# Clean Energy Access and Home Production Improvement: Labor Supply and Gender Difference

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**Abstract**

This paper examines how improvements in home production technology influence labor supply and time allocation within households. Using nationally representative data from Nepal, I estimate the causal impact of adopting liquefied petroleum gas (LPG) cookstoves, a cleaner and more efficient technology, on men's and women's labor market outcomes. To address endogeneity in stove adoption, I exploit geographic variation in average land slope as an instrumental variable that affects the cost and accessibility of LPG distribution but is otherwise unrelated to labor supply. The results show gender differences in response to the LPG stove adoption. LPG adoption increases men's likelihood of employment and the number of workdays per year, while women's employment and workdays decline modestly. On average, men work about 20 additional days per year following adoption, whereas women work about 20 fewer days per year. Time-use data indicate that LPG stoves substantially reduce time spent on fuel collection and cooking for both genders. Women reallocate much of this saved time to other domestic or caregiving tasks rather than market work. These findings provide empirical evidence that men and women respond differently to improvements in home production due to gender norms, labor-demand-side inequality, and intra-household bargaining power dynamics.

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# 1 Introduction

In many developing countries, cooking remains a central part of home production, and family members devote substantial time to it, often reflecting persistent gender inequalities (Dinkelman and Ngai, 2022). Studies found that adopting clean fuel stoves can save time for cooking and expand the market work through the time-saving channel.

This paper focuses on gender differences in labor supply and in the adoption of clean fuel cookstoves, which are associated with improvements in home production. By switching from an unclean fuel cookstove to a cleaner, more efficient one, household members can save time on fuel collection, lighting, and cooking (Krishnapriya et al., 2021; SDG, 2021). However, their labor supply decision takes into account various factors such as differences in gender norms and household empowerment. It is hard to conclude that time saving can be a direct link to the labor supply. In addition, home production improvement is a crucial factor influencing the household members' dynamic labor supply decision (Chiappori, 1997; Apps and Rees, 1997; Afridi et al., 2018). Beyond the adoption of clean cooking stoves and improvements in home production, this paper aims to provide empirical evidence on the impact of more efficient cookstove adoption on labor supply decisions and to quantify the gender difference in labor supply outcomes. The main results indicate that women's employment falls slightly after adopting LPG stoves, while the amount of days they spend working does not appear to change. In contrast, men show modest increases in both employment and workdays following adoption.

Existing studies have explored how access to clean cooking energy affects labor supply, but the evidence remains inconclusive. Randomized controlled trials often find no significant effects of improved stove programs on labor outcomes (Berkouwer and Dean, 2022; Afridi et al., 2023; Hanna et al., 2016; Imelda, 2020; Su and Azam, 2023; Shen et al., 2025), while quasi-experimental analyses suggest potential labor market impacts from the case study of Indonesia and China. (Imelda, 2020; Su and Azam, 2023; Shen et al., 2025).

This paper addresses three main questions on how the adoption of LPG cookstoves affects labor supply decisions. The First question is how does stove adoption influence household time allocation, such as market work, cooking fuel-related activities, cooking activities, child care, study, etc. The second question is about changes in employment outcomes, capturing changes along the extensive margin of labor supply. The third question is about the intensive margin of labor supply among workers whose main occupation is directly related to income generation, measured by the number of workdays per year.

This study faces important identification challenges. In a quasi-experimental setting, stove adoption is typically an endogenous household decision that may be correlated with unobserved characteristics such as potential income, preferences, or gender attitudes. Moreover, reverse causality may arise if individuals with greater labor market participation are more likely to adopt more efficient cookstoves. These issues complicate the isolation of the stove's pure effect on labor supply. To address these endogeneity concerns, this paper introduces a novel source of exogenous variation to identify the causal impact of clean energy stove adoption. I use average land slope as an instrumental variable (IV) for LPG stove adoption. Land slope captures geographic variation in the ease of LPG distribution and accessibility, which strongly predicts household adoption of LPG stoves. Recent paper by Lee and Kwon (2025) found a robust correlation between land slope and LPG stove adoption across Nepal, supporting the relevance of this instrument. This approach is similar in spirit to Dinkelman (2011), who used land gradient to study the impact of rural electrification on labor supply in South Africa. Since slope is a geographic characteristic determined by nature and unrelated to labor supply decisions, it provides a credible source of exogenous variation in stove adoption. Nepal offers an especially suitable context for this identification strategy. The country's mountainous terrain creates large natural differences in slope and thus in LPG accessibility across regions.

Nepal is a country where many households continue to rely on traditional open-fire stoves with non-clean fuels for cooking. Although there has been a gradual increase in the use of clean-fuel stoves, mainly LPG stoves, the adoption rate remains low. Improved cookstoves have been adopted by only a small fraction of households, with the majority still primarily using wood-based traditional open-fire stoves. According to a study by Pinto et al. (2019), 26.3% of households use LPG stoves, and 2% use biogas stoves. The situation is even more concerning in rural areas, where only 20% of households use LPG stoves, while 67% continue to rely on traditional open-fire stoves. In contrast, 47% of urban households have adopted LPG stoves. Two main types of stoves widely used among Nepalese are the wood-based traditional open-fire stove and the LPG stove. Therefore, I anticipate that the statistical results will accurately capture the impact of LPG stove adoption compared to traditional wood-burning stoves.

The results for time allocation show substantial gender differences in response to LPG stove adoption. Using household-level data, I found that men spend 164 additional minutes per day on income-generating work outside the home, while women's time in such activities does not change significantly. Adoption of LPG stoves sharply reduces time spent on fuel-related tasks for both genders. Women spend 453 fewer minutes per day collecting fuel, 79 fewer minutes preparing fuel, and 48 fewer minutes cooking. Among men, fuel collection time decreases by 209 minutes per day, fuel preparation by 121 minutes, and cooking by 29 minutes. Notably, despite spending less time cooking, women devote an additional 33 minutes per day to other activities in the kitchen.

The second part of the analysis examines the extensive margin of labor supply. Using individual-level data, the results indicate that LPG stove adoption increases men's likelihood of working by roughly 13 percentage points, while reducing women's likelihood of working by about 31 percentage points.

The third part of the analysis focuses on the intensive margin, measured by the number of workdays per year. Using individual-level data and a restricted sample of individuals whose main occupation type can generate income through additional workdays, the results show that men work about 20 more days per year following LPG stove adoption, whereas women's total number of workdays decreases by 20 days per year.

These gender-differentiated effects can be explained by the home production channel. Although LPG stoves substantially reduce the time required for fuel collection and cooking, the time saved for women may be reallocated to other household or caregiving activities rather than to market work, due to intra-household empowerment and potential wage differentials between men and women. In contrast, men appear to shift part of their saved time toward income-generating activities, such as market work. This mechanism highlights how technological improvements in home production can influence labor supply decisions differently across genders, even within the same household. (Chiappori, 1997; Apps and Rees, 1997; Afridi et al., 2018, 2023)

This paper makes several contributions to the literature. First, it provides the new causal evidence that improvements in home production technology can generate opposite-signed labor-supply responses across genders within the same household. Building on Afridi et al. (2018), who highlight the role of rising returns to home production in explaining gender gaps in labor participation, this paper advances that line of inquiry by exploiting exogenous geographic variation in land slope as an instrument for LPG stove adoption. This approach isolates changes in home production efficiency that are external to household choice and examines their implications for labor allocation. The analysis connects this empirical strategy to the collective-household framework, emphasizing how intra-household bargaining and gendered labor-market constraints mediate the effects of technological progress within the household.

Second, it contributes to the growing literature on modern energy access and its impact on economic outcomes by providing new evidence on how modern energy affects labor supply differently by gender. Several studies focus on the modern energy access impact on the labor supply (Berkouwer and Dean, 2022; Hanna et al., 2016; Verma and Imelda, 2022; Dinkelman, 2011; Greenwood et al., 2005). While they focus on energy access to electricity and improved cookstoves, this paper focuses on LPG stove adoption through the home production channel and the gender difference response.

Third, this paper contributes to the literature on clean cooking interventions, which has largely focused on health benefits, indoor air pollution, and time savings (Imelda, 2020; Krishnapriya et al., 2021). In contrast, this study emphasizes labor supply outcomes—including work time, employment, and workdays—arising from LPG stove adoption through home production channels. There are a few studies that empirically examine the impact of clean cook stoves on the labor supply outcome (Verma and Imelda, 2022; Shen et al., 2025; Li and Zhou, 2023; Su and Azam, 2023). Their main channels are health benefits and time-saving, and their results found no difference in the gender labor supply outcome. Indeed, female labor supply increased in their paper, using data from China and Indonesia. However, this paper documents the main channel as a home production improvement with gender differences in labor supply decisions using nationally representative Nepal data.

Finally, the paper contributes to broader debates on female labor supply and home production. Previous studies document the "working women puzzle" in India, where female labor force participation remains low despite economic development Afridi et al. (2018); Fukui et al. (2023). Theoretical models highlight that household labor supply decisions are made jointly among members (Chiappori, 1997; Apps and Rees, 1997). Using nationally representative data from Nepal, this paper provides new empirical evidence on this puzzle in the context of modern energy adoption, underscoring the importance of intra-household mechanisms and women's empowerment in shaping labor market outcomes.

The remainder of the paper is organized as follows. Section 2 describes the data sources, sample construction, and variable construction. Section 3 presents the theoretical background. Section 4 explains the empirical identification strategy, with a particular focus on the instrumental variable approach used to address endogeneity concerns. Section 5 examines the impact of modern energy access on time allocation, including the model specification and estimation results. Section 6 presents the main findings on the labor supply outcomes, focusing on both the intensive and extensive margins. Section 7 discusses the home production mechanism, which is the central channel in this study, alongside other potential pathways. Section 8 concludes.

# 2 Data

## 2.1 Multi-Tier Framework (MTF) Data and Variable Construction

This study uses data from the Multi-Tier Framework (MTF) Survey – Nepal, a nationally representative dataset that provides detailed information on household energy access, including cooking fuels and stove types. The survey also collects rich socioeconomic data on household characteristics, asset ownership, and transportation access.

The MTF survey, developed by the Energy Sector Management Assistance Program (ESMAP), supports monitoring progress toward the Sustainable Development Goals (SDGs) and establishes a global standard for measuring energy access. Unlike traditional binary measures of electricity access, the MTF adopts a multidimensional framework that captures availability, reliability, convenience, affordability, and safety (Bhatia and Angelou, 2015). Using a tiered classification system ranging from 0 to 5, it provides a nuanced understanding of household energy access and its implications for welfare.

The MTF data are particularly suitable for this study because they record detailed information on the types of fuels used for each household stove. Nepalese households report a broad range of cooking fuels, including animal waste, biomass, charcoal, coal, plant residues, garbage, peat, pellets, sawdust, wood, biogas, electricity, kerosene, LPG, natural gas, and solar energy. Using this information, I can clearly identify households that use clean fuels—LPG, biogas, electricity, or solar energy—enabling a precise analysis of LPG adoption.

Most importantly, the MTF survey collects information on labor supply and time usage data, which are key outcome variables for this study. To be specific, the MTF survey collects information on total household time spent on cooking and related domestic activities, which is reported at the household level rather than by individual members. Accordingly, I use the household-level dataset for this analysis.

The main outcome variables capture individual labor supply. The variable workdays per year is constructed by combining two MTF questions: "How many months did you work?" and "How many days did you work in a typical month?" Multiplying these responses yields the total number of days worked per year. The MTF also records each respondent's main job type, which I use to construct several labor-outcome measures: a binary work indicator and a nonfarm employment dummy. Figure 1 shows the distribution of job types by gender

For the individual-level sample, I exclude respondents classified as "student," "retired/pensioner," "too old to work," or "disabled," since their labor market participation decisions are not comparable to those of working-age adults. For example, students invest in education to increase future earnings, so their current labor supply reflects different welfare trade-offs. The key outcome variable, employment, is defined as a binary indicator equal to one if the respondent's main occupation is listed as wage employee (farm or non-farm), self-employed (farm or non-farm), assisting in a family enterprise, or casual laborer, and zero otherwise.

For the intensive margin analysis, the outcome variable workdays per year is used to measure labor supply among individuals whose work intensity directly affects their income. Accordingly, I restrict the sample to respondents whose main occupation is wage employment (farm or non-farm) or non-farm self-employment, where the number of days worked is closely linked to earnings.

Household income is proxied by total household expenditure, following standard practice in settings where income data are noisy or incomplete. I construct a household wealth index based on housing materials—specifically, wall and roof composition—reflecting the correlation between physical dwelling characteristics and long-term wealth (Bergeron et al., 2021).

To control for contextual and demographic heterogeneity, I include control variables that correspond to the unit of analysis for each outcome. For the household-level time allocation outcomes, I construct household-level controls, including the household head's age, gender, years of education, and main occupation. Additional household controls include the number of adult men, women, and children, the number of stove burners, and an indicator for bank account ownership. For the individual-level outcomes—employment status and workdays per year—I include both household and individual characteristics. Household-level controls include an urban–rural indicator, fuel availability, cooking frequency, and the number of stove burners. Individual-level controls include marital status, age, education, household size, number of children, and whether the individual is the household head.

Table 1 presents summary statistics for the main individual-level variables, disaggregated by gender and LPG adoption status. The table reports means and standard deviations. On average, individuals in LPG-using households have higher total household expenditures, higher education levels, and better dwelling quality. Urban residence and bank account ownership are also more prevalent among LPG users. Employment rates are substantially higher for men than for women across both groups, while average workdays per year are similar across LPG and non-LPG users. These descriptive patterns provide a preliminary overview of household and individual characteristics before turning to the empirical analysis.

Table 2 and 3 report household-level summary statistics for women and men, separately by LPG adoption status. The tables compare time use, household characteristics, and household-head characteristics for households without LPG access and those that have adopted LPG. Among women, LPG adoption is associated with large reductions in time spent on fuel collection and fuel preparation, as well as lower cooking time, alongside higher household expenditure and greater access to financial services. In contrast, women in LPG households spend more time in paid inside work, study, and leisure activities. Among men, LPG adoption is also associated with substantial reductions in time devoted to fuel collection and fuel preparation, while time spent in paid outside work, leisure, and non-farm employment is higher in LPG households. LPG-adopting households are more urban, wealthier, and have higher rates of bank-account ownership, and household heads in these households are more educated and more likely to be employed outside agriculture. Summary statistics are restricted to households with at least one adult woman or at least one adult man, respectively.

### 2.2 Geography Data (Instrumental Variable)

To capture geographic variation and construct the instrumental variable, I use average land slope measured at the municipality level, corresponding to GADM level 4—the smallest available administrative boundary (Hijmans et al., 2015, 2022; Ribeiro and Diggle, 2003). [1] Slope values range from 0 to 90 degrees and provide fine-grained spatial variation across Nepal's topography. For each administrative unit, I calculate the mean land slope. Figure 2 presents the elevation map. It shows the geographical variation in Nepal. Figure 3 illustrates the administrative boundaries used in the analysis.

The MTF dataset contains geographic identifiers at the province, district, and municipality levels. I merge the average slope of each municipality with the MTF data, allowing for municipality-level identification and a more granular empirical analysis.

## 3 Theory Background

This section provides a conceptual framework to understand how the adoption of improved home production technology—specifically, LPG stoves—affects household members' time allocation and labor supply. The analysis builds on the collective household model of Chiappori (1997), Apps and Rees (1997), and Donni (2008), where household labor supply decisions are jointly determined within the household. The model highlights

[1] https://gadm.org/

how improvements in home production efficiency alter the opportunity cost of time spent on domestic tasks and, in turn, influence market labor supply.

## 3.1 Model Setup

Consider a household composed of two members, indexed by $i = 1, 2$. Each member derives utility from private consumption $x_i$, a domestic good $y_i$, and leisure $L_i$:

$$\max_{x_i, y_i, L_i} u^i(x_i, y_i, L_i) \tag{1}$$

Following the collective household model of Chiappori (1997) and Donni (2008), the household is assumed to reach Pareto-efficient allocations. This implies the existence of a sharing rule, $\phi_i(\cdot)$, that determines how total household resources are divided between members as a function of their potential wages, $w_i$, non-labor income, $m_i$, and bargaining power, $\theta$, captures the relative bargaining position within the household. It may be influenced by factors such as education, asset ownership, or social norms:

$$s_i = \phi_i(w_1, w_2, m_1, m_2, \theta) \tag{2}$$

The sharing rule summarizes the intra-household allocation of resources and determines each member's individual budget constraint. Improvements in home production technology—such as LPG stove adoption—may influence this sharing rule by reducing domestic time requirements and potentially shifting bargaining power within the household.

The domestic good is produced through a household production $h(t_1, t_2)$, where $t_i$ denotes the time member $i$ devotes to home production. The level of home production efficiency is denoted by $A > 0$, representing the technology parameter that improves with LPG stove adoption.

The household maximizes the net value of domestic production:

$$\max_{t_1, t_2} pAh(t_1, t_2) - w_1 t_1 - w_2 t_2 \tag{3}$$

where $p$ is the price of the domestic good, and $w_i$ denotes the potential market wage for member $i$. For simplicity, the model assumes that domestic goods are marketable, a common assumption, especially in rural and farming areas of developing countries. Also, the market is complete, so households are price takers for the domestic good; thus, $p$ is exogenous.[2]

[2]Following Chiappori (1997), the model assumes that domestic goods are marketable and markets are

### 3.2 Home Production

The first-order conditions are:

$$pA\frac{\partial h(t_1,t_2)}{\partial t_1} = w_1, \quad \text{and} \quad pA\frac{\partial h(t_1,t_2)}{\partial t_2} = w_2 \tag{4}$$

These equations determine the optimal allocation of time to home production for each member. An increase in $A$ reduces the marginal time required to produce a given level of domestic good, implying $\frac{\partial t_i}{\partial A} < 0$.

### 3.3 Individual Utility Maximization

Each member allocates income across private consumption, domestic goods, and leisure, solving:

$$\max_{x_i, y_i, L_i} u^i(x_i, y_i, L_i) \tag{5}$$

subject to the budget constraint:

$$x_i + py_i + w_i L_i = s_i \tag{6}$$

where $s_i$ stands for member $i$'s income sharing from the potential household income. The total household potential income is given by:

$$s = s_1 + s_2 = (w_1 + w_2)T + m_1 + m_2 + pAh(t_1, t_2) - w_1 t_1 - w_2 t_2 \tag{7}$$

where $T$ is the total available time and $m_i$ represents nonlabor income. Standard first-order conditions yield:

$$\frac{\partial u^i}{\partial x_i} = \frac{1}{p}\frac{\partial u^i}{\partial y_i} = \frac{1}{w_i}\frac{\partial u^i}{\partial L_i} \tag{8}$$

which characterizes the optimal allocation between consumption and leisure.

complete. Households, therefore, take prices as given, and the price of the domestic good is exogenous. Allowing for non-marketable domestic goods would imply endogenous (shadow) prices and non-separable household decisions, substantially complicating the analysis.

### 3.4 Effect of Improved Home Technology

Total labor supply for member *i* be:

$$l_i = T - L_i(w_i, s_i^*) - t_i(w_1, w_2, A) \tag{9}$$

where $s_i^*$ denotes the individual's optimized share of household resources determined by the sharing rule. Differentiating with respect to A,

$$\frac{\partial l_i}{\partial A} = -\frac{\partial L_i}{\partial s_i^*}\frac{\partial s_i^*}{\partial A} - \frac{\partial t_i}{\partial A} \tag{10}$$

Because $\frac{\partial t_i}{\partial A} < 0$, $\frac{\partial s_i^*}{\partial A} > 0$, and $\frac{\partial L_i}{\partial s_i^*} > 0$, the first term is negative while the second is positive. The net effect of improved home technology on labor supply is therefore ambiguous. If the time-saving effect, $-\frac{\partial t_i}{\partial A} < 0$, dominates, household member *i*'s labor supply increases. If the income effect $-\frac{\partial L_i}{\partial s_i^*}\frac{\partial s_i^*}{\partial A}$ dominates, *i*'s labor supply decreases.

Because labor supply decisions within the household are jointly determined, changes in one member's time allocation resulting from adopting an LPG stove, an advanced clean cooking stove, framework provides the basis for the empirical analysis, which examines how LPG adoption, representing an improvement in home production technology, affects male and female labor supply and time allocation.

## 4 Identification Strategy and Instrumental Variable

A key econometric concern in this study is the potential endogeneity of the main explanatory variable—LPG stove adoption. The decision to adopt an LPG stove is not random but arises from household self-selection. Unobserved factors, such as preferences for market work or time-saving technologies, may influence both stove adoption and labor outcomes. Households with stronger work preferences or higher earnings potential may be more inclined to invest in modern cooking technologies, leading to biased estimates if not properly addressed. To correct for this bias, I employ an IV strategy using a control function approach.

The instrument for LPG adoption is the average land slope at the municipality level. The idea builds on Dinkelman (2011), who used land slope as an instrument for electricity grid expansion in South Africa. In her study, steeper terrain increased the cost of extending the electrical grid, making grid connections less likely in such areas and thereby providing exogenous variation in access to electricity.

A similar logic applies to LPG stove adoption in Nepal. While the primary clean cooking technology in Nepal is the LPG stove, access to LPG depends on the ability to transport and refill gas cylinders—typically 3 kilograms or larger. In regions with rugged or mountainous terrain, higher transport costs and weaker supply infrastructure make LPG adoption less likely. Consistent with this mechanism, recent evidence from Nepal shows that average land slope strongly predicts household LPG adoption rates (Lee and Kwon, 2025). Land slope thus serves as a plausible proxy for the geographic difficulty of LPG distribution. It is correlated with stove adoption but not directly with household labor supply, except through its effect on LPG access. Based on this rationale, I use average land slope as an instrumental variable for LPG stove adoption in the empirical analysis.

The exclusion restriction requires that land slope affect labor supply only through its effect on LPG adoption. A first potential threat is that installing an LPG stove could itself induce labor-supply adjustments if households increase work effort to cover the continuing cost of LPG refills. This mechanism would violate the exclusion restriction if installation creates unanticipated financial pressure. In this setting, however, households make adoption decisions by weighing the full present value of the operating costs associated with LPG use. Refilling fees and accessibility constraints are widely known and highly salient. As a result, households internalize the stream of expected LPG expenses at the time of adoption with the forward-looking decision process, and installation does not introduce new, unexpected economic burdens that would alter labor-supply behavior independently.

A second concern is that slope may be correlated with commuting costs because rugged terrain can increase the effort required to reach work. However, these effects are likely limited, as households typically stay in the same locality for long periods and adapt routines to the terrain. This adaptation means that commuting burdens vary little among households within an area. Furthermore, without substantial population movement, land roughness is unlikely to cause systematic differences in work preferences.

As noted by Dinkelman (2011), slope may, however, be correlated with labor supply in the farm sector, since agricultural productivity tends to be higher on flatter land. If so, the IV could pick up differences in farm labor rather than the causal effect of LPG adoption. To address this concern, I estimate heterogeneous effects across urban and rural areas, where the sectoral composition of employment differs. Rural areas are far more reliant on agriculture, while urban areas are dominated by non-farm activities. Tables 17 and 18 show that the estimated effects are similar across these settings. This pattern suggests that any bias arising from differences in land productivity across slopes is likely limited.

# 5 Households' Time Allocation

The analysis begins by exploring how the adoption of LPG stoves influences time use among women and men, as adults typically carry the main responsibility for how time is allocated within the household. Since the MTF dataset reports time-use data in aggregate form by gender—capturing the total time spent by men and women in each household rather than individual-level data—the focus is placed on adult men and women, who are primarily responsible for both income generation and home production.

## 5.1 Empirical Framework

The main equation with time allocation outcome variable is following:

$$y^*_{hj} = \alpha_0 + \alpha_1 T_{hj} + X'_{hj}\alpha_2 + \alpha_3 \hat{r}_{hj} + \epsilon_{hj}, \quad \epsilon_{hj}|T_{hj}, X_{hj}, \hat{r}_{hj} \sim \mathcal{N}(0, \sigma^2) \tag{11}$$

$$y_{hj} = max(0, y^*_{hj}) \tag{12}$$

where $y^*_{hj}$ representing time spent on the activity, and $y_{hj}$ is the observed censored value. $T_{hj}$ indicates whether household $h$ in region $j$ has adopted an LPG stove, and $X_{hj}$ denotes the vector of household covariates such as total household expenditure, housing structure quality, cooking fuel availability, credit, the number of households, household head's education level, age, gender, and marital status.. The coefficient of interest, $\alpha_1$, captures the causal effect of LPG adoption on household time use. The outcome variable time allocation, so it is censored below zero.

Since $T_{hj}$ is endogenous, I use an IV approach implemented through a control function framework, which allows the inclusion of a residual correction term in the Tobit specification.

In the first stage, I estimate the probability of LPG adoption using a probit model:

$$Pr[T_{hj} = 1|Z_j, X_{hj}] = \Phi(\beta_0 + \beta_1 Z_j + X'_{hj}\delta) \tag{13}$$

$Z_j$ is an instrumental variable (average land slope in region $j$), and $X_{hj}$ represents the vector of same household controls as in the second stage. Because the first stage is nonlinear, I compute the generalized residual following the standard control functio prodecure:

$$\hat{r}_{hj} \equiv T_{hj}\lambda(\hat{\beta}_0 + \hat{\beta}_1 Z_j + X'_{hj}\hat{\delta}) - (1 - T_{hj})\lambda(-(\hat{\beta}_0 + \hat{\beta}_1 Z_j + X'_{hj}\hat{\delta})) \tag{14}$$

where, $\lambda(\cdot)$ is Inverse Mills Ratio (IMR). The estimated residual, $\hat{r}_{hj}$ is then included in the Tobit regression to correct for endogeneity in $T_{hj}$

## 5.2 Results

Table 4 reports the estimated effects of LPG stove adoption on the time men and women spend working outside the home. The analysis is conducted separately by gender to account for systematic differences in labor participation. In the simple OLS specification, LPG adoption is not significantly associated with time spent on outside work for either group. However, when endogeneity is addressed using the two-stage least squares (2SLS) approach, LPG adoption shows a significant effect, with the magnitude and direction differing by gender. Once nonlinearity is incorporated through the control function approach—using a probit first stage and a Tobit second stage—the results indicate that LPG adoption significantly increases the time men devote to outside work by about 164 minutes on a typical day, while the effect for women remains statistically insignificant. These findings suggest that improvements in household production technology primarily relax men's time constraints for market work, with limited immediate effects on women's labor supply.

This analysis raises the question of how households reallocate their time when they gain access to clean energy, and whether these adjustments differ between men and women. The MTF dataset provides detailed information on the time men and women spend on a range of daily activities, including work inside the home, fuel collection and preparation, cooking, time spent in the cooking area, childcare, studying, and leisure or entertainment.

Tables 5 and 6 show that LPG stove adoption affects time allocation differently for women and men. Both groups experience substantial reductions in time spent on fuel collection and preparation, though the magnitude of these effects varies. For women, fuel collection time declines by about 454 minutes, compared to 209 minutes for men. In contrast, men show a larger reduction in fuel preparation time. These results indicate that LPG adoption significantly reduces the total time devoted to fuel-related activities, particularly those associated with cooking. This pattern is consistent with previous evidence on the time-saving effects of clean energy and improved cooking technologies such as LPG and improved cookstoves (Berkouwer and Dean, 2022).

One interesting finding from the results is that men save time on cooking fuel-related activities, and they use that saved time for other activities such as work, studying, and entertainment. On the other hand, women also save time on cooking fuel-related activities, but they tend to use that saved time for studying and entertainment. Despite the decrease in cooking time, women still spend more time on activities in the cooking area compared to men. This suggests that while cleaner cooking technology alleviates fuel-related burdens for both genders, gendered roles within the household continue to shape how time savings are distributed.

A limitation of the MTF data is that time-use information is reported at the group level—men, women, boys, and girls—rather than for individual household members. Consequently, these variables capture the combined time allocation of household members within each group. For instance, if fuel collection time rises, multiple household members may contribute, raising the group's total. Alternatively, if one person specializes in a task—such as a man primarily responsible for collecting fuel—the group's total will largely reflect his contribution. Therefore, the interpretation of these results should be understood at the group rather than the individual level.

# 6 Employment and Workdays

This section examines the effects of LPG stove adoption on individual labor supply, focusing on two complementary outcomes: (i) employment status (the extensive margin) and (ii) the number of workdays per year (the intensive margin). Both outcomes are estimated using the IV strategy described above. The first-stage specification remains the same, but the second-stage model differs according to the outcome variable. Employment is modeled using an IV-Probit regression, while workdays are estimated using a linear IV specification. The workdays sample is restricted to individuals in wage employment, for whom the number of workdays is closely linked to earnings.

Figure 4 illustrates the simple relationship between LPG stove adoption and employment rates for men and women across regions. Regions with higher LPG adoption rates tend to show higher male employment and negative correlation with female employment. These descriptive patterns are not causal but suggest possible gender differences in how access to modern cooking technology relates to labor supply.

Figures 4, 5, and 6 present simple descriptive relationships between LPG stove adoption and labor supply outcomes. Figure 4 shows the correlation between LPG adoption and employment rates for men and women, while Figure 5 and Figure 6 plot the distribution of the number of workdays per year against LPG adoption for women and men, respectively. In the Figure 4, regions with higher rates of LPG adoption exhibit higher male labor participation, whereas the association for women is negative. These figures are not intended to suggest causality but to illustrate the broad gender differences that motivate the empirical analysis. In the Figure 5 and Figure 6, the average of the workdays is higher if they have LPG stove for both male and female. These figures are not intended to suggest causality but to illustrate the broad gender differences that motivate the empirical analysis.

## 6.1 Extensive Margin - Employment

### 6.1.1 Empirical Framework

Employment status is a binary variable, so the model has a binary outcome. To take into account the nonlinearity from this binary outcome variable and binary endogenous variable, I use the probit model for the first and second stage equations with IV.

The main equation is:

$$Pr[W_{ihj} = 1|T_{ihj}, M_{ihj}, \hat{r}_{ihj}] = \Phi(\alpha_0 + \alpha_1 T_{ihj} + M'_{ihj}\alpha_2 + \alpha_3 \hat{r}_{ihj}) \tag{15}$$

$W_{ihj}$ represents the employment status of individual $i$. Since $W_{ihj}$ is a dummy variable and equal to 1 if the individual is working, the probit model is used. $M_{ihj}$ is a vector of controls both individual- and household-level characteristics. Individual-level controls are age, gender, education, marital status, and household head status. Household-level controls include total expenditure, dwelling quality, fuel availability, household size, and an urban–rural indicator. The term $\hat{r}_{ihj}$ is the generalized residual from the first-stage Probit regression.

The first stage employs the probit model, as the endogenous variable, LPG stove adoption, is a dummy variable.

$$Pr[T_{ihj} = 1|Z_j, M_{ihj}] = \Phi(\beta_0 + \beta_1 Z_j + M'_{ihj}\zeta) \tag{16}$$

$Z_j$ serves as an IV for this study, representing the average land slope of region $j$. $M'_{hj}$ denotes the same household characteristics with the second stage regression. To implement the control function approach, let $\hat{r}_{ihj}$ be the generalized residual extracted from the first-stage probit model. Then, I have.

$$\hat{r}_{ihj} \equiv T_{ihj}\lambda(\hat{\beta}_0 + \hat{\beta}_1 Z_j + M'_{ihj}\hat{\zeta}) - (1 - T_{ihj})\lambda(-(\hat{\beta}_0 + \hat{\beta}_1 Z_j + M'_{ihj}\hat{\zeta}) \tag{17}$$

$\lambda(\cdot)$ represents an IMR estimated from the first regression.

### 6.1.2 Results

Table 7 reports the estimated effects of LPG stove adoption on employment status for women and men. The Linear Probability Model(LPM) estimates in columns (1) and (3) suggest a small and significant relationship between LPG adoption and employment for men, but a negative association for women. However, these LPM estimates may be biased due to the endogeneity of LPG adoption.

After correcting for endogeneity using the IV approach with the control function correction, the results change substantially. In the IV specification, LPG stove adoption has a strong negative effect on women's employment and a positive effect on men's employment, both statistically significant. The coefficient for women, -0.944, implies that households adopting LPG stoves are significantly less likely to have women engaged in market work, while the coefficient for men, 0.905, indicates a positive association with men's market work.

To better interpret these nonlinear effects, Table 8 presents the average marginal effects derived from the IV-Probit estimation. The results show that, on average, LPG adoption reduces women's probability of market work by about 31 percentage points, whereas it increases men's probability of market work by about 13 percentage points.

The adoption of modern, time-saving cooking technology appears to enable men to increase their participation in market work, potentially because time saved from fuel-related tasks is reallocated to income-generating activities. In contrast, women's employment declines following LPG adoption. This may reflect persistent intra-household gender norms and low potential wage because of the gender inequality in labor demand, where reductions in domestic workload do not necessarily translate into greater market work participation for women. Instead, women may use the saved time for leisure, education, or other non-market activities, as the Table 5 shows the time women's allocation change.

These gender-differentiated effects are consistent with predictions from the collective household model discussed in Section 3. Within this framework, LPG adoption increases household efficiency in home production, effectively raising the total household income or potential surplus. However, how this gain translates into individual labor supply depends on the sharing rule—the intra-household allocation of resources that reflects each member's bargaining power. For men, the substitution effect from time saved in domestic activities appears to dominate: reduced home production time increases their opportunity to engage in market work. For women, by contrast, the income effect arising from a higher household surplus may offset the time-saving substitution effect. If the sharing rule allocates part of the gain from improved home technology toward women's consumption or leisure, their incentive to supply additional labor declines. Consequently, even though LPG adoption reduces women's time burden, it does not lead to a corresponding rise in employment.

These findings indicate that access to clean cooking technology affects the extensive margin of labor supply differently for men and women. While LPG adoption relaxes time constraints and promotes men's engagement in market work, women's labor supply appears less responsive, highlighting the importance of intra-household allocation dynamics and the home production channel.

#### 6.1.3 Non-Farm Employment

Table 9 reports estimates from linear probability LPM and IV specifications examining the relationship between LPG adoption and non-farm employment for women and men. The dependent variable is an indicator for participation in non-farm employment.

For women, LPG ownership is positively associated with non-farm employment in the LPM specification, with a coefficient of 0.044. However, the IV estimate is larger in magnitude, 0.080, but imprecisely estimated, suggesting limited statistical power or a weak first stage. Among men, the association is substantially stronger. The LPM coefficient is 0.217 and highly significant, while the IV estimate increases markedly to 0.847, also statistically significant. These results indicate that LPG access has a much larger estimated impact on men's non-farm employment once endogeneity is addressed.

The IV residual term is insignificant for women and only marginally significant for men, suggesting that selection into LPG adoption may be less pronounced for women but more relevant for men. Across specifications, the inclusion of controls for LPG availability and cooking frequency ensures that the results are not driven by supply constraints or differences in cooking behavior.

Table 10 presents average marginal effects from the nonlinear specification. The estimated marginal effect of LPG use on women's non-farm employment is 0.046 and statistically insignificant, whereas the effect for men is 0.310 and significant. These results reinforce the earlier findings: while LPG access appears to modestly improve women's likelihood of entering non-farm work, the effect for men is considerably stronger, consistent with gendered differences in labor market opportunities and time allocation.

#### 6.1.4 Heterogeneity by Total Household Expenditure Quintile

Tables 11 and 12 present the IV-Probit results and corresponding average marginal effects for employment, estimated separately by household total expenditure quintile. This analysis explores whether the effects of LPG stove adoption on labor market participation differ across the total expenditure distribution.

For women, the results reveal a pronounced gradient by total expenditure level. Among households in the lowest total expenditure quintile, LPG adoption significantly reduces women's employment, with a stronger impact for wealthier household women. The estimated coefficients of -0.649, -0.898, and -1.018 for the first, second, and third quintiles correspond to average marginal effects of approximately -22, -29, and -33 percentage points, respectively. This indicates that, in wealthier households, adopting an LPG stove is associated with a sizable decline in women's employment likelihood.

For men, the pattern is reversed. The coefficients on LPG adoption are small and statistically insignificant among low-total expenditure households, but they turn positive and significant for middle and highest-total expenditure households, with a coefficient of 1.417 and 0.906, and an average marginal effect of 0.24 and 0.166. These results suggest that the employment gains from cleaner cooking technology accrue primarily to men in middle and highest-total-expenditure households.

The heterogeneity analysis suggests that the labor market effects of LPG adoption differ by household total expenditure and gender. Women may face structural constraints—such as limited local employment opportunities or liquidity barriers—that reduce their ability to translate time savings into market work.

These heterogeneous responses may also be related to differences in potential market wages or women's empowerment within the household. If wealthier household women have much lower bargaining power than men, possibly due to limited job opportunities or gender inequality in labor demand, then even if production technology reduces domestic time requirements, the incentives to reallocate time toward market work may remain weak. Thus, disparities in labor demand could partly reinforce intra-household asymmetries by limiting the extent of women's labor-supply adjustments.

## 6.2 Intensive Margin - Workdays

### 6.2.1 Empirical Framework

Unlike employment, Workdays are a continuous variable, so the main equation for this question is:

$$D_{ihj} = \gamma_0 + \gamma_1 T_{ihj} + M_{ihj}^{'}\gamma_2 + \hat{r}_{ihj} + u_{ihj} \tag{18}$$

where $D_{ihj}$ is workdays per year for individual $i$, household $h$, and living in region $h$. To control the endogeneity of $T_{ihj}$, $\hat{r}_{ihj}$, generalized residual from the first stage regression from Equation 16 and Equation 17.

### 6.2.2 Results

Table 13 presents the estimated effects of LPG stove adoption on the number of workdays per year, capturing the intensive margin of labor supply. Columns (1) and (3) report the OLS estimates for women and men, respectively, while columns (2) and (4) show the IV results using the control function correction.

The OLS results suggest that LPG adoption is positively correlated with the number of workdays for both genders, although the relationship is modest in magnitude. However, after accounting for endogeneity using the IV specification, the effects diverge sharply by gender. For men, LPG adoption significantly increases the number of workdays per year by about 20 days on average, significant at the 5 percent level. In contrast, for women, the IV estimate is negative, -20 days, and statistically significant.

Taken together with the employment results, these findings suggest that LPG adoption increases male labor supply on both the extensive and intensive margins, while the women's extensive and intensive margins of labor supply decrease. The magnitude of the male effect implies that the time savings generated by improved cooking technology are reallocated toward additional work outside the home. For women, despite similar time savings from fuel-related tasks, their time is not reallocated to market work. This may reflect persistent intra-household dynamics that constrain women's participation in market work.

This gender asymmetry aligns with the collective household model discussed earlier. Under this framework, improvements in home production efficiency from LPG adoption increase total household resources, but how these gains translate into individual labor supply depends on the sharing rule. For men, the substitution effect dominates—the reduced time cost of domestic activities raises the opportunity to supply labor. For women, however, the income effect from the household's higher effective wealth, coupled with intra-household allocation preferences, may offset the substitution effect. As a result, women may choose to allocate the saved time to leisure or household-based activities rather than additional market work.

# 7 Channels for Time Allocation and Labor Supply

## 7.1 Home Production

The adoption of clean stoves affects time allocation and labor supply primarily through changes in home production. As outlined in Section 3, the theoretical model shows that improvements in household production technology, such as the adoption of LPG stoves, can alter household members' labor supply decisions. Empirical evidence from this study confirms that the home production channel plays a key role in explaining these shifts.

LPG stoves produce steady heat more quickly and generate far fewer biomass emissions, reducing health risks associated with smoke exposure. Prior studies have highlighted these benefits (Afridi et al., 2023), emphasizing both time savings and health improvements. Consequently, acquiring an LPG stove can be viewed as a form of technological progress in home production.

However, the collective household model suggests that improvements in home production can have ambiguous effects on labor supply. On one hand, better technology reduces the time and effort required for domestic tasks, potentially freeing time for market work (a substitution effect). On the other hand, by increasing household efficiency and overall utility, the same technology can raise the effective household income and lead to greater demand for leisure or other non-market activities (an income effect). The net outcome depends on the relative strength of these forces, as well as contextual factors such as gender norms, potential market wages, and labor market demand.

The empirical findings of this study are consistent with this theoretical ambiguity. Men's market work hours, employment, and workdays increase significantly following LPG adoption, while women's total work hours and workdays remain unchanged and women's employment declines. Despite spending less time cooking, women appear to allocate more time to other non-market activities, including study, entertainment, and other home-based tasks. Interestingly, women also spend more time in cooking areas, possibly reflecting social or caregiving roles that remain tied to domestic spaces. These patterns suggest that even though LPG adoption improves household production efficiency, structural gender differences in labor market opportunities and social expectations prevent women from translating time savings into increased market participation. Instead, the benefits of home production improvements accrue disproportionately to men, whose higher potential wages and greater access to employment opportunities enable a stronger labor supply response.

### 7.2 Other Channels

Beyond home production, the relationship between clean stove adoption and labor supply can operate through several complementary channels, including time savings, health improvements, local economic effects, and spillovers.

The most direct link is time savings. Clean fuels substantially reduce cooking time by providing consistent heat and eliminating the need for fuel collection. Studies using multi-country data (Krishnapriya et al., 2021) document wide variation in time-saving effects, though few directly examine labor supply responses.

A second important channel is health. Verma and Imelda (2022) provide empirical evidence that improved respiratory health, measured through lung capacity rather than self-reported symptoms, increases labor supply among main cooks. The logic is straightforward: healthier household members experience fewer sick days and greater work capacity, which can indirectly enable other members to allocate more time to market activities. However, in contexts where women remain primarily responsible for domestic work, the health gains may improve well-being without substantially changing female labor supply, whereas men may experience a more direct productivity gain in market work.

Together, these mechanisms suggest that clean stove adoption can improve household welfare and productivity, but the translation of these gains into labor market outcomes is mediated by gendered constraints in home production and labor demand.

## 8 Conclusion

This study examines the impact of adopting LPG stoves on men's and women's labor supply and time allocation. Using an instrumental variable approach based on average land slope, the analysis finds that LPG stove adoption increases men's market work hours, employment, and workdays. For women, the estimated effects on total work hours are negative but statistically imprecise, indicating no robust change in their market labor supply, and fewer women are employed after adoption. Also, women work fewer days. Rather than reallocating saved cooking time toward market work, women appear to devote more time to non-market activities such as leisure, study, and other home-based tasks. Interestingly, even though they use the LPG stove less frequently, women spend more time in cooking areas, suggesting that behavioral adjustments extend beyond simple time reallocation.

From the perspective of home production theory, these results underscore the ambiguous relationship between improvements in domestic technology and labor supply. The net effect depends on the balance between the time-saving (substitution) effect and income effects, as well as structural factors such as potential market wages, gender norms, and demand-side constraints. When men face higher market wages or women have weaker bargaining power, time savings from improved home technology may not translate into increased female labor supply but rather a reallocation of time toward non-market or caregiving activities.

The findings also carry important policy implications. Expanding access to cleaner and more efficient cookstoves can improve household welfare and reduce time burdens, but such interventions alone are unlikely to enhance women's economic empowerment. Complementary policies addressing labor market inequality—such as fostering female-oriented industries or incentivizing employers to hire women—may be required to ensure that technological progress in home production translates into broader gender equity.

A key limitation of this study is that the time-use data are aggregated by gender rather than observed at the individual level. This aggregation limits the ability to identify which individuals adjust their time allocation and by how much, requiring the assumption that responses reflect comparative advantage within each group. Future research should collect more detailed, individual-level time-use data to capture intra-household dynamics. Moreover, while this study focuses on LPG stoves, such technologies may be unaffordable for households in extreme poverty. Evaluating the impacts of more affordable improved cookstoves on labor supply and welfare would provide valuable complementary insights for policy design.

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## Table 1: Descriptive Statistics (Individual)

| | Female | | Male | | Total |
|---|---|---|---|---|---|
| Variable | No LPG | LPG | No LPG | LPG | All |
| Workdays per year | 318.55 (69.98) | 321.92 (57.36) | 302.94 (75.33) | 319.89 (53.48) | 313.17 (67.80) |
| Employed (=1) | 0.47 (0.50) | 0.37 (0.48) | 0.91 (0.28) | 0.90 (0.30) | 0.64 (0.48) |
| Total monthly expenditure (USD) | 400.68 (493.44) | 652.75 (625.18) | 411.65 (468.36) | 672.69 (634.42) | 501.78 (556.37) |
| Married (=1) | 0.93 (0.26) | 0.90 (0.30) | 0.89 (0.31) | 0.82 (0.38) | 0.90 (0.31) |
| Urban (=1) | 0.42 (0.49) | 0.78 (0.41) | 0.42 (0.49) | 0.79 (0.41) | 0.56 (0.50) |
| Primary fuel always available (=1) | 0.89 (0.32) | 0.91 (0.29) | 0.90 (0.31) | 0.91 (0.29) | 0.90 (0.30) |
| Primary fuel mostly available (=1) | 0.10 (0.29) | 0.09 (0.28) | 0.09 (0.28) | 0.09 (0.29) | 0.09 (0.29) |
| Primary fuel sometimes available (=1) | 0.01 (0.10) | 0.00 (0.03) | 0.01 (0.10) | 0.00 (0.03) | 0.01 (0.08) |
| Bank account (index) | 0.51 (0.50) | 0.90 (0.31) | 0.51 (0.50) | 0.90 (0.30) | 0.66 (0.47) |
| Household size | 5.50 (2.45) | 4.92 (2.15) | 5.67 (2.48) | 5.14 (2.22) | 5.37 (2.38) |
| Working burners (number) | 1.68 (0.57) | 2.05 (0.24) | 1.70 (0.56) | 2.06 (0.24) | 1.85 (0.49) |
| Dwelling quality index | 1.52 (0.60) | 1.82 (0.41) | 1.51 (0.61) | 1.81 (0.42) | 1.63 (0.56) |
| Age (years) | 34.11 (8.78) | 34.72 (8.53) | 34.69 (8.82) | 35.76 (8.44) | 34.67 (8.70) |
| Years of education | 3.80 (4.55) | 7.76 (4.97) | 6.88 (4.52) | 10.06 (4.17) | 6.52 (5.09) |
| Cooks every day (=1) | 0.83 (0.37) | 0.83 (0.38) | 0.02 (0.13) | 0.01 (0.12) | 0.47 (0.50) |
| Cooks few times/week (=1) | 0.09 (0.29) | 0.09 (0.29) | 0.09 (0.28) | 0.06 (0.23) | 0.09 (0.28) |
| Cooks once/week (=1) | 0.01 (0.09) | 0.01 (0.07) | 0.02 (0.13) | 0.01 (0.10) | 0.01 (0.10) |
| Cooks few times/month (=1) | 0.04 (0.20) | 0.05 (0.21) | 0.17 (0.38) | 0.15 (0.36) | 0.10 (0.30) |
| Cooks once/month (=1) | 0.01 (0.08) | 0.01 (0.08) | 0.04 (0.20) | 0.04 (0.19) | 0.02 (0.14) |
| Children (number) | 0.69 (0.89) | 0.41 (0.68) | 0.68 (0.88) | 0.40 (0.69) | 0.58 (0.83) |
| Household head (=1) | 0.11 (0.31) | 0.13 (0.33) | 0.56 (0.50) | 0.48 (0.50) | 0.30 (0.46) |
| Observations | | | | | 10,771 |

Means reported; standard deviations in parentheses.

Table 2: Household-Level Summary Statistics for Women

| | No LPG | | LPG | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| *Time use (minutes per day)* | | | | |
| Paid outside work (min) | 113.85 | 181.62 | 111.98 | 208.87 |
| Paid inside work (min) | 34.38 | 111.59 | 54.46 | 155.53 |
| Fuel collection (min) | 135.95 | 160.26 | 21.02 | 85.58 |
| Fuel preparation (min) | 21.41 | 31.48 | 3.86 | 21.15 |
| Cooking (min) | 165.59 | 71.04 | 130.10 | 60.86 |
| Time in cooking area (min) | 22.39 | 39.91 | 25.65 | 43.62 |
| Childcare (min) | 129.77 | 236.55 | 105.18 | 237.20 |
| Study (min) | 27.76 | 79.00 | 40.50 | 90.43 |
| Leisure and entertainment (min) | 47.33 | 60.41 | 89.00 | 100.77 |
| *Household characteristics* | | | | |
| Total HH expenditure (USD) | 368.47 | 450.43 | 609.96 | 607.03 |
| Urban residence | 0.44 | 0.50 | 0.79 | 0.41 |
| Primary fuel always available | 0.90 | 0.30 | 0.91 | 0.29 |
| Primary fuel mostly available | 0.09 | 0.28 | 0.09 | 0.29 |
| Primary fuel sometimes available | 0.01 | 0.09 | 0.00 | 0.03 |
| Household owns a bank account | 0.49 | 0.50 | 0.88 | 0.32 |
| Household size | 4.81 | 2.08 | 4.34 | 1.80 |
| Number of stove burners | 1.65 | 0.56 | 2.05 | 0.24 |
| House quality index | 1.51 | 0.61 | 1.82 | 0.41 |
| Age of main cook | 38.20 | 12.97 | 39.71 | 11.95 |
| *Household head characteristics* | | | | |
| Age of household head | 48.68 | 14.18 | 49.59 | 13.37 |
| Male household head | 1.18 | 0.38 | 1.24 | 0.42 |
| Years of education (HH head) | 3.96 | 4.39 | 7.00 | 4.99 |
| Self-employed household head | 0.53 | 0.50 | 0.51 | 0.50 |
| Non-farm employed household head | 0.24 | 0.43 | 0.47 | 0.50 |
| *Household composition* | | | | |
| Number of adult women | 1.77 | 0.89 | 1.82 | 0.90 |
| Number of adult men | 1.56 | 0.98 | 1.56 | 0.94 |
| Number of children | 0.54 | 0.77 | 0.32 | 0.59 |
| Observations | 2,819 | | 2,086 | |

*Notes*: Sample restricted to households with at least one woman. Time-use variables are measured in minutes per day.

Table 3: Household-Level Summary Statistics for Men

| | No LPG | | LPG | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| *Time use (minutes per day)* | | | | |
| Paid outside work (min) | 311.91 | 245.94 | 348.02 | 287.96 |
| Paid inside work (min) | 43.91 | 127.95 | 59.91 | 171.51 |
| Fuel collection (min) | 111.62 | 158.61 | 23.05 | 80.00 |
| Fuel preparation (min) | 23.30 | 40.10 | 3.46 | 31.90 |
| Cooking (min) | 16.39 | 37.84 | 9.10 | 28.53 |
| Time in cooking area (min) | 4.04 | 19.29 | 3.50 | 14.56 |
| Childcare (min) | 26.94 | 66.21 | 19.72 | 54.23 |
| Study (min) | 26.73 | 84.23 | 28.41 | 84.67 |
| Leisure and entertainment (min) | 57.26 | 62.33 | 79.41 | 86.29 |
| *Household characteristics* | | | | |
| Total HH expenditure (USD) | 378.66 | 461.15 | 626.97 | 622.05 |
| Urban residence | 0.43 | 0.50 | 0.79 | 0.41 |
| Primary fuel always available | 0.90 | 0.30 | 0.90 | 0.29 |
| Primary fuel mostly available | 0.09 | 0.28 | 0.09 | 0.29 |
| Primary fuel sometimes available | 0.01 | 0.10 | 0.00 | 0.03 |
| Household owns a bank account | 0.49 | 0.50 | 0.89 | 0.31 |
| Household size | 4.94 | 2.09 | 4.46 | 1.79 |
| Number of stove burners | 1.67 | 0.56 | 2.05 | 0.24 |
| House quality index | 1.50 | 0.62 | 1.82 | 0.41 |
| Age of main cook | 38.31 | 12.96 | 39.97 | 11.88 |
| *Household head characteristics* | | | | |
| Age of household head | 49.32 | 13.91 | 50.34 | 13.01 |
| Male household head | 1.10 | 0.30 | 1.16 | 0.37 |
| Years of education (HH head) | 4.08 | 4.40 | 7.14 | 4.98 |
| Self-employed household head | 0.54 | 0.50 | 0.53 | 0.50 |
| Non-farm employed household head | 0.26 | 0.44 | 0.50 | 0.50 |
| *Household composition* | | | | |
| Number of adult women | 1.77 | 0.92 | 1.82 | 0.92 |
| Number of adult men | 1.71 | 0.90 | 1.71 | 0.84 |
| Number of children | 0.53 | 0.78 | 0.31 | 0.58 |
| Observations | 2,606 | | 1,919 | |

The sample is restricted to households with at least one man. Time-use variables are measured in minutes per day.

## Table 4: Work outside minutes per day

| | Work outside-women | | | Work outside-men | | |
|---|---|---|---|---|---|---|
| | OLS | 2sls | IV-Tobit | OLS | 2sls | IV-Tobit |
| LPG | 5.962 | -64.412* | -67.967 | 2.513 | 337.504*** | 163.636*** |
| | (7.229) | (36.659) | (61.318) | (10.363) | (52.170) | (39.408) |
| Total expenditure (Dollar) | 0.006 | 0.011* | 0.018 | 0.019** | -0.007 | 0.010 |
| | (0.006) | (0.007) | (0.016) | (0.008) | (0.010) | (0.010) |
| Urban | -34.203*** | -22.158*** | -118.352*** | -27.384*** | -85.835*** | -81.373*** |
| | (5.784) | (8.188) | (20.752) | (8.100) | (12.444) | (13.231) |
| Bank account own | 10.768* | 23.408** | 39.866* | 12.403 | -49.974*** | -17.381 |
| | (6.402) | (9.112) | (22.446) | (9.008) | (13.974) | (14.634) |
| Household size | -4.779* | -7.531** | -17.743** | 4.378 | 18.082*** | 15.001*** |
| | (2.787) | (3.105) | (9.009) | (3.840) | (4.819) | (5.692) |
| Stove burner number | -21.165*** | -2.642 | -73.677*** | 34.281*** | -49.914*** | 2.678 |
| | (6.444) | (11.129) | (23.594) | (7.939) | (15.871) | (14.821) |
| Age (HH head) | 0.473* | 0.679** | 1.561* | -0.602* | -1.644*** | -1.630*** |
| | (0.285) | (0.311) | (0.827) | (0.364) | (0.429) | (0.532) |
| Gender (HH head) | 35.538*** | 42.369*** | 102.098*** | -13.664 | -46.636*** | -39.816** |
| | (8.776) | (9.342) | (24.765) | (13.114) | (15.285) | (17.961) |
| Educ year (HH head) | 0.343 | 1.401 | 1.585 | -0.771 | -5.687*** | -3.470** |
| | (0.699) | (0.887) | (2.318) | (0.933) | (1.307) | (1.453) |
| Elevation | 0.017*** | 0.011*** | 0.052*** | -0.044*** | -0.021*** | -0.050*** |
| | (0.003) | (0.004) | (0.011) | (0.004) | (0.006) | (0.007) |
| Self emp (HH head) | 22.604*** | 19.971*** | 100.881*** | -2.813 | 7.880 | 5.430 |
| | (5.720) | (5.827) | (17.926) | (7.682) | (8.976) | (11.124) |
| Non farm emp (HH head) | 15.411** | 23.563*** | 33.725 | 78.689*** | 38.243*** | 86.104*** |
| | (6.782) | (7.982) | (21.312) | (8.937) | (11.806) | (13.231) |
| Age (main cook) | -0.159 | -0.121 | -0.117 | -0.696* | -0.931** | -0.952* |
| | (0.275) | (0.276) | (0.769) | (0.362) | (0.401) | (0.496) |
| Women number | 38.832*** | 41.284*** | 102.985*** | 3.752 | -8.011 | -4.854 |
| | (5.072) | (5.205) | (14.057) | (6.643) | (7.514) | (8.831) |
| Men number | -1.504 | -0.779 | -6.116 | 53.826*** | 50.270*** | 64.989*** |
| | (4.174) | (4.192) | (13.150) | (6.567) | (7.196) | (8.277) |
| Kids number | -5.431 | -5.773 | -12.547 | 4.039 | 4.486 | 0.927 |
| | (4.939) | (4.981) | (15.162) | (7.292) | (8.055) | (9.573) |
| Generalized residual | | | 38.354 | | | -109.384*** |
| | | | (37.182) | | | (23.902) |
| Constant | 35.880 | -27.324 | -472.116*** | 203.086*** | 495.874*** | 256.044** |
| | (56.623) | (64.575) | (161.366) | (72.662) | (83.746) | (99.988) |
| Fuel availability | Yes | Yes | Yes | Yes | Yes | Yes |
| House quality | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 4905 | 4905 | 4905 | 4525 | 4525 | 4525 |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## Table 5: Time Allocation Effects of LPG Adoption (Women)

| | (1) IV Tobit Work Inside | (2) IV Tobit Fuel collection | (3) IV Tobit Fuel preparation | (4) IV Tobit Cooking | (5) IV Tobit Cooking area | (6) IV Tobit Childcare | (7) IV Tobit Study | (8) IV Tobit Entertain |
|---|---|---|---|---|---|---|---|---|
| LPG | -183.109** | -448.887*** | -77.136*** | -57.284*** | 37.325*** | -34.033 | 116.499*** | 95.351*** |
| | (80.020) | (25.094) | (7.243) | (7.174) | (8.614) | (53.426) | (30.972) | (13.722) |
| Total HH Expenditure (USD) | 0.066*** | 0.009 | 0.004** | 0.007*** | 0.008*** | 0.005 | 0.001 | 0.010*** |
| | (0.020) | (0.007) | (0.002) | (0.002) | (0.002) | (0.015) | (0.008) | (0.004) |
| Urban | 52.429* | 8.128 | 1.652 | 4.459* | -2.686 | 3.049 | 33.842*** | -14.194*** |
| | (27.392) | (7.881) | (2.239) | (2.382) | (2.844) | (17.727) | (10.322) | (4.588) |
| Bank Account Own | 108.454*** | 25.108*** | -8.466*** | -0.521 | 1.352 | 27.805 | -6.218 | 22.148*** |
| | (29.980) | (8.569) | (2.427) | (2.609) | (3.136) | (19.458) | (11.305) | (5.018) |
| Household Size | 12.377 | 2.626 | 2.896*** | 3.702*** | 3.897*** | 31.510*** | 57.587*** | -5.235*** |
| | (11.498) | (3.432) | (0.971) | (1.028) | (1.216) | (7.399) | (4.396) | (1.983) |
| Stove Burner Number | 56.497* | 42.096*** | 9.280*** | -1.649 | 2.991 | 39.079* | -33.282*** | -10.419* |
| | (31.420) | (9.154) | (2.590) | (2.757) | (3.273) | (20.207) | (11.961) | (5.341) |
| Age (HH head) | -0.582 | 0.244 | 0.164* | 0.147 | -0.008 | 0.707 | -0.876** | 0.209 |
| | (1.106) | (0.326) | (0.094) | (0.095) | (0.111) | (0.693) | (0.404) | (0.182) |
| Gender (HH head) | 95.210*** | 33.581*** | -0.836 | -5.486* | -11.579*** | -6.830 | -3.947 | -1.980 |
| | (32.841) | (10.134) | (2.986) | (2.896) | (3.500) | (22.149) | (12.390) | (5.527) |
| Educ Years (HH head) | 2.780 | 0.168 | -0.036 | 0.509* | -1.146*** | 1.231 | 3.867*** | 0.827* |
| | (2.988) | (0.943) | (0.272) | (0.266) | (0.315) | (1.993) | (1.116) | (0.502) |
| Self-Employed (HH head) | 92.887*** | 2.785 | 3.001 | 4.874** | 6.628*** | 27.982* | 11.662 | 22.296*** |
| | (23.752) | (6.959) | (1.995) | (2.037) | (2.435) | (15.330) | (8.748) | (3.900) |
| Non-Farm Employed (HH head) | 156.945*** | 27.059*** | -1.016 | -4.323* | -2.716 | -21.060 | -13.916 | -17.221*** |
| | (27.687) | (8.469) | (2.433) | (2.441) | (2.897) | (18.424) | (10.493) | (4.637) |
| Age (main cook) | -0.704 | -0.835*** | -0.171* | -0.136 | -0.296*** | -7.001*** | -2.097*** | -0.397** |
| | (1.057) | (0.309) | (0.088) | (0.090) | (0.105) | (0.684) | (0.400) | (0.171) |
| Women Number | 25.357 | 11.378** | -1.874 | 4.024** | 11.485*** | -2.889 | 16.828*** | 18.141*** |
| | (17.741) | (5.556) | (1.595) | (1.616) | (1.882) | (11.996) | (6.413) | (3.068) |
| Men Number | 2.665 | -11.917** | -3.845*** | 2.679* | 1.525 | -59.990*** | -63.327*** | 13.013*** |
| | (16.641) | (5.127) | (1.478) | (1.492) | (1.747) | (11.477) | (6.398) | (2.831) |
| Kids Number | -29.288 | -19.139*** | -0.252 | 1.095 | 0.012 | 352.925*** | -47.386*** | -3.801 |
| | (19.651) | (5.820) | (1.638) | (1.732) | (2.044) | (12.116) | (7.038) | (3.342) |
| Elevation | 0.095*** | 0.041*** | 0.005*** | -0.003*** | -0.006*** | 0.009 | -0.010* | -0.003 |
| | (0.014) | (0.004) | (0.001) | (0.001) | (0.002) | (0.009) | (0.006) | (0.002) |
| Generalized Residual | 170.750*** | 139.905*** | 12.745*** | 19.012*** | -18.173*** | 44.674 | -48.303** | -38.559*** |
| | (48.614) | (14.803) | (4.279) | (4.356) | (5.222) | (32.177) | (18.884) | (8.315) |
| Constant | -1025.454*** | 99.105* | 49.510*** | 64.018*** | 51.177** | -427.061*** | -249.949*** | -116.955*** |
| | (183.824) | (57.119) | (15.637) | (18.083) | (19.915) | (123.714) | (78.039) | (43.939) |
| Fuel availability | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| House quality | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 4905 | 4905 | 4905 | 4905 | 4905 | 4905 | 4905 | 4905 |

Sample includes the household has at least one adult women. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

# Table 6: Time Allocation Effects of LPG Adoption (Men)

| | (1)<br>IV Tobit<br>Paid work | (2)<br>IV Tobit<br>Fuel collection | (3)<br>IV Tobit<br>Fuel preparation | (4)<br>IV Tobit<br>Cooking | (5)<br>IV Tobit<br>Cooking area | (6)<br>IV Tobit<br>Childcare | (7)<br>IV Tobit<br>Study | (8)<br>IV Tobit<br>Leisure |
|---|---|---|---|---|---|---|---|---|
| LPG | -154.170* | -203.190*** | -109.812*** | -24.133* | 0.170 | 25.896 | 75.151* | 40.146*** |
| | (81.458) | (24.445) | (10.956) | (14.298) | (15.505) | (25.806) | (40.669) | (12.037) |
| Total HH Expenditure (USD) | 0.036* | 0.007 | -0.004 | 0.002 | 0.005 | 0.002 | 0.013 | 0.007** |
| | (0.021) | (0.007) | (0.003) | (0.004) | (0.004) | (0.007) | (0.010) | (0.003) |
| Urban | 47.276* | -25.111*** | -0.737 | 13.594*** | 12.173** | 6.254 | 25.563* | -17.484*** |
| | (27.494) | (8.027) | (3.365) | (5.085) | (5.728) | (8.667) | (13.688) | (4.052) |
| Bank Account Own | 96.631*** | 4.311 | -10.315*** | -15.059*** | -3.075 | 3.004 | -36.807** | 23.756*** |
| | (30.603) | (8.902) | (3.681) | (5.495) | (6.147) | (9.542) | (15.082) | (4.458) |
| Household Size | -6.986 | 7.177** | 0.942 | -1.488 | -0.321 | 10.097*** | 53.216*** | -9.553*** |
| | (11.929) | (3.473) | (1.468) | (2.183) | (2.407) | (3.603) | (5.874) | (1.760) |
| Stove Burner Number | 18.870 | 11.427 | 10.805*** | 4.071 | 8.895 | -7.139 | -22.608 | -8.412* |
| | (31.231) | (9.032) | (3.732) | (5.291) | (5.796) | (9.499) | (15.340) | (4.582) |
| Age (HH head) | -0.279 | -0.380 | -0.118 | 0.021 | 0.283 | 0.136 | -1.057* | 0.053 |
| | (1.129) | (0.328) | (0.142) | (0.205) | (0.219) | (0.341) | (0.562) | (0.162) |
| Gender (HH head) | 25.120 | -22.978** | -1.499 | 5.838 | 3.779 | -2.539 | 89.287*** | 6.365 |
| | (38.585) | (11.449) | (5.156) | (6.924) | (7.583) | (12.257) | (18.260) | (5.377) |
| Educ Years (HH head) | 3.725 | -2.977*** | -0.298 | 0.577 | 0.265 | -0.353 | 7.306*** | 0.688 |
| | (3.045) | (0.918) | (0.408) | (0.560) | (0.603) | (0.967) | (1.494) | (0.441) |
| Self-Employed (HH head) | 227.412*** | 15.453** | 10.481*** | 20.619*** | -3.365 | 35.496*** | 36.905*** | 19.327*** |
| | (25.081) | (6.913) | (2.991) | (4.374) | (4.861) | (7.449) | (11.657) | (3.405) |
| Non-Farm Employed (HH head) | 74.298*** | -2.967 | -1.159 | -2.648 | 14.486** | -23.928*** | -9.419 | -11.754*** |
| | (27.786) | (8.260) | (3.608) | (5.117) | (5.625) | (8.974) | (13.726) | (4.041) |
| Age (main cook) | -0.748 | -0.570* | -0.267** | 0.345* | 0.004 | -2.679*** | -1.244** | -0.168 |
| | (1.065) | (0.305) | (0.132) | (0.190) | (0.206) | (0.333) | (0.536) | (0.150) |
| Women Number | 21.143 | -7.651 | 0.366 | -18.615*** | -7.276* | -13.145** | -68.340*** | 10.897*** |
| | (18.262) | (5.472) | (2.389) | (3.536) | (3.817) | (5.900) | (9.153) | (2.697) |
| Men Number | 51.347*** | 6.143 | 6.735*** | 12.655*** | 9.368*** | -16.984*** | 43.821*** | 24.457*** |
| | (16.998) | (5.114) | (2.194) | (3.182) | (3.506) | (5.686) | (7.970) | (2.526) |
| Kids Number | 4.338 | -8.942 | -1.194 | -4.280 | 0.952 | 102.085*** | -70.774*** | -0.184 |
| | (19.858) | (5.849) | (2.464) | (3.758) | (4.128) | (5.944) | (9.948) | (2.952) |
| Elevation | 0.079*** | 0.033*** | 0.012*** | 0.042*** | 0.030*** | 0.018*** | -0.000 | 0.001 |
| | (0.014) | (0.004) | (0.002) | (0.003) | (0.003) | (0.004) | (0.007) | (0.002) |
| Generalized Residual | 116.547** | 76.519*** | 19.723*** | 7.856 | 12.180 | -11.476 | -56.128** | -17.054** |
| | (49.241) | (14.812) | (6.424) | (8.695) | (9.310) | (15.628) | (24.889) | (7.314) |
| Constant | -744.483*** | 200.551*** | 10.437 | -98.921*** | -107.536*** | -45.692 | -515.205*** | -67.680** |
| | (186.311) | (57.182) | (22.758) | (30.990) | (31.131) | (54.929) | (101.852) | (33.095) |
| Fuel availability | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| House quality | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 4525 | 4525 | 4525 | 4525 | 4525 | 4525 | 4525 | 4525 |

Sample includes the household has at least one adult men. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

## Table 7: Extensive Margin - Employment

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Female | | Male | |
| | LPM | IV | LPM | IV |
| | *Dependent variable: Employment* | | | |
| LPG | -0.090*** | -0.944*** | 0.043*** | 0.905*** |
| | (0.017) | (0.133) | (0.012) | (0.181) |
| Total HH Expenditure(Dollar) | -0.000*** | -0.000* | -0.000 | -0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Married | -0.086*** | -0.221*** | 0.149*** | 0.551*** |
| | (0.027) | (0.072) | (0.021) | (0.084) |
| Urban | -0.039*** | 0.022 | -0.035*** | -0.385*** |
| | (0.014) | (0.043) | (0.010) | (0.070) |
| Bank Account Own | -0.030* | 0.066 | -0.019* | -0.292*** |
| | (0.016) | (0.055) | (0.011) | (0.095) |
| Household Size | 0.002 | -0.009 | 0.001 | 0.025* |
| | (0.003) | (0.010) | (0.002) | (0.014) |
| Stove Burner Number | -0.104*** | -0.092 | -0.021** | -0.305*** |
| | (0.015) | (0.061) | (0.009) | (0.071) |
| House Quality | 0.068*** | 0.263*** | -0.009 | -0.124** |
| | (0.013) | (0.038) | (0.007) | (0.055) |
| Age | 0.004*** | 0.014*** | 0.004*** | 0.023*** |
| | (0.001) | (0.003) | (0.001) | (0.005) |
| Educ year | 0.013*** | 0.050*** | -0.000 | -0.010 |
| | (0.002) | (0.005) | (0.001) | (0.007) |
| Kids Number | -0.011 | -0.047 | 0.018*** | 0.117** |
| | (0.010) | (0.029) | (0.007) | (0.050) |
| HH Head | 0.149*** | 0.405*** | 0.050*** | 0.423*** |
| | (0.023) | (0.063) | (0.011) | (0.086) |
| Non-Farm Work | 0.289*** | | 0.209*** | |
| | (0.016) | | (0.009) | |
| Self Employed | 0.694*** | | 0.165*** | |
| | (0.010) | | (0.008) | |
| Cons | 0.285*** | -1.522 | 0.488*** | 0.019 |
| | (0.095) | (1.335) | (0.108) | (0.440) |
| Generalized Residual | | 0.467*** | | -0.432*** |
| | | (0.077) | | (0.108) |
| Availability | Yes | Yes | Yes | Yes |
| Cook Frequency | Yes | Yes | Yes | Yes |
| *N* | 5155 | 5155 | 4114 | 4114 |

Control-function estimation is employed. The generalized residual is obtained from the first-stage probit model. Standard errors are bootstrapped with 800 replications and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Extensive Margin - Average Marginal Effect

| | (1) Female | (2) Male |
|---|---|---|
| | *Dependent variable: Employment* | |
| LPG (Average Marginal Effect) | -0.312*** | 0.134*** |
| | (0.036) | (0.028) |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Non-Farm Employment

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Female | | Male | |
| | LPM | IV | LPM | IV |
| | *Dependent variable: Non-farm Employment* | | | |
| LPG | 0.044*** | 0.080 | 0.217*** | 0.847*** |
| | (0.012) | (0.187) | (0.019) | (0.154) |
| Total HH Expenditure (Dollar) | 0.000 | 0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Married | -0.113*** | -0.309*** | 0.102*** | 0.304*** |
| | (0.023) | (0.079) | (0.025) | (0.072) |
| Urban | 0.022** | 0.172*** | 0.050*** | 0.090* |
| | (0.009) | (0.065) | (0.016) | (0.053) |
| Bank Account Own | 0.021** | 0.228*** | 0.140*** | 0.320*** |
| | (0.009) | (0.088) | (0.018) | (0.059) |
| Household Size | -0.003 | -0.027** | -0.004 | -0.004 |
| | (0.002) | (0.013) | (0.004) | (0.014) |
| Stove Burner Number | 0.006 | 0.032 | 0.015 | -0.023 |
| | (0.009) | (0.088) | (0.016) | (0.056) |
| House Quality | 0.009 | 0.083 | 0.010 | -0.001 |
| | (0.007) | (0.058) | (0.014) | (0.039) |
| Age | 0.003*** | 0.014*** | 0.001 | 0.002 |
| | (0.001) | (0.003) | (0.001) | (0.003) |
| Educ year | 0.019*** | 0.096*** | 0.016*** | 0.042*** |
| | (0.001) | (0.008) | (0.002) | (0.005) |
| Kids Number | -0.019*** | -0.123*** | 0.019 | 0.057 |
| | (0.006) | (0.042) | (0.012) | (0.036) |
| HH Head | 0.042** | 0.261*** | 0.038* | 0.129** |
| | (0.017) | (0.076) | (0.019) | (0.065) |
| Cons | 0.098 | -1.934 | 0.327*** | -0.420 |
| | (0.068) | (1.825) | (0.124) | (0.311) |
| Generalized Residual | | 0.086 | | -0.176* |
| | | (0.111) | | (0.093) |
| availability | Yes | Yes | Yes | Yes |
| cook frequency | Yes | Yes | Yes | Yes |
| *N* | 5155 | 5155 | 4114 | 4114 |

Estimation follows a control-function approach. The generalized residual is obtained from the first-stage probit model. The second-stage outcome variable equals one if the individual is in non-farm employment and zero if the individual is in farm employment or not working. Standard errors are bootstrapped with 800 replications and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Non-Farm Employment - Average Marginal Effect

| | (1) Female | (2) Male |
|---|---|---|
| | *Dependent variable: Non-Farm Employment* | |
| LPG (Average Marginal Effect) | 0.046 | 0.310*** |
| | (0.032) | (0.054) |
| *N* | 5155 | 4114 |

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Extensive Margin Quintile

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | Female | | | Male | |
| | | Quintile | | | Quintile | |
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| | *Dependent variable: Employment* | | | | | |
| LPG | -0.649** | -0.898*** | -1.018*** | 0.015 | 1.471*** | 0.906*** |
| | (0.299) | (0.229) | (0.205) | (0.521) | (0.376) | (0.312) |
| Total HH Expenditure(Dollar) | -0.004*** | 0.000 | -0.000 | -0.001 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.000) | (0.002) | (0.001) | (0.000) |
| Married | -0.025 | -0.280* | -0.303** | 0.709*** | 0.649*** | 0.400*** |
| | (0.152) | (0.152) | (0.118) | (0.167) | (0.166) | (0.131) |
| Urban | -0.185** | 0.111 | 0.110 | -0.196 | -0.492*** | -0.397*** |
| | (0.081) | (0.079) | (0.083) | (0.151) | (0.126) | (0.146) |
| fin_bank_acc1 | 0.252*** | -0.057 | 0.111 | -0.161 | -0.270* | -0.310* |
| | (0.078) | (0.093) | (0.102) | (0.162) | (0.152) | (0.167) |
| Household Size | 0.063** | -0.034 | -0.002 | 0.045 | 0.052 | 0.035 |
| | (0.025) | (0.024) | (0.014) | (0.045) | (0.044) | (0.023) |
| Stove Burner Number | -0.227** | -0.166 | 0.136 | -0.075 | -0.500*** | -0.296** |
| | (0.091) | (0.102) | (0.088) | (0.174) | (0.150) | (0.141) |
| House Quality | 0.149** | 0.290*** | 0.334*** | 0.133 | -0.155 | -0.410*** |
| | (0.062) | (0.076) | (0.078) | (0.095) | (0.109) | (0.131) |
| Age | 0.008 | 0.014*** | 0.021*** | 0.032*** | 0.020** | 0.026*** |
| | (0.005) | (0.005) | (0.004) | (0.010) | (0.010) | (0.008) |
| Educ year | 0.031*** | 0.057*** | 0.057*** | -0.011 | -0.013 | -0.003 |
| | (0.011) | (0.010) | (0.008) | (0.016) | (0.015) | (0.013) |
| Kids Number | -0.015 | 0.016 | -0.149*** | 0.083 | 0.191* | 0.047 |
| | (0.055) | (0.059) | (0.047) | (0.100) | (0.099) | (0.081) |
| HH Head | 0.494*** | 0.461*** | 0.218* | 0.419*** | 0.381** | 0.478*** |
| | (0.107) | (0.122) | (0.118) | (0.158) | (0.152) | (0.144) |
| Cons | 0.256 | -0.676 | -2.714 | 0.085 | -0.247 | 0.711 |
| | (0.558) | (2.033) | (1.823) | (0.616) | (1.989) | (1.146) |
| Generalized Residual | 0.436** | 0.474*** | 0.412*** | 0.066 | -0.630*** | -0.522*** |
| | (0.179) | (0.140) | (0.123) | (0.312) | (0.226) | (0.198) |
| Availability | Yes | Yes | Yes | Yes | Yes | Yes |
| Cook Frequency | Yes | Yes | Yes | Yes | Yes | Yes |
| *N* | 1593 | 1619 | 1936 | 1191 | 1262 | 1645 |

Female and male samples are analyzed separately by total household expenditure quintile. The third quintile corresponds to the highest level of total household expenditure. The generalized residual is obtained from the first-stage probit model. Standard errors are bootstrapped with 800 replications and reported in parentheses. $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Table 12: Extensive Margin Quintile - Average Marginal Effect

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | Female Quintile | | | Male Quintile | |
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| | *Dependent variable: Employment* | | | | | |
| LPG (AME) | -0.221** | -0.290*** | -0.330*** | 0.002 | 0.240*** | 0.166*** |
| | (0.092) | (0.061) | (0.054) | (0.052) | (0.063) | (0.063) |

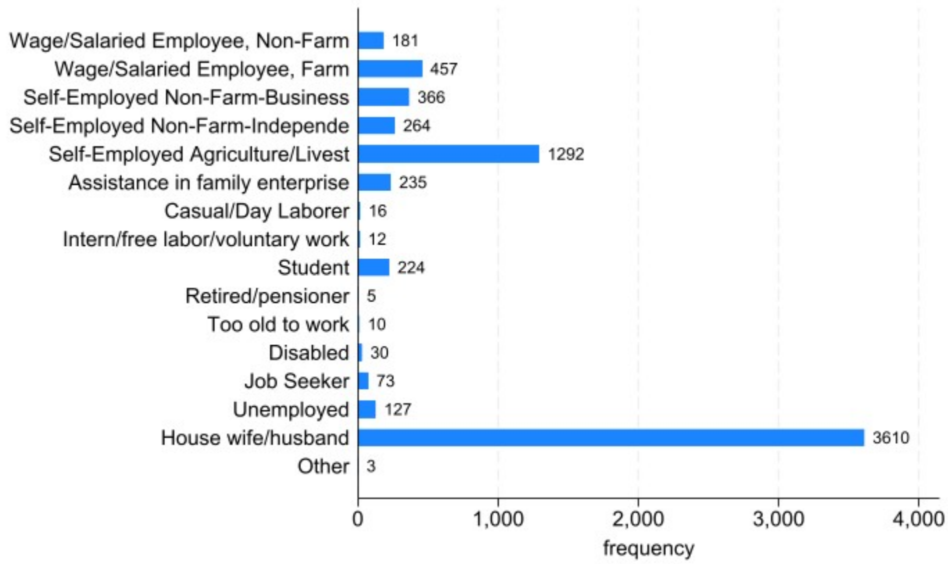
Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Work Days Per Year

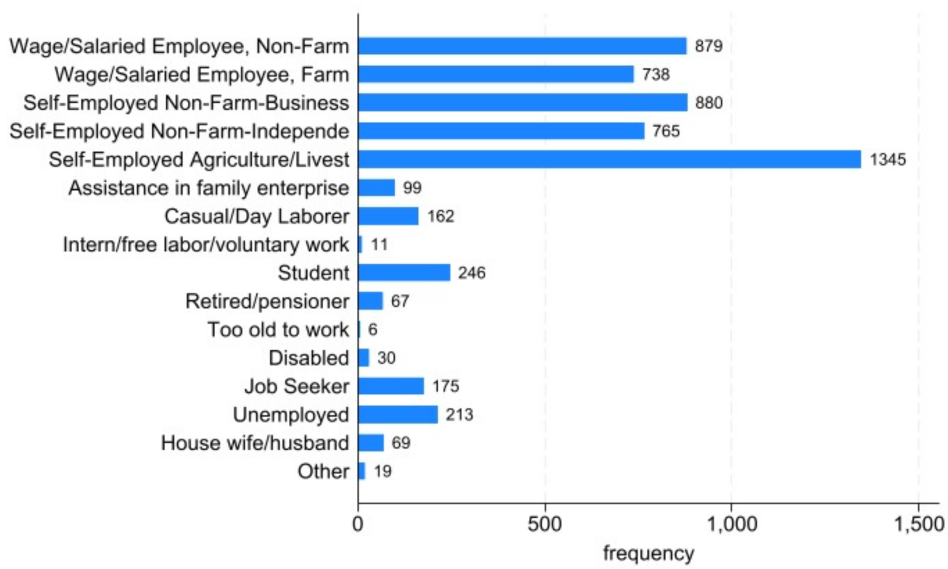
| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Female | | Male | |
| | OLS | IV | OLS | IV |
| | *Dependent variable: Workdays per Year* | | | |
| LPG | 8.996* | -19.981* | 15.971*** | 20.028** |
| | (5.349) | (11.770) | (3.006) | (9.108) |
| Total HH Expenditure(Dollar) | 0.000 | 0.001 | 0.001 | 0.001 |
| | (0.002) | (0.003) | (0.002) | (0.002) |
| Married | 4.258 | 2.036 | 3.912 | 4.108 |
| | (5.852) | (5.640) | (3.862) | (3.886) |
| Urban | -6.013 | 0.604 | 0.586 | -0.356 |
| | (4.896) | (5.709) | (2.715) | (3.271) |
| Bank Account Own | 0.484 | 4.568 | -3.826 | -4.645 |
| | (5.903) | (6.526) | (3.247) | (3.680) |
| Household Size | 0.613 | 0.066 | 1.929*** | 2.014*** |
| | (1.030) | (1.055) | (0.576) | (0.622) |
| Stove Burner Number | -11.485*** | -3.239 | -8.838*** | -9.932** |
| | (4.325) | (5.600) | (2.943) | (3.959) |
| House Quality | 21.109*** | 25.369*** | -4.993** | -5.500** |
| | (5.486) | (5.342) | (2.394) | (2.632) |
| Age | -0.242 | -0.153 | -0.331* | -0.348** |
| | (0.315) | (0.348) | (0.178) | (0.172) |
| Educ year | -0.253 | 0.081 | 0.068 | 0.036 |
| | (0.495) | (0.528) | (0.304) | (0.295) |
| Kids Number | -0.680 | -0.793 | 0.334 | 0.437 |
| | (3.336) | (3.671) | (1.845) | (1.846) |
| HH Head | 0.041 | -0.334 | 6.501** | 6.704** |
| | (5.798) | (5.564) | (2.937) | (2.993) |
| Non-Farm Work | -12.538* | -5.991 | -3.717 | -4.079 |
| | (6.897) | (7.079) | (4.013) | (3.993) |
| Self Employed | 29.375*** | 29.058*** | 16.605*** | 16.318*** |
| | (4.811) | (5.123) | (2.640) | (2.739) |
| Cons | 168.500*** | 135.933** | 287.257*** | 289.259*** |
| | (51.880) | (55.098) | (27.552) | (26.517) |
| Generalized Residual | | 20.122** | | -2.670 |
| | | (8.102) | | (5.524) |
| availability | Yes | Yes | Yes | Yes |
| cook frequency | Yes | Yes | Yes | Yes |
| *N* | 1072 | 1069 | 2586 | 2586 |

Estimation follows a control-function approach. The generalized residual is obtained from the first-stage probit model. In column (2), three observations are dropped because the first-stage predicted probabilities are extremely close to 0 or 1. Standard errors are bootstrapped with 800 replications and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Main Job Type




(a) Main Job Type - Women




(b) Main Job Type - Men

Figure 2: Elevation-Nepal

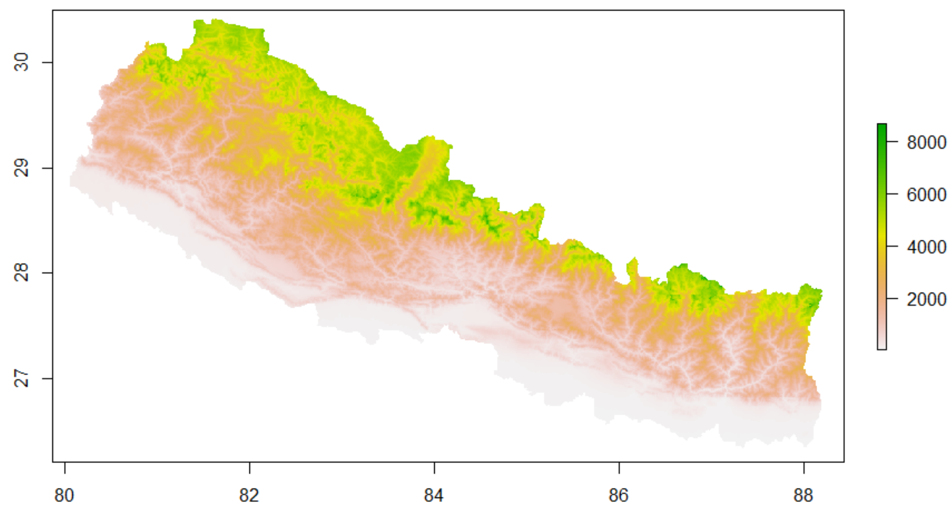
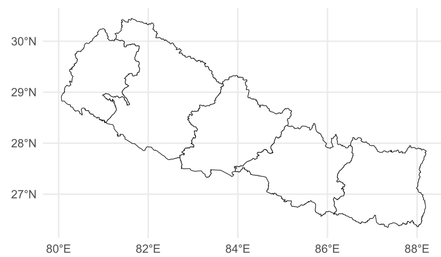
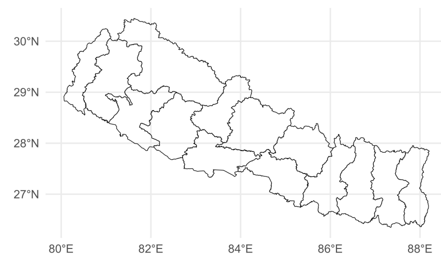


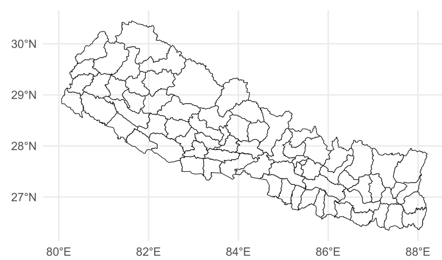

Figure 3: GADM level



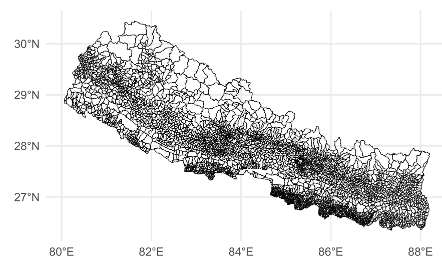

(a) GADM level1




(b) GADM level2




(c) GADM level3




(d) GADM level4

Figure 4: Employment and LPG adoption by Region

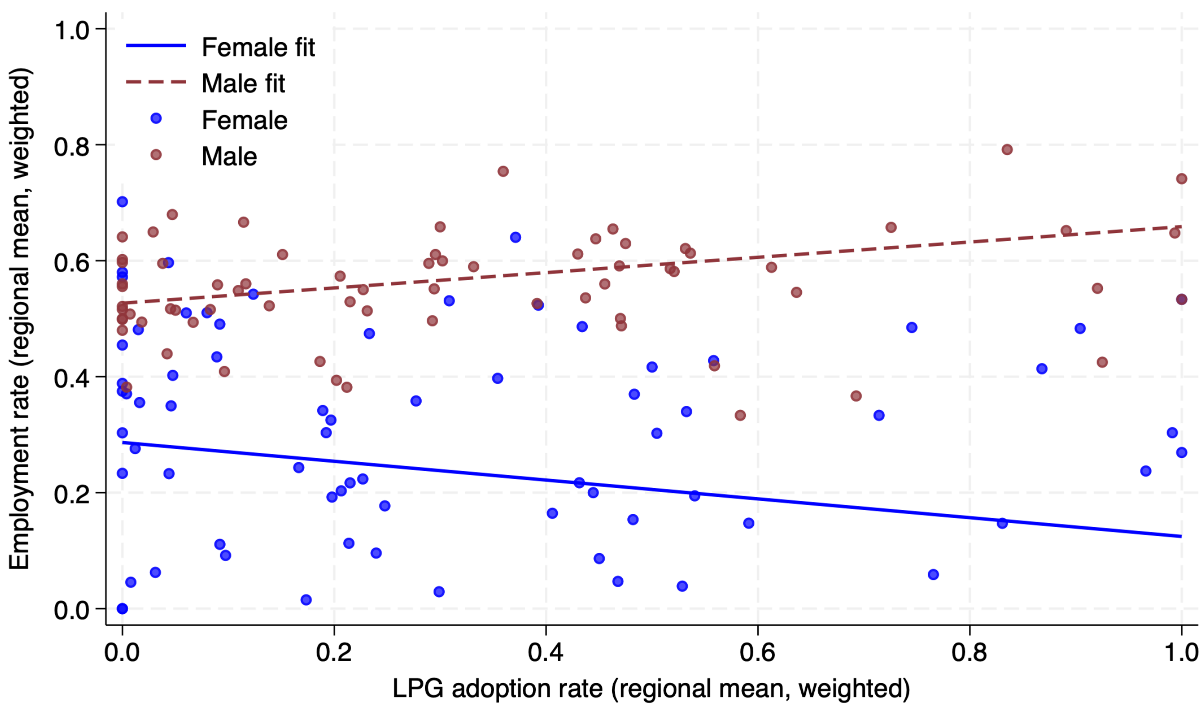


Figure 5: Work Days Per Year - Female

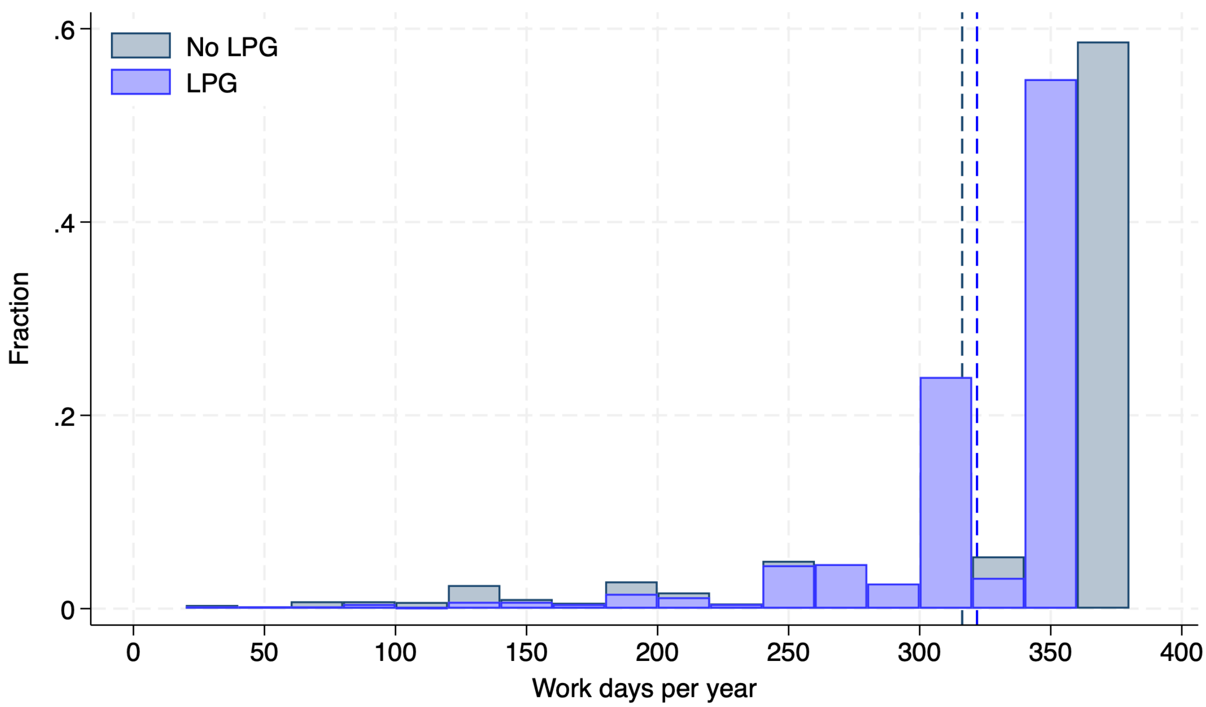
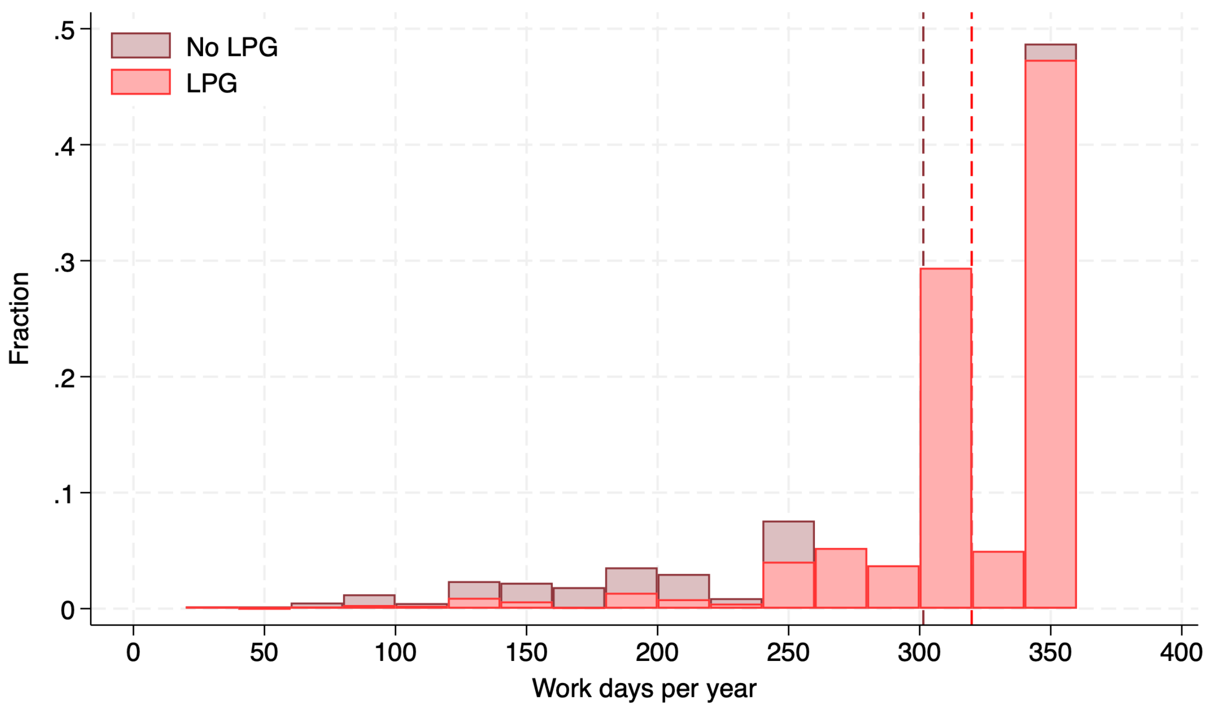


Figure 6: Work Days Per Year - Male



# A Appendix: First Stage

Table 14: First-Stage for Time Allocation: Probit Model

| | (1) Female | (2) Male |
|---|---|---|
| | *Dependent Var: LPG* | |
| slope(instrument) | -0.017*** | -0.018*** |
| | (0.001) | (0.001) |
| Total HH Expenditure(Dollar) | 0.000*** | 0.000*** |
| | (0.000) | (0.000) |
| Urban | 0.121*** | 0.122*** |
| | (0.010) | (0.011) |
| Bank Account Own | 0.153*** | 0.158*** |
| | (0.012) | (0.012) |
| Household Size | -0.034*** | -0.035*** |
| | (0.005) | (0.006) |
| Stove Burner Number | 0.265*** | 0.249*** |
| | (0.012) | (0.013) |
| Age(HH head) | 0.003*** | 0.003*** |
| | (0.000) | (0.001) |
| Gender(HH head) | 0.088*** | 0.075*** |
| | (0.015) | (0.017) |
| Educ year(HH head) | 0.013*** | 0.012*** |
| | (0.001) | (0.001) |
| Self Emp(HH head) | -0.035*** | -0.032*** |
| | (0.011) | (0.011) |
| Non-Farm Emp(HH head) | 0.090*** | 0.094*** |
| | (0.012) | (0.012) |
| Age(main cook) | 0.000 | 0.000 |
| | (0.000) | (0.000) |
| Women Number | 0.031*** | 0.029*** |
| | (0.009) | (0.009) |
| Men Number | 0.001 | 0.003 |
| | (0.008) | (0.008) |
| Kids Number | -0.005 | -0.003 |
| | (0.009) | (0.010) |
| elevation | 0.000 | 0.000* |
| | (0.000) | (0.000) |
| Availability | Yes | Yes |
| House Quality | Yes | Yes |
| *N* | 4,905 | 4,525 |

Reported coefficients are **average marginal effects** from Probit models where the dependent variable equals one if the household uses LPG. Standard errors in parentheses. $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

Table 15: First Stage for Employment: Probit Model

| | (1) Female | (2) Male |
|---|---|---|
| | *Dependent Var: LPG* | |
| Slope (instrument) | -0.017*** | -0.019*** |
| | (0.001) | (0.001) |
| Total HH Expenditure (Dollar) | 0.000*** | 0.000*** |
| | (0.000) | (0.000) |
| Married | 0.013 | -0.028 |
| | (0.019) | (0.019) |
| Urban | 0.122*** | 0.137*** |
| | (0.010) | (0.012) |
| Bank Account Own | 0.157*** | 0.171*** |
| | (0.012) | (0.014) |
| Household Size | -0.018*** | -0.021*** |
| | (0.003) | (0.003) |
| Stove Burner Number | 0.266*** | 0.247*** |
| | (0.016) | (0.018) |
| House Quality | 0.119*** | 0.130*** |
| | (0.010) | (0.012) |
| Age | 0.004*** | 0.004*** |
| | (0.001) | (0.001) |
| Educ year | 0.019*** | 0.013*** |
| | (0.001) | (0.001) |
| Kids Number | -0.022*** | -0.015 |
| | (0.008) | (0.009) |
| HH Head | 0.021 | -0.039** |
| | (0.016) | (0.015) |
| Observations | 5155 | 4114 |
| Availability | Yes | Yes |
| Cook Frequency | Yes | Yes |

Reported coefficients are **average marginal effects** from Probit models where the dependent variable equals one if the household uses LPG. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

# B Additional Heterogeneity

Table 16: First Stage for Work Days: Probit Model

| | (1) Female | (2) Male |
|---|---|---|
| | *Dependent Var: LPG* | |
| Slope (instrument) | -0.019*** | -0.018*** |
| | (0.002) | (0.001) |
| Total HH Expenditure (Dollar) | 0.000 | 0.000*** |
| | (0.000) | (0.000) |
| Married | -0.058* | -0.016 |
| | (0.032) | (0.026) |
| Urban | 0.124*** | 0.168*** |
| | (0.021) | (0.014) |
| Bank Account Own | 0.128*** | 0.135*** |
| | (0.026) | (0.018) |
| Household Size | -0.018*** | -0.016*** |
| | (0.006) | (0.004) |
| Stove Burner Number | 0.237*** | 0.245*** |
| | (0.023) | (0.017) |
| House Quality | 0.105*** | 0.118*** |
| | (0.021) | (0.013) |
| Age | 0.001 | 0.002** |
| | (0.002) | (0.001) |
| Educ year | 0.012*** | 0.010*** |
| | (0.002) | (0.002) |
| Kids Number | -0.009 | -0.024** |
| | (0.017) | (0.011) |
| HH Head | 0.014 | -0.032 |
| | (0.030) | (0.019) |
| Non-Farm Work | 0.092*** | 0.064*** |
| | (0.032) | (0.023) |
| Self Employed | 0.029 | 0.071*** |
| | (0.028) | (0.017) |
| Observations | 1069 | 2586 |
| Availability | Yes | Yes |
| Cook Frequency | Yes | Yes |

Reported coefficients are **average marginal effects** from Probit models where the dependent variable equals one if the household uses LPG. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 17: Urban and Rural Heterogeneity

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Female | | Male | |
| | Rural | Urban | Rural | Urban |
| | *Dep Variable: Employment* | | | |
| LPG | -1.347*** | -0.826*** | 0.938* | 0.808*** |
| | (0.255) | (0.165) | (0.497) | (0.226) |
| Total HH Expenditure (USD) | -0.000 | -0.000 | -0.000* | -0.000* |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Married | 0.112 | -0.348*** | 0.534*** | 0.541*** |
| | (0.146) | (0.096) | (0.154) | (0.100) |
| Bank Account Own | 0.007 | 0.159** | -0.441*** | -0.170 |
| | (0.075) | (0.079) | (0.161) | (0.106) |
| Household Size | -0.016 | -0.002 | 0.041 | 0.013 |
| | (0.016) | (0.015) | (0.031) | (0.023) |
| Stove Burner Number | -0.028 | -0.144** | -0.143 | -0.375*** |
| | (0.086) | (0.072) | (0.142) | (0.099) |
| House Quality | 0.223*** | 0.315*** | 0.021 | -0.214*** |
| | (0.049) | (0.063) | (0.092) | (0.082) |
| Age | 0.019*** | 0.011*** | 0.029*** | 0.022*** |
| | (0.004) | (0.004) | (0.011) | (0.005) |
| Educ year | 0.059*** | 0.045*** | -0.024* | -0.002 |
| | (0.009) | (0.007) | (0.014) | (0.010) |
| Kids Number | 0.017 | -0.106*** | 0.131 | 0.105 |
| | (0.045) | (0.038) | (0.093) | (0.064) |
| HH Head | 0.625*** | 0.322*** | 0.396*** | 0.420*** |
| | (0.122) | (0.077) | (0.150) | (0.110) |
| Residual | 0.690*** | 0.386*** | -0.525* | -0.337** |
| | (0.149) | (0.100) | (0.295) | (0.146) |
| Availability FE | Yes | Yes | Yes | Yes |
| Cook frequency FE | Yes | Yes | Yes | Yes |
| *N* | 2090 | 3065 | 1649 | 2437 |

One of the availability variables, which has three dummies, is excluded from Column (1) because the probit model does not converge when it is included. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 18: Urban and Rural Heterogeneity - Average Marginal Effects

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Female | | Male | |
| | Rural | Urban | Rural | Urban |
| | *Dependent Variable: Employment* | | | |
| LPG (Average Marginal Effects) | -0.392*** | -0.281*** | 0.090** | 0.147*** |
| | (0.046) | (0.049) | (0.042) | (0.044) |
| $N$ | 2090 | 3065 | 1649 | 2437 |

One of the availability variables, which has three dummies, is excluded from Column (1) because the probit model does not converge when it is included. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.