018).

We contribute to this literature on electrification and gendered labor allocation in several ways. First, we add empirical evidence from a setting in sub-Saharan Africa where many households and individuals are still involved in subsistence-oriented farming activities. It is likely that the effects differ by context, depending on economic and cultural factors. Recent studies emphasize the need for more studies to better understand the gender implications of electrification under various conditions (Leduchowicz-Municio et al., 2023; Beyene et al., 2024).

Second, while existing studies with individual-level data focus primarily on working-age men and women, we additionally look at children and the elderly. This is particularly important in the context of low-income countries, where children and the elderly are often engaged in labor activities (ILO, 2017; WHO, 2024).

Third, whereas much of the existing research focuses primarily on the effects of electrification on off-farm employment (Dinkelman, 2011; Grogan, 2018; Rathi and Vermaak, 2018; Pelz et al., 2023), we also look at the effects on own farming activities and unpaid household work. In rural sub-Saharan Africa, own farming and unpaid household work often make up a large part of people's daily time allocation, especially for women, so a focus on off-farm activities alone is insufficient to understand possible gender dynamics.

Fourth, while previous research predominantly focuses on grid-based electrification (exceptions are Kannan and Bessette (2023) and Beyene et al. (2024)), we differentiate between grid and off-grid sources of electricity. Especially in rural areas of sub-Saharan Africa, where grid connections are still patchy, off-grid solar solutions may be an important element to achieve universal electrification, but the implications are not yet sufficiently understood.

Our empirical analysis refers to Ethiopia. We use nationwide household-level and individual-level panel data covering the period 2011-2022. Ethiopia is an interesting study country due to its rapid recent electricity expansion. Currently, 55% of the population in Ethiopia is electrified, yet with large differences between urban and rural areas (World Bank, 2024a, World Bank, 2024b). Furthermore, Ethiopia explicitly includes off-grid technologies in its strategy to achieve universal electrification (MoWIE, 2019)[1]. Grid electrification typically provides higher capacity access (Bhatia and Angelou, 2015), whereas off-grid solutions only offer lower capacity access, often limited to powering a single lightbulb or charging a mobile phone (Padam et al., 2018). Regarding Ethiopia's labor market, while most of the employment is concentrated in the agricultural sector (World Bank, 2024c), many households diversify their income through off-farm activities (Musungu et al., 2024). Although the majority of women is economically active (World Bank, 2024d), traditional gender roles persist. Specifically, women in Ethiopia allocate much more time than men to unpaid work such as household chores and childcare (Getahun and Mekonnen, 2024).

The remainder of this article is organized as follows. Section 2 provides a conceptual framework, laying out the different channels identified in the literature through which electricity might influence male and female time use. Based on these channels, we develop a few concrete research hypotheses. Section 3 describes the empirical strategy including the data and the statistical methods used. In section 4, we present the results, whereas section 5 concludes with a set of concrete research and policy recommendations.

[1] The National Electrification Program has set the ambitious goal of universal electrification by 2025. Sixty-five percent of the required connections shall be made via the national grid, with the remainder being provided by off-grid technologies (MoWIE, 2019). Off-grid technologies involve primarily small solar appliances and home systems. In 2017, only 0.1% of the population used mini-grids or generators as their source of electricity (Padam et al., 2018). Off-grid electrification is considered a preliminary development step in Ethiopia; the government seeks to achieve a grid-coverage of 96% by 2030 (MoWIE, 2019).

2. Conceptual Framework

The literature identifies several channels through which electrification may influence the labor allocation of households and individuals (Figure 1). One key factor is electric lighting, which allows people to pursue certain economic activities also after sunset. Moreover, electric light extends the time available for productive use by shifting leisure and domestic work into the evening, thereby freeing daylight hours for farm and off-farm work (Dinkelman, 2011; Khandker et al., 2013; Van de Walle et al., 2015; Peters and Sievert, 2016; Rathi and Vermaak, 2018; Beyene et al., 2024). In fact, the availability of electric light was shown to alter the labor allocation in households, even in the absence of direct productive uses of electricity (Grogan and Sadanand, 2013).

A second channel mentioned in the literature is the use of electric appliances, which often increase labor productivity. The adoption of appliances for tasks such as manufacturing, food processing, and other activities can foster the establishment and expansion of off-farm enterprises (Peters and Sievert, 2016). This might even play a role in areas with lower-tier electrification, as medium-load appliances, such as refrigerators and food processors, typically require only tier-three electricity access, which can be provided also by many solar home systems (Bhatia and Angelou, 2015)[2].

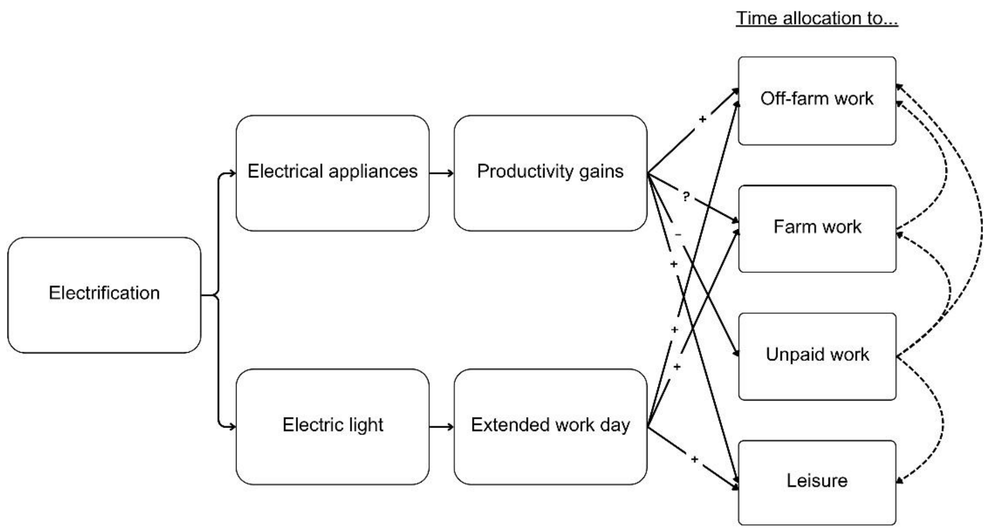

Figure 1: Channels of influence between electrification and labor allocation
Source: Authors' illustration

[2] The World Bank categorizes electricity access based on capacity, reliability, affordability, quality, and availability. Access is categorized into five tiers, from tier 1, providing enough energy to power one lightbulb, to tier 5, which allows for general lighting and continuous use of high-power domestic appliances (Bhatia and Angelou, 2015).

More generally, electricity might enhance local economic conditions and thus create off-farm employment opportunities. There is substantial evidence that access to electricity contributes to increased household incomes (Khandker et al., 2013; Rathi and Vermaak, 2018), although some studies find only modest effects (Lenz et al., 2017). Gains in household incomes could stimulate local demand for various types of goods and services, thereby also increasing the demand for labor (Peters and Sievert, 2016; Fried and Lagakos, 2021).

Electricity may lead to productivity gains in all economic sectors, including agriculture. For instance, electric irrigation, whether grid- or solar-powered, was shown to be relevant in Ethiopia (Fried and Lagakos, 2021). Furthermore, the use of mobile phones improves farmers' access to information and extension, thus contributing to agricultural productivity gains in some situations (Rajkhowa and Qaim, 2021; Amuakwa-Mensah and Surry 2022). However, the productivity effects of electricity in agriculture may be smaller than those in other sectors, where electrical appliances often play a more important role. Greater productivity gains in non-agricultural sectors may mean that people shift some of their time from farm to off-farm work, which would imply that electrification possibly contributes to structural transformation of the local economy (Chhay and Yamazaki, 2021; Gaggl et al., 2021).

Electrical appliances might also affect the time allocated to unpaid household work. Household appliances – such as refrigerators, washing machines, microwaves, water heaters, and cookstoves – often reduce the time needed for household chores. Due to prevailing traditional gender roles, such time savings might predominantly affect women, allowing them to be more involved in income-generating activities (Dinkelman, 2011; Rathi and Vermaak, 2018; Beyene et al., 2024). In particular, the use of electricity for cooking may not only reduce the time required for preparing food but also the time for fetching firewood. Further, electric pumps for domestic water use can decrease the time required for water collection. Fried and Lagakos (2021) confirm that after electrification, villages in Ethiopia are more likely to have access to tap water. However, electricity may not reduce the unpaid work burden everywhere. For example, Kannan and Bessette (2023) find that women in Zambia actually increase their time spent on cooking with electrification.

Lastly, it is worth mentioning that both longer days with light and improved productivity could also translate into increased time spent on leisure. Electricity tends to increase the marginal value of free time due to appliances such as TVs, radios, and mobile phones. Empirical evidence for increased ownerships and use of leisure appliances in electrified households exists for various countries (Barron and Torero, 2014; Grogan, 2018).

Based on the different channels of influence, we propose the following hypotheses:

Hypothesis 1: Electricity increases the time allocation of working-age adults, both men and women, to income-generating work. While increases in farm and off-farm work are possible in principle, we expect larger increases in off-farm work, given that electricity may increase off-farm productivity more than farm productivity.

Hypothesis 2: Electricity decreases the time spent on unpaid household work, and – given traditional gender roles – this effect is particularly pronounced for women.

Hypothesis 3: The effects of electricity on labor allocation are similar for working-age adults and elderly individuals above 64 years of age. However, given that the elderly generally provide fewer working hours, smaller effects are expected for this group.

Hypothesis 4: Electricity does not affect the work time of children. Even though effects on child labor are possible in principle, we do not expect them, as schooling is compulsory in Ethiopia (World Bank, 2024e).

Hypothesis 5: The effects of grid electrification are larger than those of off-grid solar electrification.

3. Empirical Strategy

3.1 Data

We use data from the Ethiopian Socioeconomic Survey (ESS), collected by the World Bank and the Ethiopian Central Statistical Agency between 2011 and 2022 (LSMS-ISA). The dataset consists of two non-overlapping panels, one including three survey waves conducted in 2011-2012 (CSA and LSMS Team, 2014), 2013-2014 (CSA and LSMS Team, 2015), and 2014-2015 (CSA, 2017); and the other including two survey waves conducted in 2018-2019 (CSA, 2020) and 2021-2022 (ESS, 2023). Both panels are unbalanced. Specifically, households in large towns (>10,000 inhabitants) were not included in the first wave, while households in the Tigray region were not surveyed in the fifth wave due to ongoing conflicts. As a result, Panel 1 is representative of rural areas and small towns in the first wave, and nationally representative in the second and third wave. Panel 2 is nationally and regionally representative, except for the fifth wave where Tigray region is missing.

The survey questionnaires in both panels were very similar. The data include detailed socioeconomic information at the household and community levels, including farm and off-farm economic activities, food and non-food consumption, and electricity use. Furthermore, sociodemographic details of all individuals living in the sample households, and daily time use data for all household members above the age of 7 years, are also included.

We use all household- and individual-level observations from the five survey waves for which time-use data are available, including rural and urban areas. Observations with missing data for relevant variables or with unreasonably high values for particular time uses are excluded. Furthermore, to take advantage of the panel structure, we exclude households and individuals that were only included in one of the survey waves. This results in a pooled total sample of 22,257 household-level observations and 68,105 individual-level observations stemming from 9,590 different households.

3.2 Regression models

We estimate the effects of electrification on time allocation to different activities using panel data regression models. During the study period, a significant increase in electrification was observed in Ethiopia, offering a favorable context for evaluating the effects of electrification using differencing techniques. Nevertheless, identifying the causal effects on time-use outcomes is complicated due to multiple sources of endogeneity. First, village-level selection bias may occur if decisions on the rollout of electricity infrastructure are systematically linked to socioeconomic and political factors that may also influence local economic development through other mechanisms. Second, household-level selection bias may be relevant if electricity uptake is linked to the household socioeconomic status.

To address these issues, we employ panel data models with time and unit fixed effects. Such fixed effects models enables us to control for time-invariant unobserved heterogeneity, which is a clear advantage. However, fixed effects models do not control for time-variant unobserved heterogeneity which is why some endogeneity bias may remain (Wooldridge, 2010). We therefore interpret our estimates primarily in terms of associations and do not claim that they are rigorously identified in a causal sense.

Our analysis includes regression models at household and individual levels. The household is typically the primary unit of labor decision-making (see e.g. Chiappori, 1992), meaning that the household-level estimates provide valuable insights into the overall changes in labor allocation driven by electrification. In contrast, the individual-level estimates may provide a deeper understanding of distributional shifts and potential labor reallocations within the household.

The household-level models are specified as follows:

$$Y_{ht} = \beta_0 + \beta_1 E_{ht} + \beta_2 \mathbf{X}_{ht} + \delta_h + \zeta_t + u_{ht} \tag{I}$$

where Y_{ht} is the labor allocation to a particular activity of household h in time period t. Labor allocation to each activity is calculated as the sum of the daily time allocated by all household members to this activity expressed in minutes. We estimate separate models for each activity of interest. In particular, we consider (i) work on the own farm, (ii) off-farm self-employment in own non-agricultural businesses, (iii) off-farm wage work, as well as unpaid work in terms of (iv) fetching firewood and (v) fetching water. Note that detailed data on time allocation to other household chores are not available.

In equation (I), E_{ht} denotes whether or not the household is electrified. This classification is based on the household's primary source of lighting, where E_{ht} takes a value of one if the household uses any form of electricity for lighting, and zero otherwise. Correspondingly, β_1 represents the main coefficient of interest. The model additionally includes a vector of household-level controls (X_{ht}), such as household composition, wealth, infrastructure conditions, and experience of various types of shocks during the last 12 months (see Table A1 in the Appendix for a full list of control variables). δ_h represents household fixed effects, ζ_t stands for time fixed effects, and u_{ht} denotes the idiosyncratic error term.

To analyze possible differences in effects by source of electricity, we further estimate the following models:

$$Y_{ht} = \alpha_0 + \alpha_1 Eg_{ht} + \alpha_2 Es_{ht} + \alpha_3 \mathbf{X}_{ht} + \delta_h + \zeta_t + u_{ht} \tag{II}$$

where we use two separate electrification dummies, one for grid electricity (Eg_{ht}), and the other for off-grid solar electricity (Es_{ht}). These two dummies are mutually exclusive, and other sources of electricity are negligible in this context of Ethiopia. The other variables are as defined above. Here, we are particularly interested in the coefficients α_1 and α_2.

Beyond these household-level models, we estimate models at the individual level as follows:

$$Y_{iht} = \gamma_0 + \gamma_1 E_{ht} + \gamma_2 \mathbf{X}_{ht} + \gamma_3 \mathbf{Z}_{iht} + \delta_{ih} + \zeta_t + \varepsilon_{iht} \quad \text{(III)}$$

where Y_{iht} is the labor allocation to a particular activity of individual i in household h and time period t, measured in minutes per day. In addition to the electricity variable (in separate regressions, we also differentiate between source of electricity) and household-level controls, we also control for relevant individual-level factors that may influence time allocation, such as age, literacy, health, and marital status (Z_{iht}), and for unobserved individual-level fixed effects (δ_{ih}).

Equation (III) is estimated separately for male and female individuals in three age groups, namely children aged 7 to 14, working-age adults aged 15 to 64[3], and elderly individuals 65 and above. Note that for elderly women the sample size gets relatively small, so the estimates for this group should be interpreted with some caution. For children, wage work is rarely observed in our sample, which may be due to underreporting, as child wage work is formally not allowed.

3.3 Robustness checks

We carry out several robustness checks in order to test how sensitive our results are to specific characteristics of the data and modeling approaches used. First, we re-run the regression models with modified samples. As explained, the data are not fully representative of Ethiopia in all of the survey waves; in wave 1, large towns were not included, while in wave 5, Tigray region is missing. We do not expect that these data characteristics cause any bias in our fixed effects estimates because the location of households and individuals is time-invariant and therefore not expected to be correlated with the idiosyncratic error term (Wooldridge, 2013). Nevertheless, to check the robustness of the estimates, we run alternative regressions in which we exclude observations from large towns and from Tigray in all survey waves.

Second, we estimate the models with two separate panels. As explained, the five survey waves of the ESS data consist of two non-overlapping panels, namely Panel 1 (waves 1-3) and Panel 2 (waves 4-5). In the main analysis, we treat the five waves as a single combined sample to enhance statistical power. We do not expect that this leads to any bias, as both panels were sampled randomly, meaning that there should be no systematic factors, other than the year, that determine why a particular household was surveyed in the first or second panel. Since we include time fixed effects in all models, correlation with the idiosyncratic error term is not expected. Nevertheless, we test the robustness of the estimates by running the analysis separately for the two panels.

Third, we provide results from a staggered difference-in-differences (DID) approach with regression adjustment (Callaway and Sant'Anna, 2021), which has certain statistical advantages for data where the treatment (electrification in our case) is rolled out sequentially.

[3] Children over the age of 14 are considered working-aged individuals, as the legal working age in Ethiopia is set at 15 (UNICEF, 2020).

However, there are also reasons why we do not use this DID approach for the main analysis. In particular, DID models rely on the stable unit treatment value assumption that requires no spillover effect from the treatment on the control group, which may not hold for household electrification (Khandker et al., 2013). Further, in the DID approach, observations that were already treated in the baseline wave (which, due to our two panels, means waves 1 and 4), observations that are always treated, and observations from households reporting electricity access in one year but not in a subsequent year are excluded from the analysis. This leads to the loss of about half of all households in our sample, and thus much lower statistical power. However, for a robustness check, the DID approach may be useful.

Fourth, in alternative estimates we account for possible error term correlation between the time use models for different activities by using the seemingly unrelated regression (SUR) approach developed by Zellner (1962). In the SUR approach, we control for time fixed effects, but we cannot control for unit fixed effects (household or individual), which means that unobserved heterogeneity may be an issue. This is why we use the SUR approach as a robustness check and compare with our main results where we include both time and unit fixed effects.

4. Results

4.1 Descriptive Results

Figure 2 illustrates the proportion of households with access to grid and solar electricity. Levels of electrification in Ethiopia increased substantially during the study period, with grid electricity consistently exceeding off-grid solar electricity. Note that the grid electricity rate of 17% in 2011 is an underestimate for Ethiopia as a whole because large towns were not included in this first survey wave. Between 2013 and 2015 grid electrification stagnated, which may be attributable to structural challenges in the national electricity sector, including the splitting up of the Ethiopian Electric Power Company in 2013 and strategic changes in the government's industrial policy (Lavers and Gebresenbet, 2024)[4]. After 2015, grid electrification showed a steady increase. Off-grid solar electrification showed a steady increase over the whole period, and especially after 2013, which aligns with a time of falling global prices for solar equipment (Ritchie et al., 2023). Furthermore, national fiscal incentives, such as the exemption of solar products from customs duties since 2010 (ACE-TAF, 2022), and a scaling up of solar technology provision under the National Growth and Transformation Plans contributed to rising solar energy use by households (MoFED, 2010; NPC, 2016).

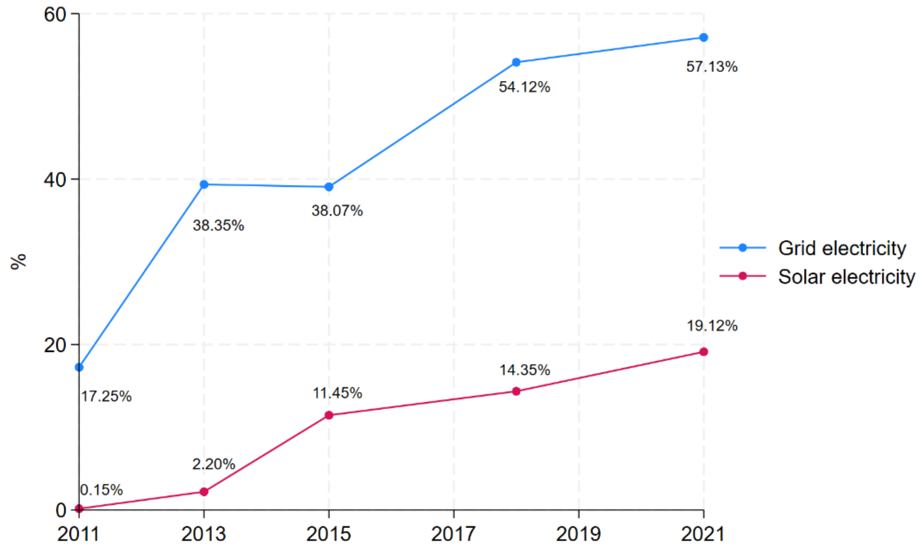

Figure 2: Share of households with electricity by energy source
Source: Authors' calculation using data from the ESS. The sample size varies by survey wave and ranges between 3351 and 4861 households.

[4] In 2013, the Ethiopian Electric Power Company was split into two companies, namely Ethiopian Electric Power and Ethiopian Electric Utility, with the first being responsible for generation and transmission lines of 66 kilovolts (kV) and above, and the latter for lines less than 66kV, including individual connections. This led to increased financial and coordination challenges (Lavers and Gebresenbet, 2024). Moreover, the government's industrial policy started focusing on the establishment of modern industrial parks, shifting the electrification focus from general grid expansion for mass electrification towards distribution and transmission for industrial parks (Lavers and Gebresenbet, 2024).

Table 1 compares characteristics of households with and without electricity in the pooled sample. Households with electricity are generally richer than those without. Among the electrified households, those with grid electricity are better-off than those with solar electricity. Additionally, electrified households, particularly those with grid connection, tend to have younger and better educated household heads. Some interesting locational patterns are also visible. Grid electrification is much more common among urban households, whereas no significant difference between rural and urban areas is observed for solar electrification. Also, grid-electrified households are less likely to own agricultural land than non-electrified or solar-electrified households. Finally, electrified households, and especially those with grid electricity, are located closer to roads than non-electrified households.

Table 1: Summary statistics

	No electricity	Grid electricity	Solar electricity
Annual consumption (Birr) [a]	9009.15	27109.8***	18663.86***
	(15852.2)	(32960.96)	(20138.25)
Literate HH head (proportion)	0.37	0.76***	0.44***
	(0.482)	(0.428)	(0.497)
Male HH head (proportion)	0.73	0.64***	0.79***
	(0.443)	(0.479)	(0.409)
Age HH head (years)	46.2	43.0***	45.6
	(15.32)	(14.92)	(14.71)
HH size (persons)	5.05	4.03***	5.24***
	(2.37)	(2.16)	(2.34)
No. of dependents (persons)	2.57	1.53***	2.53
	(1.77)	(1.49)	(1.78)
Living in rural area (proportion)	0.92	0.18***	0.91
	(0.269)	(0.388)	(0.280)
Having agric. land (proportion)	0.89	0.29***	0.91***
	(0.310)	(0.452)	(0.280)
Distance road (km)	42.88	9.42***	31.72***
	(60.15)	(25.10)	(46.12)
Distance market (km)	8.19	2.61***	8.43
	(16.97)	(18.66)	(19.69)
N	10,525	9,520	2,212

* p < .10, ** p < .05, *** p < .01, referring to tests of mean values between households of each electricity category and households with no electricity. Standard deviations are shown in parentheses. Authors' calculation using data from the ESS. The pooled sample includes observations from all survey waves. [a]Nominal annual consumption per adult equivalent. HH: household.

The average household time allocation to various activities regardless of electrification status is shown in Figure 3. The total labor time decreased considerably between 2011 and 2021[5]. The decrease in the time allocated to own farming activities is particularly noticeable.

[5] Note that in 2011 no households in large towns were surveyed, which affects the mean household size and also the time allocation. Figure 3 shows the sum of the time allocated by all household members. To make households of different sizes more comparable, we also divided the total time by the number of household members. This is shown in Figure A1 in the Appendix and supports the same conclusions.

Regarding off-farm work, while the time allocated to self-employed activities first decreased and then remained relatively stable since 2015, the time allocated to wage work increased significantly over time. For firewood and water fetching, the time allocation somewhat increased after 2013, which is not necessarily expected. However, it is possible that the ethnic tensions and civil conflict in several regions of Ethiopia – including Tigray, Oromia, Benishangul-Gumuz, Amhara, and Somali – which intensified over the study period (Admassu, 2019) may have complicated access to firewood and water for some households. Moreover, severe droughts in the eastern regions of Ethiopia between 2015 and 2018 may have played a role (NDRMC, 2018). As the total labor time of households declined, it is likely that more time was allocated to leisure activities and possibly also household chores and care work not fully captured in the survey data. Leisure activities may also include those related to electric appliances, such as TVs, radios, computers, and mobile phones (Conroy-Krutz et al., 2024; Motsaathebe and Chiumbu, 2021).

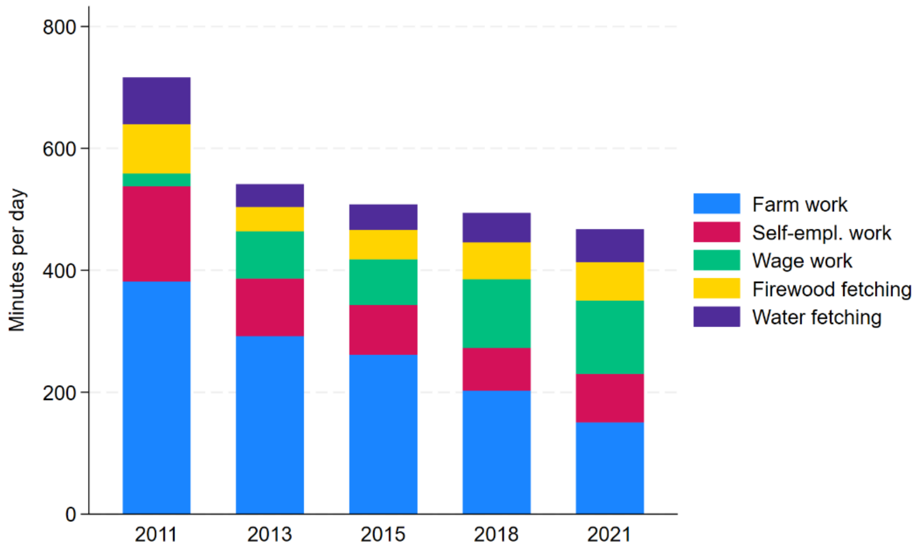

Figure 3: Daily household labor allocated to different work activities
Source: Authors' calculation using data from the ESS. The sample includes 3,351 households in wave 1, 4,861 households in wave 2, 4,733 households in wave 3, 4,656 households in wave 4, and 4,656 households in wave 5. Household daily time refers to the sum of daily minutes allocated by all household members above seven years of age to each activity.

Individual-level time allocation to the different activities is shown in Figure 4. As can be seen, the general decline in overall labor time is observed for all demographic groups[6]. The decrease in farm work and the simultaneous increase in off-farm wage work, particularly among working-age adults, indicate a structural shift in economic activities. Noticeable is also that working-age men spend more time on income-generating activities, while working-age women are more involved in unpaid work. These data suggest that the total working hours are higher for men than for women. However, this is likely due to the unavailability of time

[6] The only exceptions are working-age men and elderly individuals, for whom a slight increase in labor time between 2015 and 2018 is observed.

use data for other unpaid activities – such as cooking, cleaning, washing, and caregiving – which are predominantly performed by women. Finally, children and the elderly also contribute substantially to farm work and firewood and water fetching.

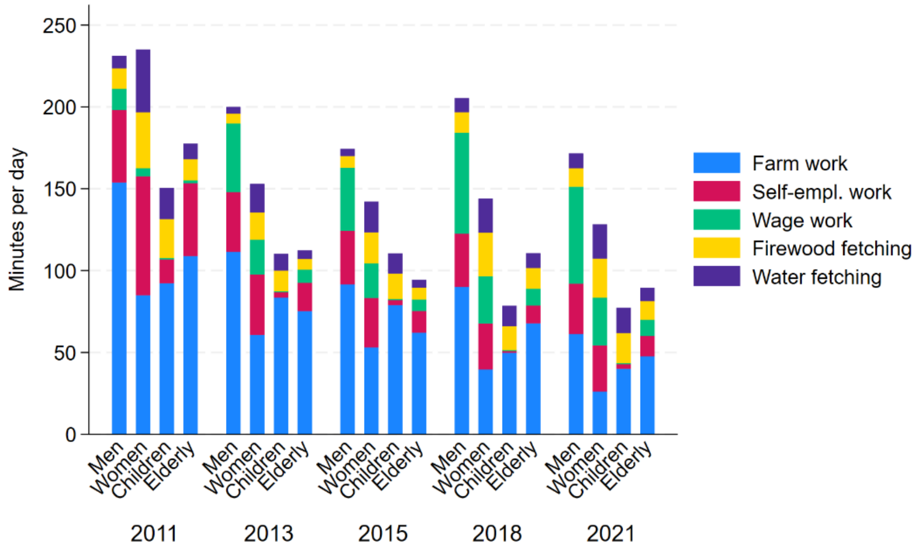

Figure 4: Daily individual labor allocation to different work categories
Source: Authors' calculation using data from the ESS. The sample includes 10,272 observations in wave 1 (3,102 men, 3,418 women, 3,252 children, 500 elderly), 15,949 observations in wave 2 (5,026 men, 5,552 women, 4,580 children, 791 elderly), 14,672 observations in wave 3 (4,937 men, 5,441 women, 3,422 children, 872 elderly), 13,606 observations in wave 4 (4,362 men, 5,045 women, 3,653 children, 546 elderly), and 13,606 observations in wave 5 (4,984 men, 5,589 women, 2,362 children, 671 elderly).

Figure 5 shows differences in time use patterns between individuals in electrified and non-electrified households. Adults, children, and elderly individuals in households with grid electricity allocate considerably more time to off-farm wage and self-employed activities than their counterparts in households without electricity or with solar electricity. Additionally, the elderly and children in grid-electrified households show lower overall work time, including both income-generating and unpaid work, than those in other households. Individuals in households with solar electricity show similar time use patterns as individuals in households without any electricity. Figure A2 in the Appendix shows a further disaggregation by survey waves with very similar patterns.

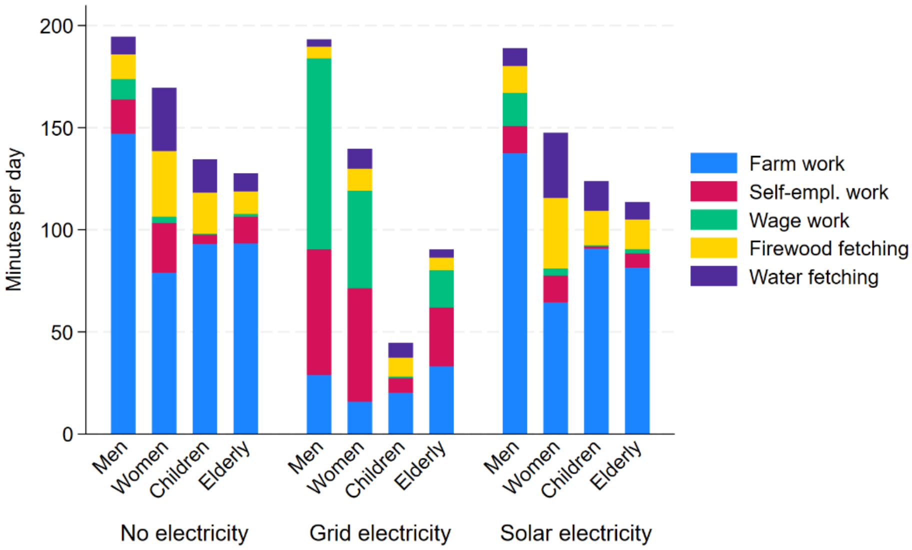

Figure 5: Daily individual labor allocated to different work activities by electrification status
Source: Authors' calculation using data from the ESS. Pooled sample including observations from all waves. The sample includes 34,602 observations from individuals in households without electricity (10,788 men, 11,754 women, 10,260 children, 1,800 elderly), 26,291 observations from individuals in households with grid electricity (9,181 men, 10,741 women, 5,136 children, 1,233 elderly), and 7,212 observations from individuals in households with solar electricity (2,442 men, 2,550 women, 1,873 children, 347 elderly).

4.2 Regression Results

4.2.1 Electrification and household labor allocation

The estimates for the associations between electrification and household labor allocation are presented in Table 2. Access to electricity is positively and significantly associated with the time allocated to off-farm self-employment. Electrified households spend around 20 minutes per day more on self-employed activities than households without electricity (Part 1). The association between electrification and off-farm wage work is positive but not statistically significant, which might be due to insufficient wage work opportunities, especially in rural Ethiopia (Musungu et al., 2024).

Turning to farm work, we find a significantly negative association with electrification. In particular, we find an estimated decrease in farm work time of 17 minutes on average, which is smaller than the estimated increase in off-farm work. This finding confirms our hypothesis that electrification leads to an increase in the time allocated to income-generating work, however, only due to increases in off-farm work and not farm work. The time reallocation from farm to off-farm work is in line with our hypothesis that electrification enhances productivity more in non-agricultural sectors than in agriculture. In this sense, electricity seems to contribute to structural transformation of the local economy.

For the time spent on firewood and water fetching, we find negative associations with electrification, even though the estimate is statistically significant only for water fetching. This finding is consistent with earlier research in Ethiopia, showing that electricity is not yet widely used for cooking purposes (Padam et al., 2018), while access to tap water is increasing with electrification in the country (Fried and Lagakos, 2021).

The lower part of Table 2 (Part 2) further disaggregates the estimates by source of electricity. The direction of the associations is mostly similar for both sources of electricity, but the absolute size of the associations is consistently larger for grid electricity than for off-grid solar electricity. Specifically, the association between electrification and the time allocated to off-farm self-employment is approximately twice as large in grid-electrified households than in solar-electrified households. Furthermore, the relationship between electrification and off-farm wage work is positive and statistically significant for grid-electrified households, but not for solar-electrified households. Grid electrification is negatively and significantly associated with the household time allocated to farm work, firewood fetching, and water fetching, whereas for solar electrification only the association with water fetching is statistically significant. These patterns are in line with our hypothesis that grid electrification has larger effects due to its greater capacity.

Table 2: Changes in household labor allocation associated with electrification

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Part 1: Total household minutes per day allocated to each activity					
Household Electricity	19.56***	4.557	-17.29*	-7.664	-12.01***
	(5.245)	(4.176)	(10.50)	(5.068)	(3.735)
Controls	Yes	Yes	Yes	Yes	Yes
N	22257	22257	22257	22257	22257
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
Part 2: Total household minutes per day allocated to each activity by electricity source					
Grid	28.81***	14.12*	-34.56***	-11.25*	-16.67***
	(8.937)	(8.036)	(11.40)	(6.803)	(5.537)
Solar (off-grid)	13.50***	-1.703	-5.976	-5.314	-8.965**
	(5.115)	(3.950)	(13.82)	(5.942)	(4.470)
Controls	Yes	Yes	Yes	Yes	Yes
N	22257	22257	22257	22257	22257
P-value	0.0000	0.0000	0.0000	0.0000	0.0000

* p < .10, ** p < .05, *** p < .01. Results estimated with fixed effects panel data models. Household-level control variables were included in estimation (see Table A1). Robust standard errors in parentheses. The outcome variables are the daily minutes allocated by all household members to each activity.

4.2.2 Electrification and individual labor allocation

Estimates of the association between electrification and individual time use are presented in Figures 6 to 8. Figure 6 shows the results for working-age adults. For women, electricity is positively associated with the time allocated to off-farm self-employment, and negatively associated with the time allocated to firewood and water fetching. These associations for women are larger than those for men in absolute terms. That is, women seem to benefit more from electricity in terms of their off-farm employment than men. This finding aligns with previous research showing that women's off-farm employment is affected more by electrification than men's, likely due to larger reductions in women's time spent on unpaid household chores (Dinkelman, 2011; Grogan and Sadanand, 2013; Grogan, 2018).

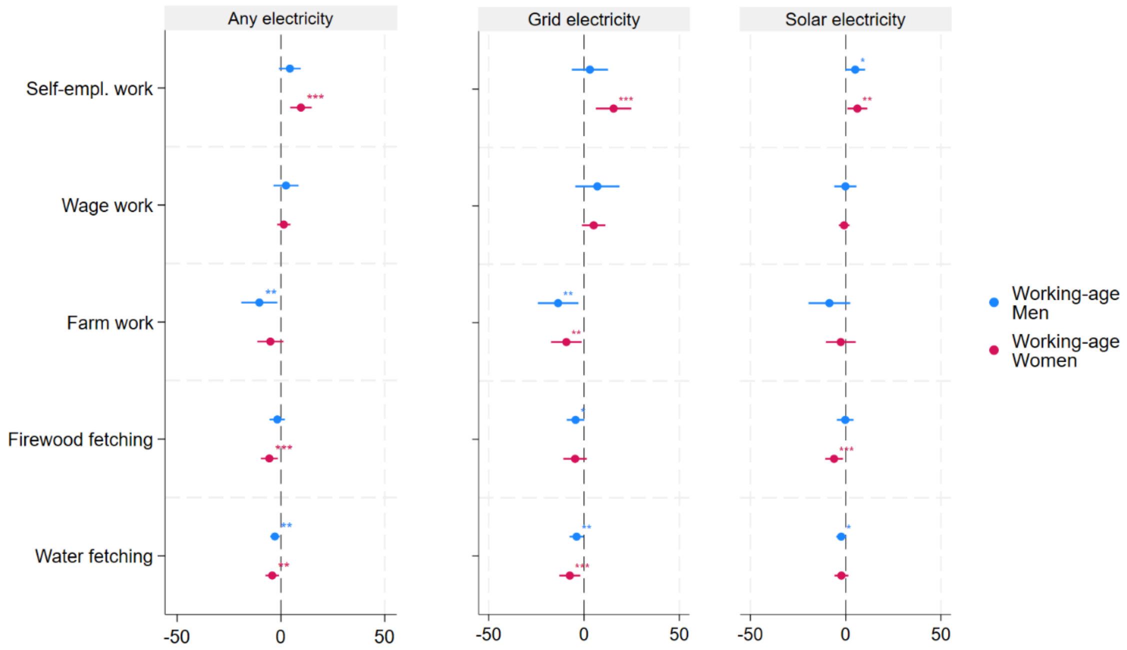

Figure 6: Changes in working-age adults' labor allocation associated with electrification
* p < .10, ** p < .05, *** p < .01. Point estimates with 95% confidence intervals from regressions of individual time allocation (minutes per day) on electrification. Results estimated with fixed effects panel data models as shown in Tables A2 and A3 in the Appendix.

For working-age men, electrification is negatively and significantly associated with farm work and water fetching. Regarding the time spent on all income-generating activities, electrification is associated with a significant decrease for men, but with an increase for women. For women, the decrease in farm work time is smaller than the increase in off-farm work time, especially time spent in self-employed activities. These patterns underline that individual-level disaggregation is important.

Distinguishing between grid and solar electrification, as shown in the middle and right charts of Figure 6, offers additional insights. As expected, the results for both sources of electricity point in the same directions, but the associations are larger in absolute terms for grid electricity than for solar electricity. The gendered patterns remain the same.

Figure 7 shows the results for elderly individuals. For older men, electrification is significantly associated with a reduction in the time spent on farm work and an increase in time spent on off-farm self-employment and wage work. Differentiating between electricity sources, only grid electrification is positively associated with older men's time spent on off-farm self-employment, whereas solar electrification is negatively associated with farm work. For older women, we find no significant associations. While this may be due to the smaller sample size, it could also reflect traditional gender norms, where older women spend more time on childcare or other unpaid tasks (Gibson and Mace, 2005; Samman et al., 2016), for which no data are available.

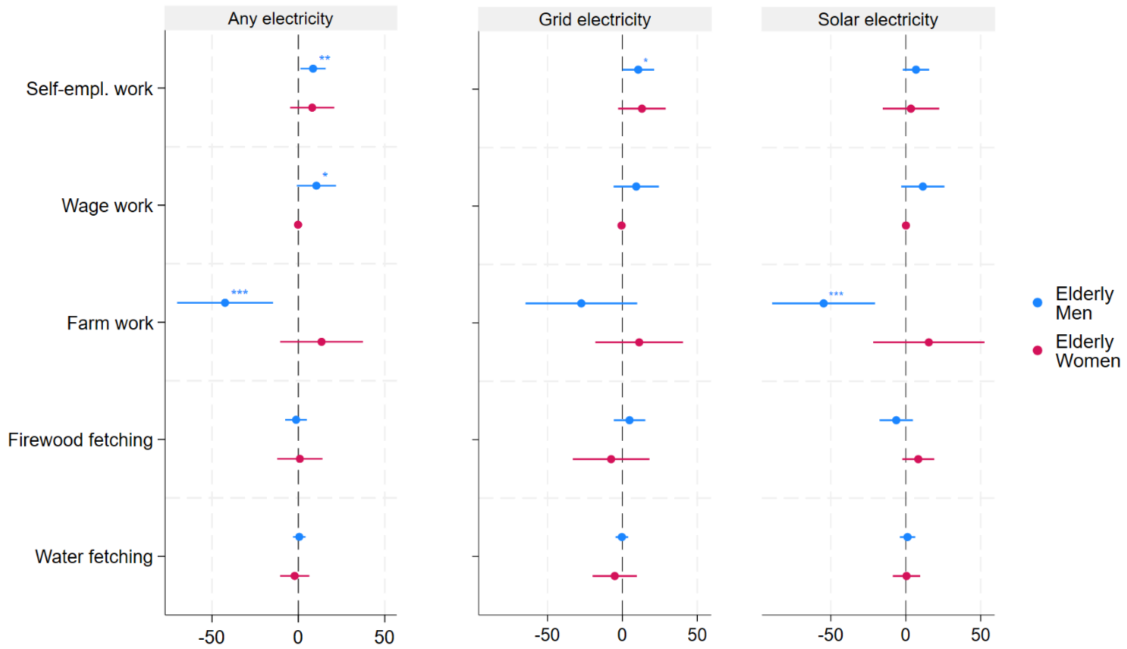

Figure 7: Changes in elderly individuals' labor allocation associated with electrification
* p < .10, ** p < .05, *** p < .01. Point estimates with 95% confidence intervals from regressions of individual time allocation (minutes per day) on electrification. Results estimated with fixed effects panel data models as shown in Tables A4 and A5 in the Appendix.

Figure 8 presents the results for children. Most of the associations are small and not statistically significant, which is in line with our hypothesis. However, grid electrification is positively and significantly associated with boys' time spent on farm work. This suggests that boys may take on farm tasks that were previously performed by adults.

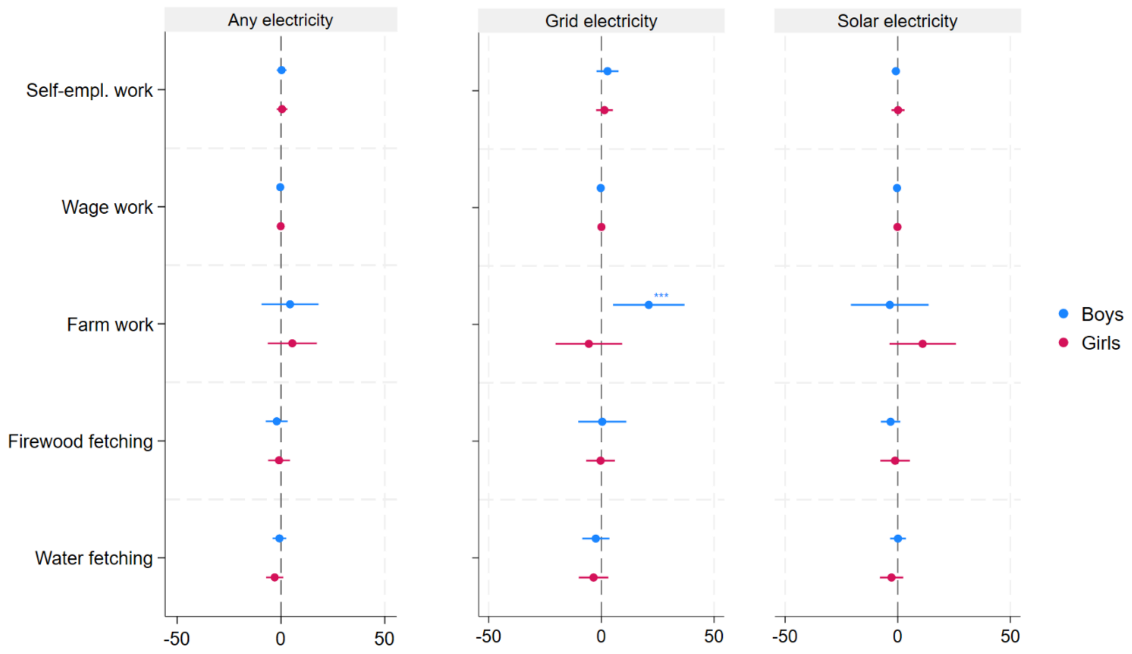

Figure 8: Changes in children's labor allocation associated with electrification
* p < .10, ** p < .05, *** p < .01. Point estimates with 95% confidence intervals from regressions of individual time allocation (minutes per day) on electrification. Results are estimated with panel data fixed effects models as shown in Tables A6 and A7 in the Appendix.

4.3 Robustness checks

In this subsection, we summarize the results from the robustness checks. First, we run regressions with a sample that excludes observations from large towns and from Tigray in all survey waves (Tables A8 and A9 in the Appendix). Second, we run the analysis separately for Panel 1 (waves 1-3) and Panel 2 (waves 4-5) (Tables A10 to A13 in the Appendix). These alternative estimates are consistent with our main findings, thus underlining that the results are robust to several sample variations. Specifically, it is confirmed that electrification is associated with a reduction in time spent on farm work and unpaid work and an increase in self-employed off-farm work at the household level. At the individual level, the associations between electrification and off-farm self-employment are larger for working-age women, while the reductions in farm work are more pronounced for men.

Third, we provide results from a staggered DID estimation with regression adjustment (Tables A14 and A15 in the Appendix). The signs of the associations are consistent with those estimated with the fixed effects models. However, especially for the household-level models and for working-age adults, many of the DID estimates are not statistically significant. This is in line with Pelz et al. (2023) who analyze the effects of grid-electrification on non-farm employment using waves 1-3 of the ESS, employing a staggered DID model. They do not find significant effects and stress the problem of the small size of the treatment group and the corresponding lack of statistical power. One difference to our main results is that the DID estimates for children suggest a significantly positive association between electrification and boys’ as well as girls’ time allocated to farm work (Table A15), whereas the fixed effects models show a significant association only for boys.

Finally, we provide results estimated with SUR models (Tables A16 and A17 in the Appendix). These results largely align with our main findings, even though the SUR coefficients are generally somewhat larger in magnitude. For children, the SUR models result in significantly negative associations between electrification and farm work. These discrepancies are unsurprising, as the SUR models do not control for household and individual fixed effects. Households with electricity are generally better off and tend to be located in areas with better economic prospects. It is therefore plausible that such households provide more off-farm and less farm work, with less work provided by children, to begin with. We argue that our main results with fixed effects are more reliable, as failing to control for household- and individual-specific unobserved heterogeneity may easily result in estimation bias.

5. Conclusion and policy implications

While electrification has generally been linked to positive economic development effects, these benefits might not extend equally to all demographic groups. We contribute to a better understanding of the full scope of electrification benefits and potential trade-offs by analyzing its association with changes in the labor allocation to income-generating and unpaid work among individuals in Ethiopia. Specifically, we look at male and female adults, children, and elderly, to understand possible gender and age differences and substitution effects. Moreover, we differentiate between grid and off-grid solar electrification, which is of particular relevance in rural sub-Saharan Africa.

Our findings show that electrification is associated with a reduction in the time households spend on farm work and unpaid work, alongside an increase in self-employed off-farm work. These patterns are observed in both grid- and solar-electrified households, yet with more pronounced associations in grid-electrified households. At the individual level, our analysis reveals that electrification is significantly associated with an increase in time allocated to self-employed off-farm activities among working-age women, and a reduction in time spent on farm work among working-age men. We observe no significant associations for elderly women, but for elderly men, electrification is significantly associated with increases in the time allocated to off-farm wage- and self-employment. Lastly, we find no significant association between electrification and time use for girls, but a significantly positive association between grid electrification and boys' time spent on farm work.

Our results provide a few important policy implications. First, electrification should be viewed as a key tool for policymakers to facilitate economic transformation from farm to off-farm employment. Through various mechanisms, electricity increases both the supply of and the demand for off-farm labor, which is relevant for equitable structural transformation. Off-farm employment is also important with a view to climate change, as climate change makes income generation from agriculture alone increasingly difficult and uncertain (Musungu et al., 2024).

Second, off-grid solar electrification also provides some benefits, but these are smaller than those from grid electrification. Hence, while off-grid solar electrification might be a cost-effective interim solution to reach remote areas, providing universal grid electrification should still be considered the long-term target, to avoid further regional inequalities. This aligns with the Ethiopian government's plan to achieve 96% grid coverage by 2030 (MoWIE, 2019).

Third, electrification improves female labor force participation in off-farm sectors, which tends to strengthen women's financial autonomy and intra-household bargaining power (Debela et al., 2021; Kamanyire et al., 2024). Hence, promoting electricity access is an important avenue to foster women's empowerment and gender equality. However, increases in women's employment will not always lead to positive social outcomes (Melaku et al., 2024). If women's increased participation in paid work is not compensated by a similar reduction in unpaid work, it could lead to a gendered disadvantage by disproportionately increasing women's workload. Measures to increase and facilitate the use of electricity for unpaid tasks, such as promoting suitable electric appliances and the use of electricity for cooking, could help achieve more gender-equitable outcomes.

Finally, our results also raise some concerns regarding the increased work burden of children, particularly boys, who seem to take over some of the farm tasks from adults in electrified households. Such negative effects may also be lowered by more time-saving appliances for household chores, as these may free up some of the adults' time. More generally, policymakers should be mindful of potential negative effects on specific groups, which requires more research with individual-level data.

References

Admassu, M. (2019). Causes of ethnic conflict in Ethiopia and its effect on development: The case of Amhara and Gumuz communities. Journal of Sustainable Development in Africa, 21(3), 64-79.

ACE-TAF. (2022). Ethiopia Customs Handbook for stand-alone solar products and components. Africa Clean Energy Technical Assistance Facility.

Amuakwa-Mensah, S., & Surry, Y. (2022). Association between rural electrification and agricultural output: Evidence from Sub-Saharan Africa. World Development Perspectives, 25, 100392. https://doi.org/10.1016/j.wdp.2021.100392.

Barron, M., & Torero, M. (2014). Electrification and time allocation: Experimental evidence from Northern El Salvador. MPRA Paper No. 63782.

Beyene, A. D., Mekonnen, A., Jeuland, M., & Czakon, S. (2024). Socioeconomic impacts of solar home systems in rural Ethiopia. Renewable and Sustainable Energy Reviews, 192, 114197. https://doi.org/10.1016/j.rser.2023.114197.

Bhatia, M., & Angelou, N. (2015). Beyond connections: Energy access redefined. World Bank.

Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. Journal of Econometrics, 225(2), 200-230. https://doi.org/10.1016/j.jeconom.2020.12.001.

Chhay, P., & Yamazaki, K. (2021). Rural electrification and changes in employment structure in Cambodia. World Development, 137, 105212. https://doi.org/10.1016/j.worlddev.2020.105212.

Chiappori, P. A. (1992). Collective labor supply and welfare. Journal of Political Economy, 100(3), 437-467. https://doi.org/10.1086/261825.

CSA (Central Statistical Agency of Ethiopia) & LSMS Team. (2014). Rural Socioeconomic Survey 2011-2012 (ERSS) [Data set]. Ref: ETH_2011_ERSS_v02_M. World Bank, Development Data Group. Retrieved from https://doi.org/10.48529/80XT-9M68. Accessed July 7, 2024.

CSA & LSMS Team. (2015). Socioeconomic Survey 2013-2014 (ESS2) [Data set]. Ref: ETH_2013_ESS_v02_M. World Bank, Development Data Group. Retrieved from https://doi.org/10.48529/MCCP-Y123. Accessed July 7, 2024.

CSA. (2017). Socioeconomic Survey 2015-2016 (ESS3) [Data set]. Ref: ETH_2015_ESS_v02_M. World Bank, Development Data Group. Retrieved from https://doi.org/10.48529/AMPF-7988. Accessed July 7, 2024.

CSA. (2020). Socioeconomic Survey 2018-2019 (ESS4) [Data set]. Ref: ETH_2018_ESS_v03. World Bank, Development Data Group. Retrieved from https://doi.org/10.48529/K739-C548. Accessed July 7, 2024.

Conroy-Krutz, J., Amakoh, K., & Amewunou, K. (2024). Africa's shifting media landscapes: Digital media use grows, but so do demographic divides. Afrobarometer Dispatch No. 800.

Debela, B. L., Gehrke, E., & Qaim, M. (2021). Links between maternal employment and child nutrition in rural Tanzania. American Journal of Agricultural Economics, 103(3), 812–830. https://doi.org/10.1111/ajae.12113.

Dinkelman, T. (2011). The effects of rural electrification on employment: New evidence from South Africa. American Economic Review, 101(7), 3078-3108. https://doi.org/10.1257/aer.101.7.3078.

ESS (Ethiopian Statistical Service). (2023). Ethiopia Socioeconomic Panel Survey 2021-2022 (ESPS-5) [Data set]. Ref: ETH_2021_ESPS-W5_v02_M. World Bank, Development Data Group. Retrieved from https://microdata.worldbank.org/index.php/catalog/3823. Accessed July 7, 2024.

Fried, S., & Lagakos, D. (2021). Rural electrification, migration and structural transformation: Evidence from Ethiopia. Regional Science and Urban Economics, 91, 103625. https://doi.org/10.1016/j.regsciurbeco.2020.103625.

Gaggl, P., Gray, R., Marinescu, I., & Morin, M. (2021). Does electricity drive structural transformation? Evidence from the United States. Labour Economics, 68, 101944. https://doi.org/10.1016/j.labeco.2020.101944.

Gibson, M. A., & Mace, R. (2005). Helpful grandmothers in rural Ethiopia: A study of the effect of kin on child survival and growth. Evolution and Human Behavior, 26(6), 469-482. https://doi.org/10.1016/j.evolhumbehav.2005.03.004.

Gibson, J., & Olivia, S. (2010). The effect of infrastructure access and quality on non-farm enterprises in rural Indonesia. World Development, 38(5), 717-726. https://doi.org/10.1016/j.worlddev.2009.11.010.

Grogan, L. (2018). Time use impacts of rural electrification: Longitudinal evidence from Guatemala. Journal of Development Economics, 135, 304- 317. https://doi.org/10.1016/j.jdeveco.2018.03.005.

Grogan, L., & Sadanand, A. (2013). Rural electrification and employment in poor countries: Evidence from Nicaragua. World Development, 43, 252-265. https://doi.org/10.1016/j.worlddev.2012.09.002.

IEA. (2024a). World Energy Outlook 2019. Available online https://www.iea.org/reports/world-energy-outlook-2019. Accessed February 6, 2025.

IEA. (2024b). Electricity access continues to improve in 2024 - after first global setback in decades. Available online https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-first-global-setback-in-decades. Accessed February 6, 2025.

ILO. (2017). Global estimates of child labour: Results and trends, 2012-2016.

Khandker, S. R., Barnes, D. F., & Samad, H. A. (2013). Welfare impacts of rural electrification: A panel data analysis from Vietnam. Economic Development and Cultural Change, 61(3), 659-692. https://doi.org/10.1086/669262.

Kamanyire, M. C., Matovu, F., Wabiga, P., & Nanyiti, A. (2024). Rural electrification and women empowerment: Do bargaining game approaches with real household items reduce the bias?. The Electricity Journal, 37(6), 107420. https://doi.org/10.1016/j.tej.2024.107420.

Kannan, S., & Bessette, D. L. (2023). Time-use among men and women in Zambia: A comparison of grid, off-grid, and unconnected households. Energy for Sustainable Development, 76, 101276. https://doi.org/10.1016/j.esd.2023.101276.

Lavers, T., & Gebresenbet, F. (2024). Electrifying Ethiopia, Consolidating Power: The Challenge of Distributing Electricity. In T. Lavers (Eds.), Dams, Power, and the Politics of Ethiopia's Renaissance, (pp. 177- 209). Oxford University PressOxford. https://doi.org/10.1093/oso/9780192871213.003.0008.

Leduchowicz-Municio, A., Domenech, B., Ferrer-Martí, L., Udaeta, M. E. M., & Gimenes, A. L. V. (2023). Women, equality, and energy access: Emerging lessons for last-mile rural electrification in Brazil. Energy Research & Social Science, 102, 103181. https://doi.org/10.1016/j.erss.2023.103181.

Lenz, L., Munyehirwe, A., Peters, J., & Sievert, M. (2017). Does large-scale infrastructure investment alleviate poverty? Impacts of Rwanda's electricity access roll-out program. World Development, 89, 88-110. https://doi.org/10.1016/j.worlddev.2016.08.003.

Melaku, A.B., Qaim, M., & Debela, B.L. (2024). Maternal employment in high-value agriculture and child nutrition: Evidence from the Ethiopian cut-flower industry. Food Policy, 128, 102732. https://doi.org/10.1016/j.foodpol.2024.102732.

MoFED. (2010). Growth and Transformation Plan I. Ministry of Finance and Economic Development.

Motsaathebe, G., & Chiumbu, S. (Eds.). (2021). Television in Africa in the digital age. Palgrave Macmillan.

MoWIE. (2019). National Electrification Program 2.0. Integrated Planning for Universal Access. Ministry of Water, Irrigation and Energy.

Musungu, A., Kubik, Z., & Qaim, M. (2024). Drought shocks and labour reallocation in rural Africa: Evidence from Ethiopia. European Review of Agricultural Economics, 51(4), 1045-1068. https://doi.org/10.1093/erae/jbae020.

NDRMC. (2018). Ethiopia: 2018 Humanitarian and Disaster Resilience Plan. National Disaster Risk Management Commission.

NPC. (2016). Growth and Transformation Plan II. National Planning Commission.

Padam, G., Rysankova, D., Portale, E., Koo, B. B., Keller, S., & Fleurantin, G. (2018). Ethiopia–Beyond connections: energy access diagnostic report based on the multi-tier framework. World Bank.

Pelz, S., Pachauri, S., & Falchetta, G. (2023). Short-run effects of grid electricity access on rural non-farm entrepreneurship and employment in Ethiopia and Nigeria. World Development Perspectives, 29, 100473. https://doi.org/10.1016/j.wdp.2022.100473.

Peters, J., & Sievert, M. (2016). Impacts of rural electrification revisited–the African context. Journal of Development Effectiveness, 8(3), 327-345. https://doi.org/10.1080/19439342.2016.1178320.

Rajkhowa, P., & Qaim, M. (2021). Personalized digital extension services and agricultural performance: Evidence from smallholder farmers in India. PloS One, 16(10), e0259319. https://doi.org/10.1371/journal.pone.0259319.

Rathi, S. S., & Vermaak, C. (2018). Rural electrification, gender and the labor market: A cross-country study of India and South Africa. World Development, 109, 346-359. https://doi.org/10.1016/j.worlddev.2018.05.016.

Ritchie, H., Rosado, P., & Roser, M. (2023). Solar photovoltaic module price. Available online https://ourworldindata.org/grapher/solar-pv-prices. Accessed February 9, 2025.

Samman, E., Presler-Marshall, E., Jones, N., Bhatkal, T., Melamed, C., Stavropoulou, M., & Wallane, J. (2016). Women's work: Mothers, children and the global childcare crisis. Oversees Development Institute.

UN. (2024). Sustainable Development Goal 7. Available online https://sdgs.un.org/goals/goal7. Last accessed 06.02.2025. Accessed February 9, 2025.

UNICEF. (2020). Child labour and the youth labour market in Ethiopia. Policy Brief.

van de Walle, D., Ravallion, M., Mendiratta, V., & Koolwal, G. (2015). Long-Term Gains from Electrification in Rural India. The World Bank Economic Review, lhv057. https://doi.org/10.1093/wber/lhv057.

Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data. (2nd ed.). MIT Press.

Wooldridge, J. M. (2013). Introductory Econometrics: A Modern Approach. (5th ed.). South-Western Cengage Learning.

World Bank. (2024a). Access to electricity, rural (% of rural population) - Ethiopia. Available online https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=ET. Accessed February 6, 2025.

World Bank. (2024b). Access to electricity, urban (% of urban population) - Ethiopia. Available online https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=ET. Accessed February 6, 2025.

World Bank. (2024c). Employment in agriculture (% of total employment) – Ethiopia. Available online https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=ET. Accessed February 6, 2025.

World Bank. (2024d). Labor force participation rate, female (% of female population ages 15-64) – Ethiopia. Available online https://data.worldbank.org/indicator/SL.TLF.ACTI.FE.ZS?locations=ET. Accessed February 6, 2025.

World Bank. (2024e). Compulsory education, duration (years) – Ethiopia. Available online https://data.worldbank.org/indicator/SE.COM.DURS?locations=ET. Accessed April 11, 2025.

WHO. (2024). Labour force participation rate by older people (65+ years) (SDG 8.5). Available online https://platform.who.int/data/maternal-newborn-child-adolescent-ageing/indicator-explorer-new/MCA/labour-force-participation-rate-by-older-people-(sdg-8.5). Accessed February 6, 2025.

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. Journal of the American Statistical Association, 57(298), 348-368. https://doi.org/10.1080/01621459.1962.10480664.

APPENDIX

Table A1: Name and definition of variables

Name	Measurement Unit	Definition
Household electricity	Dummy (1=yes, 0=no)	Takes on 1 if the household's main source of light is grid electricity (private or shared meter) or solar energy, 0 otherwise.
Grid electricity	Dummy (1=yes, 0=no)	Takes on 1 if the household's main source of light is grid electricity (private or shared meter) takes on 0 otherwise.
Solar (off-grid) electricity	Dummy (1=yes, 0=no)	Takes on 1 if the household's main source of light is solar energy, takes on 0 otherwise.
Household level controls		
Household size	Number	Total number of household members
No. of women	Number	Number of working aged women (15-64) in the household
No. of dependents	Number	Number of elderly (<64) and children (<15) in the household
Age of HH head	Years	Age of the household head
Gender of HH head	Dummy (1=Male, 0= Female)	Takes on 1 if the household head is male, 0 otherwise
Literacy of HH head	Dummy (1=yes, 0=no)	Takes on 1 if the household head is able to read and write or, if this information was missing, completed more than 4 years of school
Assets	Number of assets per household member	Assets considered here are blankets, mattresses, watches, sofas, bikes, motorbikes, carts, cars, gold, silver, wardrobes, shelfs and water storages
Remittances	Dummy (1=yes, 0=no)	Takes on 1 if the household receives some incoming transfers from abroad
Weather shock	Dummy (1=yes, 0=no)	Takes on 1 if the household experienced a drought, flood, landslide, heavy rains or fire during the last 12 months
Health shock	Dummy (1=yes, 0=no)	Takes on 1 if the household experienced the death or illness of a household member during the last 12 months
Income shock	Dummy (1=yes, 0=no)	Takes on 1 if the household experienced a job loss, crop damage, or the great loss/death of livestock during the last 12 months
Violence shock	Dummy (1=yes, 0=no)	Takes on 1 if the household experienced theft/robbery and other violence, involuntary loss of house/land, displacement (due to government development projects) or local unrest/violence during the last 12 months
Distance market	Kilometer	Distance to the nearest large weekly market
Distance road	Kilometer	Distance to the nearest tar/ asphalt road
Distance financial	Kilometer	Distance to the nearest bank or microfinance institute
Livestock value	1000 Birr	Value of livestock owned by the household. The monetary value of livestock is constructed from the average sale and purchase price in the corresponding survey wave
Land size	Hectare	Size of (agricultural) land owned by the household
Farming area	Dummy (1=yes, 0=no)	Takes on 1 if the most common use of land in this community is pasture or farming. Takes on 0 if the most common use of land is planned housing, squatter settlement, industry or manufacture, shops or trade or other
Consumption poor	Dummy (1=yes, 0=no)	Takes on 1 if the household is in the lowest two consumption quintiles

Individual level controls		
Age	Years	Age of the individual
Literacy	Dummy (1=yes, 0=no)	Takes on 1 if the individual is able to read and write or, if this information is missing, completed more than 4 years of school
Health	Dummy (1=yes, 0=no)	Takes on 1 if the individual has been sick during the last two months (waves 1-3) or the last four weeks (waves 4-5)
Married	Dummy (1=yes, 0=no)	Takes on 1 if the individual is married

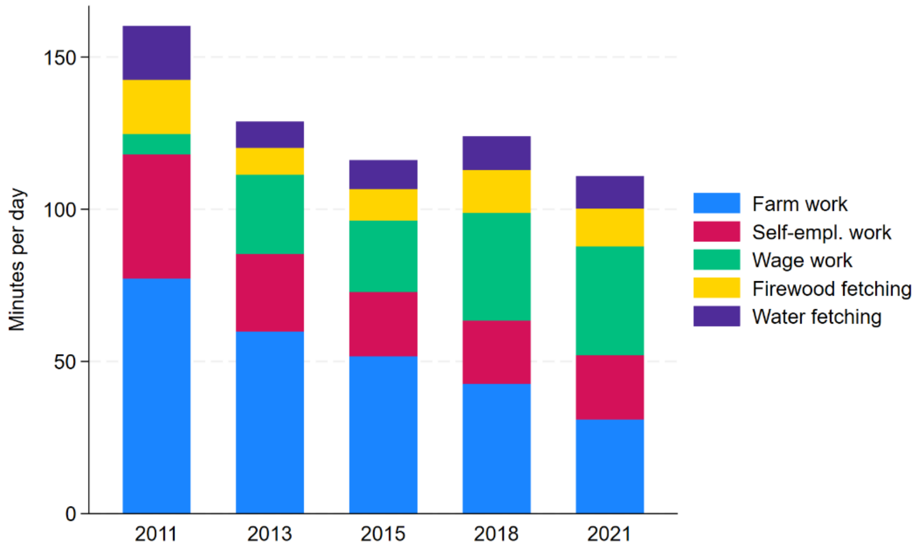

Figure A1: Per capita daily household labor allocated to different work activities

Source: Authors' calculation using data from the Ethiopian Socioeconomic Survey. The sample includes 3,351 households in wave 1, 4,861 households in wave 2, 4,733 households in wave 3, 4,656 households in wave 4 and 4,656 households in wave 5. Per capita household daily time refers to the sum of daily minutes allocated by all household members above seven years of age to each time use category divided by the number of individuals in the household.

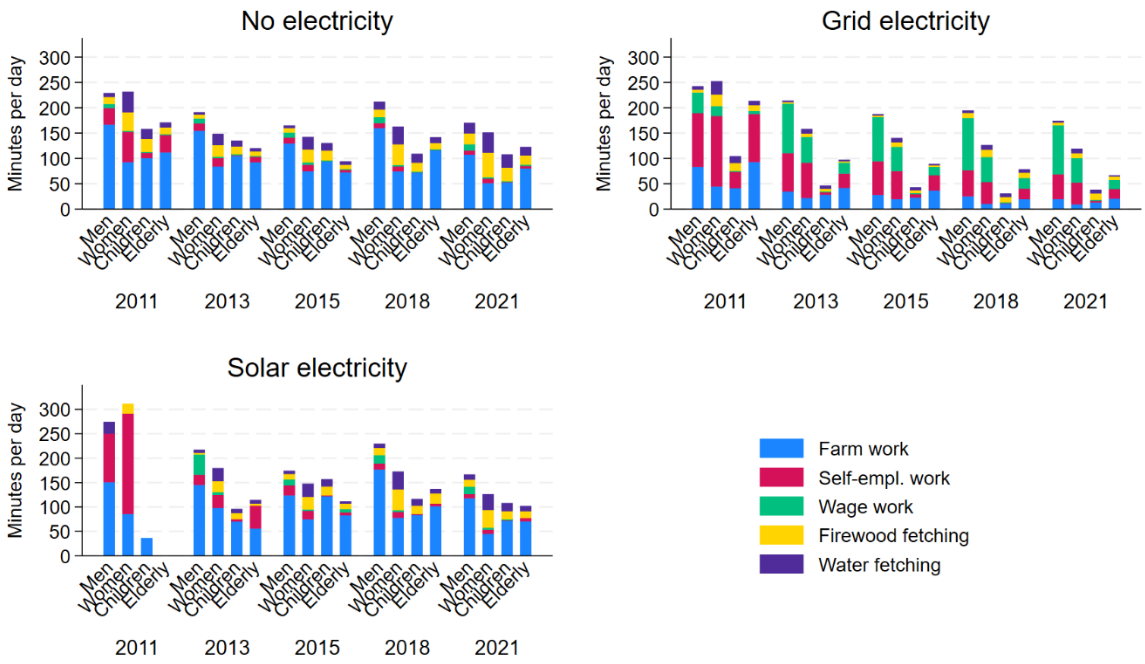

Figure A2: Individual labor allocation to different work categories by energy source
Source: Authors' calculation using data from the Ethiopian Socioeconomic Survey. The sample of individuals with no electricity consists of 8,701 observations in wave 1, 10,167 observations in wave 2, 7,602 observations in wave 3, 4,590 observations in wave 4 and 3,542 observations in wave 5. The sample of individuals with grid electricity consists of 1,558 observations in wave 1, 5,396 observations in wave 2, 5,161 observations in wave 3, 6,882 observations in wave 4 and 7,294 observations in wave 5. The sample of individuals with solar energy consists of 13 individuals in wave 1, 386 individuals in wave 2, 1,909 individuals in wave 3, 2,134 individuals in wave 4 and 2,770 individuals in wave 5.

Table A2: Changes in working-age adults' labor allocation associated with electrification

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	4.308	2.430	-10.39**	-1.766	-2.906**
	(2.688)	(3.079)	(4.426)	(1.873)	(1.161)
Controls	Yes	Yes	Yes	Yes	Yes
N	22411	22411	22411	22411	22411
R2 within	0.0121	0.00410	0.0255	0.00966	0.0131
R2 between	0.00617	0.0191	0.00207	0.00202	0.00719
R2 overall	0.00763	0.00751	0.00585	0.00386	0.00803
P-value	0.0000	0.0001	0.0000	0.0000	0.0000
Panel 2: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	9.642***	1.386	-5.085	-5.562***	-4.191**
	(2.641)	(1.631)	(3.196)	(2.088)	(1.662)
Controls	Yes	Yes	Yes	Yes	Yes
N	25045	25045	25045	25045	25045
R2 within	0.0477	0.00322	0.0110	0.0142	0.0279
R2 between	0.00718	0.000814	0.0123	0.0171	0.00796
R2 overall	0.000466	0.00181	0.00213	0.0149	0.0128
P-value	0.0000	0.0374	0.0000	0.0000	0.0000

* p < .10, ** p < .05, *** p < .01. Point estimates and robust standard errors (s.e.) (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from fixed-effects models at the individual level, with household and individual controls (see Table A1). Sample includes working-age adults.

Table A3: Changes in working-age adults' labor allocation associated with electrification by electricity source

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Men)					
1. Grid	3.084	6.978	-13.63**	-4.469*	-3.893**
	(4.859)	(5.914)	(5.439)	(2.364)	(1.904)
2. Solar (off-grid)	5.002*	-0.146	-8.555	-0.235	-2.348*
	(2.661)	(2.964)	(5.593)	(2.245)	(1.335)
Controls	Yes	Yes	Yes	Yes	Yes
N	22411	22411	22411	22411	22411
R2 within	0.0121	0.00421	0.0256	0.00992	0.0132
R2 between	0.00459	0.00414	0.00741	0.00582	0.00922
R2 overall	0.00631	0.000834	0.0109	0.00658	0.00916
P-value	0.0000	0.0002	0.0000	0.0000	0.0000
Panel 2: Minutes per day allocated to each activity by each individual (Women)					
1. Grid	15.50***	5.059	-9.305**	-4.698	-7.469***
	(4.736)	(3.154)	(4.083)	(3.154)	(2.818)
2. Solar (off-grid)	6.141**	-0.808	-2.563	-6.079***	-2.232
	(2.653)	(1.425)	(3.994)	(2.358)	(1.848)
Controls	Yes	Yes	Yes	Yes	Yes
N	25045	25045	25045	25045	25045
R2 within	0.0480	0.00339	0.0111	0.0143	0.0282
R2 between	0.00372	0.0138	0.00283	0.0134	0.0225
R2 overall	0.00142	0.0123	0.0000151	0.0128	0.0226
P-value	0.0000	0.0287	0.0000	0.0000	0.0000

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes working-age adults.

Table A4: Changes in elderly individuals' labor allocation associated with electrification

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	8.538**	10.46*	-42.42***	-1.310	0.504
	(3.715)	(5.780)	(14.15)	(3.201)	(1.847)
Controls	Yes	Yes	Yes	Yes	Yes
N	1747	1747	1747	1747	1747
R2 within	0.0496	0.0276	0.0845	0.0424	0.0374
R2 between	0.000132	0.00263	0.0159	0.0000703	0.00102
R2 overall	0.00259	0.00591	0.0338	0.00421	0.00140
P-value	0.1031	0.7775	0.0000	0.0000	0.7186
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	8.012	-0.181	13.43	0.873	-2.119
	(6.515)	(0.342)	(12.23)	(6.688)	(4.322)
Controls	Yes	Yes	Yes	Yes	Yes
N	1633	1633	1633	1633	1633
R2 within	0.125	0.00895	0.0551	0.0301	0.0483
R2 between	0.000461	0.00000593	0.0120	0.00554	0.00174
R2 overall	0.0103	0.000273	0.00125	0.0117	0.0000932
P-value	0.0000	1.0000	0.0726	0.3648	0.0711

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes elderly individuals.

Table A5: Changes in elderly individuals' labor allocation associated with electrification by electricity source

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
1. Grid	10.59*	9.273	-27.38	4.794	-0.318
	(5.404)	(7.728)	(19.00)	(5.367)	(2.151)
2. Solar (off-grid)	6.849	11.44	-54.81***	-6.341	1.181
	(4.509)	(7.337)	(17.49)	(5.672)	(2.612)
Controls	Yes	Yes	Yes	Yes	Yes
N	1747	1747	1747	1747	1747
R2 within	0.0497	0.0277	0.0860	0.0472	0.0375
R2 between	0.00000016	0.00184	0.00570	0.00368	0.000811
R2 overall	0.00350	0.00495	0.0231	0.00160	0.00150
P-value	0.1004	0.8175	0.0000	0.0000	0.7466
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
1. Grid	13.09	-0.520	11.23	-7.471	-5.053
	(8.085)	(0.546)	(14.90)	(13.05)	(7.533)
2. Solar (off-grid)	3.476	0.120	15.40	8.326	0.502
	(9.604)	(0.326)	(18.91)	(5.443)	(4.674)
Controls	Yes	Yes	Yes	Yes	Yes
N	1633	1633	1633	1633	1633
R2 within	0.125	0.00897	0.0551	0.0323	0.0495
R2 between	0.000291	0.00000254	0.0105	0.0158	0.000141
R2 overall	0.0110	0.000200	0.000882	0.0206	0.00272
P-value	0.0000	1.0000	0.0913	0.3726	0.0905

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes elderly individuals.

Table A6: Changes in children's labor allocation associated with electrification

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	0.326	-0.317	4.383	-2.035	-0.726
	(1.188)	(0.212)	(7.008)	(2.689)	(1.673)
Controls	Yes	Yes	Yes	Yes	Yes
N	8878	8878	8878	8878	8878
R2 within	0.0206	0.00637	0.0165	0.0108	0.0160
R2 between	0.000955	0.0000750	0.0277	0.00412	0.00246
R2 overall	0.00357	0.000102	0.0243	0.00513	0.0000795
P-value	0.0000	0.9966	0.0000	0.0000	0.0001
Panel 2: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	0.552	-0.0831	5.469	-0.910	-3.004
	(1.300)	(0.177)	(6.039)	(2.688)	(2.098)
Controls	Yes	Yes	Yes	Yes	Yes
N	8391	8391	8391	8391	8391
R2 within	0.0320	0.00412	0.0147	0.0145	0.0195
R2 between	0.00108	0.000205	0.00466	0.000214	0.000596
R2 overall	0.000706	0.00000014	0.00677	0.00234	0.00238
P-value	0.0000	1.0000	0.0016	0.0010	0.0003

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes children.

Table A7: Changes in children's labor allocation associated with electrification by electricity source

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Boys)					
1. Grid	2.726	-0.303	21.02***	0.386	-2.480
	(2.501)	(0.268)	(8.094)	(5.447)	(3.072)
2. Solar (off-grid)	-0.815	-0.324	-3.535	-3.186	0.108
	(0.870)	(0.206)	(8.798)	(2.203)	(1.798)
Controls	Yes	Yes	Yes	Yes	Yes
N	8878	8878	8878	8878	8878
R2 within	0.0211	0.00637	0.0175	0.0109	0.0162
R2 between	0.00151	0.0000733	0.00235	0.00230	0.000901
R2 overall	0.00446	0.000104	0.00501	0.00362	0.000588
P-value	0.0.0000	0.9977	0.0000	0.0000	0.0002
Panel 2: Minutes per day allocated to each activity by each individual (Girls)					
1. Grid	1.364	0.0122	-5.566	-0.369	-3.485
	(1.888)	(0.152)	(7.542)	(3.255)	(3.352)
2. Solar (off-grid)	0.140	-0.131	11.06	-1.184	-2.760
	(1.481)	(0.214)	(7.527)	(3.349)	(2.642)
Controls	Yes	Yes	Yes	Yes	Yes
N	8391	8391	8391	8391	8391
R2 within	0.0320	0.00413	0.0154	0.0145	0.0196
R2 between	0.000873	0.000184	0.0234	0.0000963	0.000832
R2 overall	0.000876	4.32e-08	0.0211	0.00201	0.00273
P-value	0.0000	1.0000	0.0019	0.0012	0.0004

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes children.

Robustness Checks

Table A8: Changes in the labor allocation of households and working-age adults associated with electrification: Excluding Tigray and large towns

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Total household minutes per day allocated to each activity					
Household electricity	23.38***	1.617	-12.22	-8.794	-15.82***
	(5.812)	(3.868)	(11.52)	(6.035)	(4.369)
Controls	Yes	Yes	Yes	Yes	Yes
N	14665	14665	14665	14665	14665
R2 within	0.0719	0.0113	0.0456	0.0289	0.0399
R2 between	0.00566	0.000825	0.128	0.0534	0.0543
R2 overall	0.00387	0.00216	0.103	0.0395	0.0466
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
Panel 2: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	5.888**	-0.416	-7.687	-2.963	-3.688***
	(2.820)	(3.014)	(4.928)	(2.163)	(1.264)
Controls	Yes	Yes	Yes	Yes	Yes
N	15046	15046	15046	15046	15046
R2 within	0.0147	0.00761	0.0397	0.0116	0.0163
R2 between	0.000548	0.00405	0.00147	0.0000278	0.00149
R2 overall	0.000752	0.00475	0.00839	0.00202	0.00488
P-value	0.0000	0.0001	0.0000	0.0000	0.0000
Panel 3: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	11.41***	0.979	-1.873	-5.825**	-5.109***
	(2.901)	(1.346)	(3.653)	(2.420)	(1.899)
Controls	Yes	Yes	Yes	Yes	Yes
N	16288	16288	16288	16288	16288
R2 within	0.0679	0.00442	0.0161	0.0186	0.0315
R2 between	0.0107	0.0180	0.000548	0.00312	0.0101
R2 overall	0.00145	0.0140	0.000733	0.00829	0.0166
P-value	0.0000	0.1267	0.0000	0.0000	0.0000

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of household (Panel 1) individual (Panels 2 and 3) time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the household (Panel 1) and individual level (Panels 2 and 3), with household (Panel 1) and household and individual (Panels 2 and 3) controls (see Table A1). Sample includes all households (Panel 1) and working-age adults (Panels 2 and 3). Households from large towns (>10.000 inhabitants) and from Tigray region are excluded.

Table A9: Changes in the labor allocation of elderly individuals and children associated with electrification: Excluding Tigray and large towns

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	7.883**	3.517	-34.05**	-3.011	0.470
	(3.894)	(3.781)	(15.75)	(2.811)	(2.478)
Controls	Yes	Yes	Yes	Yes	Yes
N	1305	1305	1305	1305	1305
R2 within	0.0691	0.0198	0.114	0.0479	0.0422
R2 between	0.00822	0.000115	0.000203	0.00139	0.00356
R2 overall	0.00000339	0.00291	0.0168	0.00277	0.000523
P-value	0.2145	1.0000	0.0000	0.0000	0.8626
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	11.57	-0.448	19.87	5.482	-0.926
	(7.065)	(0.611)	(14.48)	(4.527)	(4.501)
Controls	Yes	Yes	Yes	Yes	Yes
N	1068	1068	1068	1068	1068
R2 within	0.165	0.0121	0.0728	0.0654	0.0712
R2 between	6.61e-11	0.000618	0.000180	0.00219	0.00124
R2 overall	0.0138	0.00261	0.00470	0.0136	0.00148
P-value	0.0000	1.0000	0.0428	0.2462	0.0692
Panel 3: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	0.171	-0.0633	1.403	-1.928	-1.562
	(1.134)	(0.208)	(7.793)	(3.094)	(1.940)
Controls	Yes	Yes	Yes	Yes	Yes
N	6850	6850	6850	6850	6850
R2 within	0.0233	0.00712	0.0202	0.0131	0.0198
R2 between	0.000547	1.01e-09	0.0227	0.00445	0.000394
R2 overall	0.00386	0.000556	0.0211	0.00612	0.00131
P-value	0.0001	1.0000	0.0000	0.0498	0.0004
Panel 4: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	1.442	-0.113	1.311	-1.268	-4.426*
	(1.383)	(0.201)	(6.532)	(2.964)	(2.401)
Controls	Yes	Yes	Yes	Yes	Yes
N	6418	6418	6418	6418	6418
R2 within	0.0331	0.00437	0.0145	0.0259	0.0288
R2 between	0.000769	0.000112	0.00626	0.00417	0.000288
R2 overall	0.00102	0.000256	0.00831	0.0107	0.00276
P-value	0.0000	1.0000	0.0164	0.0001	0.0000

* $p < .10$, ** $p < .05$, *** $p < .01$. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes elderly individuals (Panels 1 and 2) and children (Panels 3 and 4). Households from large towns (>10.000 inhabitants) and from Tigray region are excluded.

Table A10: Changes in the labor allocation of households and working-age adults associated with electrification: waves 1-3

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Total household minutes per day allocated to each activity					
Household electricity	27.79***	8.187	-18.08	-3.726	-9.388***
	(8.199)	(5.851)	(15.48)	(4.634)	(3.243)
Controls	Yes	Yes	Yes	Yes	Yes
N	12945	12945	12945	12945	12945
R2 within	0.0792	0.0111	0.0308	0.0284	0.0557
R2 between	0.0177	0.00850	0.263	0.111	0.129
R2 overall	0.0362	0.00729	0.175	0.0655	0.0843
P-value	0.0000	0.0000	0.0000	0.0000	0.0000
Panel 2: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	6.961*	3.998	-12.80**	1.515	-2.328*
	(3.933)	(4.342)	(6.107)	(1.991)	(1.357)
Controls	Yes	Yes	Yes	Yes	Yes
N	13065	13065	13065	13065	13065
R2 within	0.0200	0.00701	0.0216	0.0128	0.0112
R2 between	0.0168	0.00167	0.107	0.00420	0.0213
R2 overall	0.0176	0.000192	0.0695	0.00788	0.0151
P-value	0.0000	0.0009	0.0000	0.0000	0.0000
Panel 3: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	15.48***	2.245	-6.462	-4.416*	-4.737**
	(4.135)	(2.368)	(4.640)	(2.306)	(2.182)
Controls	Yes	Yes	Yes	Yes	Yes
N	14411	14411	14411	14411	14411
R2 within	0.0708	0.00490	0.00958	0.0201	0.0449
R2 between	0.0000597	0.0247	0.00418	0.0259	0.0186
R2 overall	0.0157	0.0209	0.00669	0.0224	0.0296
P-value	0.0000	0.3361	0.0000	0.0000	0.0000

* $p < .10$, ** $p < .05$, *** $p < .01$. Point estimates and robust s.e. (in parentheses) from regressions of household (Panel 1) individual (Panels 2 and 3) time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the household (Panel 1) and individual level (Panels 2 and 3), with household (Panel 1) and household and individual (Panels 2 and 3) controls (see Table A1). Sample includes all households (Panel 1) and working-age adults (Panels 2 and 3). The sample excludes observations from waves four and five.

Table A11: Changes in the labor allocation of elderly individuals and children associated with electrification: waves 1-3

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	13.96**	7.855	-7.028	-2.012	0.736
	(5.553)	(6.682)	(16.98)	(3.943)	(1.120)
Controls	Yes	Yes	Yes	Yes	Yes
N	1136	1136	1136	1136	1136
R2 within	0.0756	0.0355	0.0879	0.0227	0.0423
R2 between	0.00610	0.00935	0.0143	0.00252	0.000223
R2 overall	0.0224	0.0154	0.00419	0.000527	0.00471
P-value	0.0038	0.9531	0.0001	0.9958	0.8361
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	20.58**	-0.00586	16.11	-5.605	1.295
	(8.581)	(0.351)	(15.31)	(9.678)	(4.376)
Controls	Yes	Yes	Yes	Yes	Yes
N	1027	1027	1027	1027	1027
R2 within	0.159	0.0105	0.0894	0.0493	0.0534
R2 between	0.00430	0.000937	0.000724	0.0170	0.00371
R2 overall	0.0508	0.00283	0.00741	0.0254	0.000395
P-value	0.0000	1.0000	0.1338	0.3174	0.0651
Panel 3: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	-0.514	-0.236	4.206	2.079	1.432
	(1.791)	(0.253)	(10.01)	(3.873)	(1.900)
Controls	Yes	Yes	Yes	Yes	Yes
N	5753	5753	5753	5753	5753
R2 within	0.0243	0.00553	0.0239	0.0125	0.0206
R2 between	0.00277	0.0000600	0.0355	0.00517	0.00175
R2 overall	0.00620	0.000324	0.0334	0.00625	0.000516
P-value	0.0001	0.9998	0.0000	0.0464	0.0001
Panel 4: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	0.257	-0.0514	7.761	0.471	-2.603
	(1.864)	(0.187)	(8.545)	(3.418)	(2.715)
Controls	Yes	Yes	Yes	Yes	Yes
N	5501	5501	5501	5501	5501
R2 within	0.0416	0.00410	0.0130	0.0208	0.0190
R2 between	0.00340	0.000120	0.0167	0.00459	0.0217
R2 overall	0.0115	0.00000036	0.0146	0.00734	0.0202
P-value	0.0000	1.0000	0.1022	0.0001	0.0021

* $p < .10$, ** $p < .05$, *** $p < .01$. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes elderly individuals (Panels 1 and 2) and children (Panels 3 and 4). The sample excludes observations from waves four and five.

Table A12: Changes in the labor allocation of households and working-age adults associated with electrification: waves 4-5

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Total household minutes per day allocated to each activity					
Household electricity	10.03*	1.098	-14.46	-13.18	-14.55**
	(5.757)	(5.811)	(13.80)	(9.593)	(7.198)
Controls	Yes	Yes	Yes	Yes	Yes
N	9312	9312	9312	9312	9312
R2 within	0.00756	0.0285	0.0477	0.0268	0.0366
R2 between	0.0135	0.00000523	0.0400	0.0258	0.0788
R2 overall	0.0117	0.000857	0.0419	0.0251	0.0603
P-value	0.0045	0.0000	0.0000	0.0000	0.0015
Panel 2: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	0.903	1.133	-5.722	-6.035*	-2.999
	(3.595)	(4.045)	(6.522)	(3.445)	(1.949)
Controls	Yes	Yes	Yes	Yes	Yes
N	9346	9346	9346	9346	9346
R2 within	0.00763	0.00619	0.0481	0.0212	0.0266
R2 between	0.0211	0.0117	0.0656	0.00191	0.00699
R2 overall	0.0155	0.00342	0.0104	0.0000460	0.00939
P-value	0.2022	0.1938	0.0000	0.0000	0.0033
Panel 3: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	3.540	0.283	-3.156	-6.221*	-3.005
	(2.965)	(2.157)	(4.368)	(3.598)	(2.544)
Controls	Yes	Yes	Yes	Yes	Yes
N	10634	10634	10634	10634	10634
R2 within	0.00628	0.00332	0.0234	0.0185	0.0109
R2 between	0.00450	0.00550	0.0293	0.0141	0.00516
R2 overall	0.00493	0.00184	0.00568	0.0150	0.00645
P-value	0.0266	0.4548	0.0000	0.0000	0.0369

* $p < .10$, ** $p < .05$, *** $p < .01$. Point estimates and robust s.e. (in parentheses) from regressions of household (Panel 1) individual (Panels 2 and 3) time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the household (Panel 1) and individual level (Panels 2 and 3), with household (Panel 1) and household and individual (Panels 2 and 3) controls (see Table A1). Sample includes all households (Panel 1) and working-age adults (Panels 2 and 3). The sample excludes observations from waves one to three.

Table A13: Changes in the labor allocation of elderly individuals and children associated with electrification: waves 4-5

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	-0.660	22.52*	-110.4***	0.613	2.742
	(4.495)	(12.78)	(25.25)	(6.333)	(6.090)
Controls	Yes	Yes	Yes	Yes	Yes
N	611	611	611	611	611
R2 within	0.148	0.0499	0.226	0.195	0.121
R2 between	0.000101	0.000131	0.136	0.00607	0.00428
R2 overall	0.00455	0.00184	0.164	0.0123	0.00102
P-value	0.9989	0.9861	0.0020	0.0000	0.4986
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	-14.42	0.307	-1.056	5.864	-8.193
	(11.72)	(0.254)	(21.02)	(8.469)	(8.870)
Controls	Yes	Yes	Yes	Yes	Yes
N	606	606	606	606	606
R2 within	0.0980	0.0824	0.138	0.0749	0.166
R2 between	0.0000253	0.000727	0.00138	0.0000984	0.00101
R2 overall	0.000916	0.00201	0.000619	0.00103	0.00387
P-value	0.9777	1.0000	0.5028	0.1073	0.0115
Panel 3: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	1.283	-0.476	1.242	-7.816**	-3.241
	(1.283)	(0.454)	(9.141)	(3.519)	(3.004)
Controls	Yes	Yes	Yes	Yes	Yes
N	3125	3125	3125	3125	3125
R2 within	0.0373	0.0236	0.0402	0.0284	0.0390
R2 between	0.00104	0.000275	0.00147	0.000215	0.000181
R2 overall	0.00692	0.000642	0.0000833	0.00369	0.00427
P-value	0.3853	1.0000	0.0021	0.0000	0.0784
Panel 4: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	0.131	-0.0263	1.364	-2.500	-3.586
	(1.505)	(0.341)	(8.007)	(4.492)	(3.396)
Controls	Yes	Yes	Yes	Yes	Yes
N	2890	2890	2890	2890	2890
R2 within	0.0283	0.0126	0.0554	0.0313	0.0736
R2 between	0.00285	0.000140	0.0253	0.000281	0.00111
R2 overall	0.000245	0.00108	0.0310	0.00287	0.00689
P-value	0.9084	1.0000	0.0014	0.0019	0.0008

* p < .10, ** p < .05, *** p < .01. Point estimates and robust s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from FE models at the individual level, with household and individual controls (see Table A1). Sample includes elderly individuals (Panels 1 and 2) and children (Panels 3 and 4). The sample excludes observations from waves one to three.

Table A14: Changes in the labor allocation of households and working-age adults associated with electrification: staggered DID

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Total household minutes per day allocated to each activity					
Household electricity	10.01	6.524	-26.74	-19.33***	-17.26***
	(7.621)	(6.529)	(19.40)	(6.475)	(5.338)
Controls	Yes	Yes	Yes	Yes	Yes
N	11549	11549	11549	11549	11549
Panel 2: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	4.852	1.697	-2.151	-6.948*	-2.062
	(4.002)	(4.434)	(8.513)	(3.737)	(1.692)
Controls	Yes	Yes	Yes	Yes	Yes
N	11836	11836	11836	11836	11836
Panel 3: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	2.869	0.280	-3.536	-7.785**	-4.378*
	(4.147)	(2.253)	(5.522)	(3.020)	(2.426)
Controls	Yes	Yes	Yes	Yes	Yes
N	12945	12945	12945	12945	12945

* p < .10, ** p < .05, *** p < .01. Point estimates and clustered s.e. (in parentheses) from regressions of household (Panel 1) individual (Panels 2 and 3) time allocation (minutes per day) on electrification are shown. Results are estimated from staggered DID models with regression adjustment (hdidregress ra) at the household (Panel 1) and individual level (Panels 2 and 3). The regression adjustment is done on the baseline values of household controls (Panel 1) and household and individual controls (Panels 2 and 3) (see table A1). Sample includes all households (Panel 1) and working-age adults (Panels 2 and 3).

Table A15: Changes in the labor allocation of elderly individuals and children associated with electrification: staggered DID

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	0.457	13.82*	-136.56***	-89.11*	-4.593
	(28.71)	(8.367)	(52.16)	(47.83)	(4.629)
Controls	Yes	Yes	Yes	Yes	Yes
N	1079	1079	1079	1079	1079
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	-2.399	1.235	-21.62	-13.25	5.087
	(11.66)	(1.424)	(76.45)	(14.30)	(12.30)
Controls	Yes	Yes	Yes	Yes	Yes
N	832	832	832	832	832
Panel 3: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	1.707	0.783	25.03**	-8.298**	-3.236
	(1.797)	(0.608)	(12.32)	(3.632)	(2.740)
Controls	Yes	Yes	Yes	Yes	Yes
N	5820	5820	5820	5820	5820
Panel 4: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	0.748	0.150	23.28**	-3.742	-15.91***
	(1.979)	(0.142)	(10.50)	(4.603)	(5.552)
Controls	Yes	Yes	Yes	Yes	Yes
N	5259	5259	5259	5259	5259

* p < .10, ** p < .05, *** p < .01. Point estimates and clustered s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from staggered DID models with regression adjustment (hdidregress ra) at the individual level. The regression adjustment is done on the baseline values of household and individual controls (see Table A1). Sample includes elderly individuals (Panels 1 and 2) and children (Panels 3 and 4).

Table A16: Changes in the labor allocation of households and working-age adults associated with electrification: SUR

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Total household minutes per day allocated to each activity					
Household electricity	63.74***	46.50***	-103.72***	-18.22***	-14.51***
	(4.013)	(3.868)	(5.859)	(2.365)	(1.739)
Controls	Yes	Yes	Yes	Yes	Yes
N	22257	22257	22257	22257	22257
R2	0.0924	0.1599	0.2696	0.0841	0.1129
Panel 2: Minutes per day allocated to each activity by each individual (Men)					
Household electricity	23.52***	25.38***	-36.91***	-3.252***	-2.889***
	(1.980)	(2.209)	(2.316)	(0.756)	(0.530)
Controls	Yes	Yes	Yes	Yes	Yes
N	22411	22411	22411	22411	22411
R2	0.0636	0.1312	0.1990	0.0183	0.0347
Panel 3: Minutes per day allocated to each activity by each individual (Women)					
Household electricity	25.07***	10.70***	-24.42***	-6.907***	-4.907***
	(1.882)	(1.488)	(1.660)	(0.982)	(0.778)
Controls	Yes	Yes	Yes	Yes	Yes
N	25045	25045	25045	25045	25045
R2	0.0552	0.0858	0.1045	0.0573	0.0898

* p < .10, ** p < .05, *** p < .01. Point estimates and s.e. (in parentheses) from regressions of household (Panel 1) individual (Panels 2 and 3) time allocation (minutes per day) on electrification are shown. Results are estimated from SUR models at the household (Panel 1) and individual level (Panels 2 and 3), with household (Panel 1) and household and individual (Panels 2 and 3) controls (see Table A1). Time fixed effects are controlled for. Sample includes all households (Panel 1) and working-age adults (Panels 2 and 3).

Table A17: Changes in the labor allocation of elderly individuals and children associated with electrification: SUR

	(I) Self-employed work	(II) Wage work	(III) Farm work	(IV) Firewood fetching	(V) Water fetching
Panel 1: Minutes per day allocated to each activity by each individual (Older Men)					
Household electricity	19.89***	11.56**	-25.18***	1.291	0.461
	(4.843)	(4.655)	(8.618)	(1.668)	(1.648)
Controls	Yes	Yes	Yes	Yes	Yes
N	1747	1747	1747	1747	1747
R2	0.0683	0.0751	0.1407	0.0255	0.0235
Panel 2: Minutes per day allocated to each activity by each individual (Older Women)					
Household electricity	7.106	-0.383	3.470	-3.118	-5.327***
	(4.980)	(1.701)	(5.726)	(3.104)	(1.697)
Controls	Yes	Yes	Yes	Yes	Yes
N	1633	1633	1633	1633	1633
R2	0.0762	0.0221	0.0941	0.0515	0.0962
Panel 3: Minutes per day allocated to each activity by each individual (Boys)					
Household electricity	2.101**	0.162	-25.42***	-7.490***	-3.839***
	(0.828)	(0.395)	(3.704)	(1.299)	(0.817)
Controls	Yes	Yes	Yes	Yes	Yes
N	8878	8878	8878	8878	8878
R2	0.0279	0.0041	0.1217	0.0214	0.0294
Panel 4: Minutes per day allocated to each activity by each individual (Girls)					
Household electricity	5.259***	0.488	-19.55***	-5.484***	-6.730***
	(0.947)	(0.305)	(2.959)	(1.577)	(1.142)
Controls	Yes	Yes	Yes	Yes	Yes
N	8391	8391	8391	8391	8391
R2	0.0410	0.0034	0.0816	0.0321	0.0554

* p < .10, ** p < .05, *** p < .01. Point estimates and s.e. (in parentheses) from regressions of individual time allocation (minutes per day) on electrification are shown. Results are estimated from SUR models at the individual level, with household and individual controls (see Table A1). Time fixed effects are controlled for. Sample includes elderly individuals (Panels 1 and 2) and children (Panels 3 and 4).