Does access to liquefied petroleum gas (LPG) reduce women household burden? Evidence from India

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Abstract

Using the nationally representative Indian Time Use Survey, we study whether the use of Liquefied Petroleum Gas (LPG) as cooking fuel affects the time spent in cooking and employment activities for Indian rural women. We instrument use of LPG by a leave-one-out spatial instrument constructed by taking the average level of LPG use in the village where the average is calculated leaving the concerned household. We find no impact of LPG on the probability of women participating in cooking activities. However, use of LPG reduces (increases) time spent in cooking (employment) activities. We also find evidence of rebound effect where use of LPG leads to marginally more cooking events in a day. We find that LPG impact on time spent in cooking and employment is mostly driven by married women.

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1 Introduction

In this paper, we examine whether the use of Liquefied Petroleum Gas (LPG) reduces the domestic cooking burden for women in rural India. This is an important question in general as nearly 2.6 billion people worldwide do not have access to clean cooking fuel in 2019 as opposed to 3 billion in 2010 (IEA et al., 2021). However, its importance is attenuated in the Indian context where the female labor force participation rate (FLFPR) remains very low compared to other countries and has witnessed a considerable decline over time. The FLFPR in India among 15+ age group declined from 31 percent in 2001 to 19 percent in 2021. In contrast, China's and world's FLFPR stands at 61 percent and 46 percent, respectively in 2021 (World Development Indicators). Given that rural women in age group 18-60 spend about 23.6 percent of their non-sleeping time on food preparation and management in contrast to only 0.6 percent of non-sleeping time for rural men, access to efficient time-saving modern energy can potentially free up women's time away from cooking activities and increase the potential time available for employment activities. For example, Greenwood, Seshadri, and Yorukoglu (2005) find that technological changes in home production, e.g. washing machines, refrigeration, saved time spent on domestic chores, and increased women's labor supply in developed countries. Similarly, electrification of rural households in South Africa enabled large, immediate shifts in home production technology, increased female employment and plausibly stimulated net labor supply increase (Dinkelman, 2011).

Ex-ante, it is not clear that access to LPG will lead to a decrease in time devoted to cooking activities. Since LPG is more efficient in cooking compared to biomass, use of LPG should decrease time spent on cooking assuming that the amount of cooking women does remains the same. At the same time, since women are becoming efficient in cooking, they may increase the amount of cooking commonly known in literature as "rebound effect".[1] For example, they may increase the variety of foods cooked or increase the frequency of

[1]Rebound effect is the phenomenon where improving energy efficiency may save less energy than expected due to a rebound of energy use.

tea/snacks preparation. In addition, since cooking with LPG is less demanding than cooking with biomass, the household may rely less on hired help. Both may lead to an increase in time spent on cooking activities by women considering women do almost all cooking in Indian rural households. Hence, conceptually, the impact of LPG on total time devoted to cooking remains ambiguous and is an empirical question.

Even in 2019, more than 50 percent of rural Indian households reported biomass as their main source of cooking in spite of considerable attempt by the Government of India to increase the use of LPG.[2] The health and environmental benefits of using LPG over biomass is well-documented (Agarwal, 1986; Bruce et al., 2000; Pillarisetti et al., 2019).[3] However, there are only few studies in developing countries context that look into time-saving aspect of access to modern cooking energy such as LPG.[4] Moreover, the existing studies are mostly based on small samples or experiments carried out in specific context on limited number of households. For example, Williams et al. (2020) use data from randomized trial on 180 adults, non-pregnant women between the ages of 25–64 residing in the high-altitude region of Puno, Peru. Half of the sample (90 women) were provided with the treatment (intervention) under which they received a three-burner locally-produced LPG stove, free continuous LPG refills delivered directly to their home for one year, and behavioral training and reinforcement for LPG use; control participants continued their baseline cooking practices. They find that exclusive use of LPG results in between 3.2 and 3.9 fewer hours cooking and 1.9 fewer hours collecting biomass fuel per week, for a total of up to 5.8 hours saved per week. In a close context to ours, Afridi, Debnath and Dinkelman (2020) conduct an experiment in one district

[2]The Indian Federal Government started a scheme known as Pradhan Mantri Ujjwala Yojna (PMUY) in 2016 with the aim of providing 50 million LPG connections to below poverty line (BPL) families with a support of Indian Rs.1600 per connection in the next three years. By December 2018, 58 million new LPG connections were distributed (source: Sharma, Anshu, "Government expands eligibility criteria to meet Pradhan Mantri Ujjwala Yojana target", CNBC TV18, 19 December 2018).

[3]Imelda and Verma (2019) use the fuel-switching program from kerosene to LPG in Indonesia to study the impact of LPG. They find that access to LPG leads to a significant improvement in women's health, particularly among those who spend most of their time indoors doing housework.

[4]A few studies have looked at whether switching to cleaner stoves can reduce time spent on cooking and collecting fuel. However, most of them have focused on improved biomass stoves that intend to reduce biomass fuel consumption through improved heat transfer efficiency (Rehfuess et al., 2014).

in Central India where they divide randomly selected villages from the district into three groups. They provide information on health benefits of LPG in one group of villages, while providing information on both health benefits of LPG and government subsidy for LPG to the second group of villages. For the third group of villages no information was provided. Thus their treatment status is based on the information campaign to improve LPG uptake of households, and they look at the impact of the information campaign on time spent in household chores.

In this paper, we use nationally representative Indian Time Use Survey 2019 (TUS-2019) to address whether the use of LPG leads to a reduction in time spent on cooking activities by adult women residing in rural India. First, we use the OLS to estimate the impact of LPG on the time spent for food management and preparation, and employment activities controlling for a large set of individual's, household's, and village observable characteristics including district fixed effects. Recognizing that the estimate for LPG may suffer from the omitted variable bias, we instrument household-level LPG using the fraction of households in the village that reported LPG as main source of cooking where the concerned household is excluded in calculating the average. We control for village level characteristics in addition to the districts fixed effects to ensure that out instrument is conditionally uncorrelated with village level geographical differences that may affect individual women time use outcome independently. We also use unconditional quantile regression to capture the heterogeneous impact of LPG based on the total time spent in food management and preparation activities.

Our paper contributes to literature in the following ways. First, to our best knowledge, ours is the first paper that looks at the impact of LPG on time spent on cooking activities using a nationally representative household survey data. In addition, we also look at the time spent on total employment activities. As previously stated, the existing studies that looked at the time spent in cooking activities are mostly based on small surveys or some experiments with the limited number of households. A few studies that look at the impact of LPG are based on small surveys from selected sites, and focus mainly on the time saving due

to decreased time burden of collecting biomass. The cooking time channel remains relatively unexplored, especially using a nationally representative data. Since cooking activities are repetitive and involve almost universal participation from women irrespective of economic status, time saved in cooking activities will have a much larger impact for the economy. For example, about 90 percent of women in rural India not only reported involvement in cooking activities, but also spent considerable time in cooking activities. Hence, the cooking activities channel is much more important.[5]

The main findings of the paper are the following. We find that the instrument variable (IV) estimates have generally the same sign as OLS estimates, but IV estimates are mostly larger in magnitude. We find that having LPG as the main cooking fuel has no impact on the extensive margin as far as cooking activity is concerned, i.e., women's involvement in cooking activities does not depend on LPG use. This is not surprising given very high participation in cooking activities by adult women in rural India. We find that having LPG as the main cooking fuel reduces the total time spent by women in food management and preparation by 5.6 minutes per day. This decline is about 2.6 percent of the average time of 212 minutes spent in food management and preparation by women per day. Looking at the different activities of food preparation and management, we find use of LPG reduces actual cooking time by 2.3 minute which is 1.6 percent of the average time of 136.5 minutes spent on actual cooking per day. We find some evidence of rebound effect mitigating the impact of LPG on actual cooking time. The women who use LPG are more likely to cook meal/snacks more than 3 times a day, while the average time spent per cooking activity is lower with LPG use. We also find LPG use reduces time spent on cleaning, storing, and other food related activities, but increases time spent for serving meals/snacks. Importantly, we find

[5]In comparison, firewood may be collected by women once every 3-7 days, and may involve children or adult males also. In our data which captures the activities for one day, only 5 percent of the women in 18-60 age group in rural India reported collecting firewood. It is possible that the 5 percent is under counting the women participation in fuel collection because of infrequent nature of the activity. However, given the nature of nationally representative data, one could infer that at any random day only 5 percent of the women in age group 18-60 were involved in fuel collection compared to 90 percent women being involved in cooking activities in rural India.

that women residing in household that use LPG as the main cooking fuel are likely to work 8.0 minutes more compared to women who reside in household that do not report LPG as main cooking fuel. Although in terms of minutes, this is not a large gain. However, given that on average, rural Indian women spend around 84.6 minutes on employment activities, this is about 9.5 percent increase in time spent in employment activities. Our unconditional quantile regression estimates suggest that the impact of LPG is only marginally larger at higher quantiles.

The remainder of the paper is organized as follows. Section 2 discusses the empirical methodology. Section 3 describes the data. Section 4 presents the results. Section 5 concludes.

2 Empirical Methodology

Our objective is to estimate the causal effect of use of LPG on the time spent in cooking activities by women, hence, we estimate the following equation:

$$Y_{ihvd} = \alpha + \delta LPG_{hvd} + \beta X_{ihvd} + \varsigma X_{vd} + \eta_d + d_\tau + \varepsilon_{ihvd} \tag{1}$$

where Y_{ihvd} denotes the time spent in cooking activities by women i, residing in household h, in village v of district d. X_{ihvd} is a matrix of both women's and household's observed characteristics, while X_{vd} contains village characteristics. η_d are districts fixed effects, d_τ represents fixed effects for the day of the week when household time use information was collected, and ε_{ihvd} is the randomly distributed error. LPG_{hvd} is the binary indicator that captures whether household's main source of cooking is LPG, and δ is our main interest parameter that captures the impact of LPG on the outcome variable. We first estimate the Equation (1) using the Ordinary Least Squares (OLS).

One potential issue with the use of OLS is that the outcome variable is zero for a significant proportion of women, especially when we consider some sub-categories of cooking

activities. In the case of censoring, alternative remains a Tobit model. Frazis and Stewart (2012) argue that OLS models are preferred in the analysis of time allocation decisions given that the estimation techniques for limited dependent variables which assume a nonlinear functional form, such as the Tobit model, will be inconsistent if one wants to estimate means of long-run time use from a sample of daily observations. Stewart (2013) finds that zero time usage is not caused by censorship, but by a discrepancy between the data reference period (diary days) and the period of interest (usually much longer than a day), and the Tobit model estimation will be inconsistent, but OLS estimates are unbiased. Gershuny (2012) asserts that there is a problem with too many zeros originating from single-day diaries, but traditional diary studies can accurately estimate the mean times in activities for samples and subsamples. Moreover, Foster and Kalenkoski (2013) find that the qualitative conclusions are similar for Tobit and OLS methods when analyzing the time allocated to childcare activities. Hence, we chose OLS over Tobit model for simplicity and ease of interpretation.

2.1 Instrument Variable Framework

The OLS estimate provides an unbiased estimate of the impact of LPG use on time spent on cooking activities if the choice of LPG is not correlated with the error term after controlling for other observables. Although we control for a large set of characteristics including household demographics and income (proxy by per capita consumption expenditure), village characteristics, and district fixed effects, it is difficult to rule out some unobserved factors that may be correlated with both the outcome and LPG use. Hence, the endogeneity of LPG cannot be ruled out.

To address the issue of the potential endogeneity of the LPG variable, we adopt an instrument variable (IV) strategy. We use the fraction of households in the village that reported LPG as main source of cooking where the concerned household is excluded in calculating average.[6] There are many studies that have used similar leave-one-out or spatial instrument,

[6]We also use average use of LPG where average is based on all households as an instrument, and results

i.e. they instrument person i's endogeneous variable with the average of endogenous variable among person i's peers, excluding i himself or herself in this average (For example, Fruehwirth et al., 2019; Khandker et al. 2014; Persson and Tabellini, 2009). Using village level average LPG use as an instrument, we estimate the following two-stage least square model:

$$LPG_{ihvd} = \gamma_0 + \gamma_1 . meanLPG_{-(ih),vd} + \gamma_2 X_{ihvd} + \gamma_3 X_{vd} + \eta_d + d_\tau + \vartheta_{ihvd} \tag{2}$$

$$Y_{ihvd} = \pi_0 + \pi_1 \widehat{LPG_{ihvd}} + \pi_2 X_{ihvd} + \pi_3 X_{vd} + \eta_d + d_\tau + \sigma_{ihvd} \tag{3}$$

where $meanLPG_{-(ih),vd}$ is the fraction of households in the village v that reported LPG as their main source of cooking, where the concerned household is excluded in calculating average for the village. There are two identifying assumptions here. First, average LPG use in a village must be correlated with the household use of LPG, i.e. $\gamma_1 \neq 0$ in Equation (2). The second condition, known as the exclusion restriction, implies that $meanLPG$ affects the outcome Y_{ihvd} only through LPG use by the household.

The fraction of households in village that reported use of LPG as main source of cooking is expected to serve as an instrument because peer pressure or demonstration effect is likely to affect a household's decision to use LPG as households tend to follow their neighbors or other associates in the village. If neighbors obtain LPG, then a household without LPG can signal lower socioeconomic standing, which households would be expected to avoid if they can afford it. There is a large body of literature on peer effects. For example, Arcidiacono and Nicholson (2005) and Jackson and Bruegmann (2009) analyze the peer effect in the context of students' academic achievement. Krauth (2003) incorporates both peer effects and selection effects to investigate the youth's decision to smoke. Cornelissen et al. (2017) focus on estimating the effect of the long-term or predetermined quality of a worker's current peers on the current wage. Nicoletti et al. (2018) provide empirical evidence that the increase in mothers' working hours is amplified through the influence of family peers. Thus, we

are similar.

postulate that the higher the percentage of households using LPG in a village, the greater the likelihood that a household living in that village will adopt LPG.

The second condition is also expected to hold as the incidence of LPG use at the village level should not directly impact the time devoted by women to cooking activities that are primarily based on individual household needs. While the first identifying assumption can be validated in the data, the exclusion restriction is debatable. One potential issue with our IV is that it may be correlated with other omitted village level geographical characteristics, and the impact on cooking time is through the correlation with omitted village level variables. To mitigate the concerns, we not only control for district fixed effects but also a set of village level characteristics. We believe that conditional on all the explanatory variables included in the estimation, only route through which village average LPG use affects individual women's time spent in cooking activities is through the influence on the household use of LPG.

3 Data

We use the Time Use Survey (TUS) 2019 collected by the Indian National Sample Survey Organization (NSSO). The survey is nationally representative and covers 1,38,799 households in both rural (82,897 households) and urban (55,902 households) India. The survey provides detailed information on time use collected over 24 hours starting from 4:00 A.M. on the day before the date of interview to 4:00 A.M. on the day of the interview. Thus, the diary time frame is 24 consecutive hours and is divided into 30-minute intervals. If multiple activities are performed during the 30-minute slot, time used in each activity is documented. The Indian TUS uses the International Classification of Activities for Time Use Statistics 2016 (ICATUS 2016) to record 3-digit codes for different activities carried out by an individual in 30-minute slots over 24 hours. Overall, the TUS has detailed time use information of 4,47,250 persons of age six years and above (rural: 2,73,195 and urban:1,74,055).

Appendix Table A1 presents the distribution of households based on the main cooking

fuel used. About 86.2 percent of urban households reported LPG as main source of cooking compared to only 51.5 percent of rural households. Since our main objective is to look at the impact of LPG use on cooking time, we restrict our sample to rural India as most of the households in urban India report use of LPG as main cooking fuel source. A household is classified as using LPG if the main cooking fuel is LPG or other natural gas. Non-LPG fuel include firewood and chips, dung cake, coke or coal, and charcoal.[7]

Given that the main burden of cooking falls on women, we restrict our sample to rural women in age 18-60 and exclude students. So, our final sample consists of 86,970 non-student women in age group 18-60 residing in rural India.[8] Table 1 shows the summary statistics of the time spent in the activities of interest for this study. On average, women (18-60 age group) in rural India spend about 3 hour and 33 minutes on food management and preparation activities that constitute about 14.8 percent of the total time available in 24 hours. However, once we exclude the sleeping time, this constitutes a staggering 23.6 percent of non-sleeping time. In contrast, the average time spent on employment activities is only 1 hour and 25 minutes which is about one third of time spent on cooking activities. Women in rural India on average cook 2.7 times in a day, and each cooking event takes about an hour.

Table 2 provides summary statistics for the control variables used in the regression analysis. The control variables include individual characteristics such as education, age, marital status, and employment types; household level characteristics such as monthly per capita expenditure, religion, caste, household demographic composition, house type, household head's education, gender, and employment types. The explanatory variables also include village characteristics such as mean consumption expenditure, employment rate, percentage of population with higher secondary or above education, percentage of upper castes

[7]About 0.68 percent of the households in rural India reported using electricity, gobar gas, other bio gas, or other fuels as theirs main fuel source. We exclude those households from our sample. In addition, we also exclude 0.46 percent of the households from our sample who do not report cooking.

[8]The survey day are coded "normal day" and " the other day". The normal days are the days on which a household member mainly pursues their routine activities, whereas the day on which the regular activities of a household member are altered for any reason is treated as "other day". We only use the data if individual reported the survey day as typical normal day.

in the population, percentage of households which contain a regular salaried member, and percentage of households living in mud house.

4 Results

Panel A of Table 3 presents OLS estimates for the impact of LPG use estimated using Equation (1). The first column of the Table 3 looks at the probability of a woman involved in cooking. As argued earlier, the ease of use for LPG compared to biomass may provide an incentive for some to get involved in cooking, i.e. the cooking increases at extensive margin. In rural India, women involvement in cooking activities is very high as 90 percent of the women in our sample report spending some time in a day in cooking activities defined as preparation of meals/snacks. The OLS estimate from column (1) suggests no impact of LPG use by household on the probability of women's involvement in the cooking activities implying that LPG has no impact on the extensive margin. This is not surprising as access to more efficient cooking methods is more likely to affect cooking time on intensive margin in a society where cooking is primarily considered as women's responsibility and a large share of women already report being involved in cooking activities. In contrast, only 3.8 percent of rural men in age group 18-60 reported spending any time in cooking activities. Hence, the probability of intra-household substitution of cooking activities across genders remains extremely low. Therefore, we do not consider men sample in our analysis.

Column (2) of Table 3 provides estimates for the impact of LPG use on total time spent on food preparation and management activities. Although the OLS estimate suggests a negative impact of LPG on total time spent, the magnitude of the impact remains very small, i.e. 1.8 minutes decline on an average of 212.5 minutes spent in a day in food preparation and management activities that translates into only 0.8 percent decline in time spent on food preparation activities. Hence based on OLS estimate, one could argue that the impact on LPG on freeing up time from the kitchen activities is limited.[9] In column (3) of Table 3, we

[9]In literature, one of the potential channels for time saving discussed is through reduced burden of

consider different activities under food preparation and management. Column (3A) looks at the actual time spent in cooking. Given the superiority of LPG in providing heat, one would expect a reduced time in actual cooking assuming that the amount of food cooked is not affected by LPG use. We find no impact on total time spent in cooking activities. Since LPG provides quick cooking start and heating compared to traditional biomass in addition to the higher thermal heat, it is surprising that there is no impact of LPG on time spent in actual cooking.[10] Perhaps, women with LPG increased the frequency of cooking, or cook more items because of ease to start heat. Since, the time and efforts required to start biomass heat are substantial, it is plausible that women club the entire day of cooking together when using biomass providing some economies of scale. We find a statistically significant negative impact on time spent on cleaning up, storing food, and other food related activities. However, minutes saved in those activities remain small to have any considerable impact on total time spent on food management and preparation. In column (4), we look at the impact of LPG on time spent in employment activities, and find a positive impact of 2 minutes. Since average time spent by women on employment activities is 84.5 minutes, this translates into an impact of about 2.5 percent increase in time in employment activities. Interestingly, the time reduction in food management and preparation (about 1.8 minutes) and time increased in employment activities are comparable in magnitude.

collection of firewood and dungs. This is captured in our data by ICATUS code 241: Gathering firewood and other natural products used as fuel for own final use. We do not consider the time spent on collecting firewood as separate outcomes, as only 5 percent of women (and 1.2 percent of men) in age group 18-60 in rural India reported spending time in collection of firewood. As stated earlier, it is possible that the 5 percent of women participation in firewood collection may be understating the true participation because of 24 hour recall period for the survey and infrequent nature of firewood collection activity. However, the survey is representative of the population activity on a given day, so on any given day only 5 percent of women participate in firewood collection. Another source of discrepancy may be because of the target population of small surveys, mostly poor residing around forest areas. The firewood collection participation is higher in poor and population residing closer to forest areas.

[10]Bruce et al. (2017) find that the reported thermal combustion efficiency of LPG is in the range of 45-60 percent depending on the stove used. They also find that, when tested in the laboratory, although some fan-assisted advanced biomass cookstoves can reach efficiency of 30-55 percent but their efficiency is quite low in everyday use. Muralidharan et al. (2015) found that the in-home efficiency of two types of advanced biomass fan stove is between 17 to 25 percent. WLPGA (2018) models the potential for mitigating greenhouse gas emissions and finds that annual per capita cooking requires 43 kg LPG instead of 400 kg of wood.

4.1 Instrument Variable Estimates

As discussed in the empirical strategy section, OLS estimates may be biased because of omitted variables. To address the endogeneity concerns, we implement the instrumental variable strategy. Appendix Table A2 presents estimates for the first stage regression, where we regress the indicator variable LPG on the meanLPG and other variables discussed earlier. The first stage results confirm a strong relationship between LPG use by the household and average of LPG use by other households in the village. The point estimate suggests that a ten-percentage point increase in the fraction of LPG usage in the village is associated with a 8.4 percentage point increase in the probability of LPG use by the household.

In Table 4, we report the results of the Durbin and Wu-Hausman tests that examine whether LPG variable can be treated as an exogenous variable in the outcome equation. For all the time outcomes except time spent in cleaning or storing, we reject the null of exogeneity of LPG variable at 5% significance level. For time spent in cleaning also, the exogeneity of LPG can be rejected at 10% significance level. For binary variable involvement in cooking activities and time spent in storing food, exogeneity of LPG cannot be rejected. Given that exogeneity of LPG is rejected for majority of our outcomes, we proceed with IV estimation and report IV estimates for all outcomes. However, recall that OLS estimates will be efficient in the case LPG variable is exogenous.

Panel B of Table 3 reports the IV estimates for all outcomes. IV estimate also suggests that having LPG as the main cooking source will not affect the probability of a woman involved in cooking, and IV estimate is similar in magnitude to OLS estimate. Hence, one can conclude that having LPG as main cooking fuel does not affect cooking activities on extensive margin. Column (2) in panel B, Table 3 indicates that the total time spent on food management and preparation is reduced because of use of LPG as main cooking fuel source. Recall that, we reject the null of exogeneity of LPG variable in the case of aggregated time spent in food management and preparation, hence, the IV estimate is preferable. Although, the signs of both OLS and IV estimates are negative suggesting a reduction in time spent, the

magnitude of the IV estimate is more than three times of the OLS estimate. This suggests positive omitted variable bias in the OLS estimate reducing the negative impact of LPG. The IV estimate suggests that use of LPG reduces time spent on food management by 5.7 minute per day that translates into 2.7 percent reduction in time spent on food management activities per day. In terms of practical impact, this suggests reduction of 40 minutes in a week, which may not seem a large impact for an individual but given 93 percent participation of rural women in food preparation and management activities, it will translate into a large number of absolute hours saved for the entire economy which could be used alternatively.

Column (3A) of Table 3 presents IV estimate for the time spent in preparing meal/snacks. Compared to OLS estimate, the magnitude of the IV estimate is considerably larger, and the IV estimate is statistically significant. The IV estimate suggests saving of 2.4 minutes on the mean 136.5 minutes which translates into 1.8 percent reduction in time spent on actual cooking activities. As stated earlier, the limited impact on actual cooking time is a little bit puzzling given the superiority of LPG on biomass in generating heat. It is entirely plausible that the women who use LPG cook more items that is not captured in data. In appendix Table A3, we check for the rebound effect. We find that women with LPG access are 1.9 percentage points more likely to cook more than three times in a day. The women with LPG access on average cook 0.06 times more in a day where the average number of cooking events are 2.73. While on average per cooking activity takes about 57.6 minutes, having access to LPG reduces average time by 3.0 minutes per cooking activity. This is about 5 percent reduction in time per cooking activity. It is important to point out that the amount of cooked food is not captured in the data. Nonetheless, there is some evidence of rebound effect where women with LPG access cook marginally more times although spend less time per cooking activity. This potentially leads to smaller effect on total time spent in cooking activities in a day.

The time spent in serving meals/snacks increased by about 2.7 minutes (column 3B, panel B of Table 3). The ease to start fire to prepare meals also implies LPG users may have

tea/coffee or other snacks more easily than traditional biomass users probably driving the positive impact. IV result for cleaning up outcome suggests that women who use LPG spend less time in cleaning up perhaps because the pots and pans are no longer covered in soot from cooking over a wood fire (Clancy et al., 2012). Similarly, LPG users spend less time in storing and other food management activities. Importantly, while both IV and OLS estimate for time spent in employment activity suggest positive impact of LPG, the IV estimate is about four times stronger than the OLS estimate (panel B, column (4) of Table 3). Women who use LPG are likely to spend 8.1 minutes more in employment activities per day compared to women who use biomass. Although in terms of minutes spent in employment activities, 8.1 minutes per day do not seem large, but given a very low employment rate in women, this translates into a 9.5 percent increase in time devoted to employment activities on an average time of 84.5 minutes.

4.2 Heterogeneity in LPG impact

The discussion so far looks at the impact of LPG on average time spent without distinguishing among LPG users. However, we do not expect that every LPG user will benefit similarly, irrespective of their cooking needs. To capture the heterogeneity in the impact of LPG, we use unconditional quantile regression (Firpo, Fortin, and Lemieux, 2009) and focus on total time spent in food management and preparation, since quantiles for other outcomes are not well defined in the presence of a large fraction of the outcome being zero. For the total time spent on food management and preparation activities, zero values only account for about 7 percent of rural women. For unconditional quantile regression, we do not instrument LPG use because of computational issues. Frolich and Melly (2013) propose a IV implementation of the quantile regression, and a STATA routine 'ivqte' is available to implement their strategy. However, the Frolich and Melly (2013) approach requires use of indicator variable as an instrument, and our instrument is a continuous variable. Khandker et al. (2014) converts their IV which is continuous average village level electrification to binary IV by using a 50

percent electrification rate as cut off. Importantly, incorporation of survey weights in the IV implementation of the quantiles is not discussed in Frolich and Melly (2013), and not incorporated in 'ivqte'. Given that the time use survey we use in our paper is a stratified sample, an unweighted IV implementation of quantiles will not provide the right answer.

In Table 5 we present the results of the unconditional quantile regressions for total time spent on food management and preparation. We considered all observations in column (1). In column (2), we dropped the observation where the reported total time spent in food management and preparation is zero. We find that the time reductions in total time spent on food management because of LPG use are larger at higher quantiles. While LPG user women spend 15.5 minutes less than non-user women at the 90th percentile of time spent, the LPG user women spend 11.5 minutes less compared to non-user at the 25th percentile of time spent.

Another source of heterogeneity in Indian context is caste, where individuals acquire their caste by virtue of birth. Historically in pre-independence era, certain groups were delegated to do menial works or were geographically isolated. At the time of independence, the Constitution of India recognized the injustice suffered by those groups and lists them under Article 341 and 342 as Scheduled Castes and Scheduled Tribes (SCs/STs). The Constitution also provided affirmative action protection for the SCs/STs in the form of reserved seats in higher educational institutions, in public sector jobs, in state legislatures and the Indian parliament. In addition to the SCs/STs, the government of India also groups a number of castes who do not belong to the SCs/STs but on economic/educational parameters they are not doing well as Other Backward Castes (OBCs), and has reserved a fraction of seats in higher education and public sector jobs for OBCs since 1993. The groups who do not belong to the SCs, STs, or OBCs form higher castes and do not get any affirmative benefits from the government. Normally in economic and social hierarchy, higher (upper) castes stand at the top, followed by the OBCs and SCs/STs. A large body of literature exist that documents the gaps among these castes on various economic outcomes (e.g., Kijima, 2006; and Hnatkovska, Lahiri, and

Paul, 2012).

Eswaran, Ramaswami, and Wadhwa (2013) postulate that women's labor market work, relative to their husbands', should decline as one moves up the caste hierarchy implying higher participation in SCs, STs, and OBCs compared to higher castes. To allow for LPG impact to vary across castes, we introduce interactions of LPG use with indicators for SCs, STs, and OBCs in Equation (1) whereas higher casters serve as the omitted group. We also instrument LPG and caste interactions with 'our leave-one-out instrument' discussed earlier and interactions of it with caste indicators. The Durbin and Wu-Hausman tests that examine whether the interaction of LPG with castes can be treated as exogenous variables show that, for all the time spent outcomes, the exogeneity of LPG variable can be rejected at the conventional 5% significance level (reported in appendix Table A4). Hence, we focus on the IV results in Table 7.[11]

Column (1) of Table 7 presents the results for the probability of involvement in cooking. Compared to higher castes, the use of LPG decreases the probability of participation in cooking for the SC and ST women but no differential impact for the OBC women. The labor force participation among the SC/ST women is much higher compared to the higher caste women. The female labor force participation in India shows an inverse relation with household income/wealth/status. Probably access to easy cooking may free up additional women from the SC/ST household from cooking requirement. With regards to the time spent on food management and preparation, there exists no statistically significant difference in the impact of LPG between higher castes and SC/ST households. Both higher caste and SC/ST households spend less time on food management and preparation with LPG than without LPG being the main source of cooking. Interestingly, the LPG users from the OBCs spend more time than non-users in food management and preparation. We do not find statistically significant differentials across castes for the impact of LPG on time spent in employment activities. Overall, the heterogeneity across castes in terms of impact of LPG on the time

[11]OLS results are reported in Appendix Table A5.

spent in food preparation and management activities do not seem strong.

Besides the caste, the marriage status may also affect the time spent in food preparation. Pepin, Sayer, and Casper (2018) find that marital status differentiated housework and the number of employment hours. To capture the impact of LPG based on marital status, we carried out our analysis separately for married women and single women. It is noteworthy that the custom of patrilocal marriage shifts a woman from her natal family to being part of her husband's household, hence a single woman is more likely to be daughters of the households while married women are daughters-in-law of the households. Panel A and Panel B of Table 8 report the IV results for married women and single women, respectively. It is interesting that while LPG access has no impact on the involvement in cooking for married women, it increases the probability of involvement in cooking for single women by 4.5 percentage points. It is important to point out that while 93 percent of married women reported participation in cooking compared to only 71 percent of single women. While the participation of single women or daughters is higher with LPG use, there is no impact of LPG on time spent in food management activities or employment activities for single women. In contrast, we see 7 minutes decrease in time spent on food management for married women. Similarly, for married women time spent in employment activities increased by 10 minutes which 13.5 percent increase in total time spent in employment activities.

5 Conclusion

We address the question of whether use of LPG reduces the time burden of cooking for rural Indian women and free up time for employment activities using the nationally representative Time Use Survey collected in 2019 by the Indian National Sample Survey Organization. To address the endogeneity of LPG, we use a leave-one-out spatial instrument constructed through taking mean level of LPG use in the village where the mean is calculated excluding the concerned household. The OLS and IV estimates are similar in sign, however, the

magnitude of IV estimates turn out much larger than the OLS estimates. We find that the LPG does not influence the probability of women's involvement in cooking activities. However, the use of LPG reduces the time spent in food management and preparation activities. Nevertheless, the magnitude of the reduction in time spent in cooking activities remains low. We find evidence of rebound effect where women with LPG access cook marginally more times potentially mitigating some of the time reducing effect of LPG on total time spent in cooking. Moreover, we find use of LPG increases time spent in employment activities by married women by 10 minutes per day. Although in terms of minutes, the time saved does not seems large, given the low amount of time spent in employment activities by married women, this translates into 13.5 percent increase in time spent in employment activities. Moreover, given that 93 percent of married women in rural India are involved in cooking with about half of them with no access to LPG, a 70 minute gain per week as a result of LPG in employment activities suggests a potential for huge amount of additional employment hours for the economy.

Time saved (or increased) in cooking (employment) activities is one dimension of potential benefits of LPG use. There are other benefits, such as environmental and health benefits, of LPG use which are well documented. The benefits of increased employment time and reduced burden (although limited) of cooking activities add to the potential benefits of LPG for the society, and reinforce the urgency shown by Indian policymakers in ensuring LPG access to majority of Indian population. There are a few caveats with our studies. Our LPG use is based on the question about the main source of household cooking fuel. LPG being main source of cooking fuel does not guarantee exclusive use of LPG. It is possible and probably expected that rural households engage in fuel stacking behavior potentially reducing the impact. For example, Cheng and Urpelainen (2014) use two rounds of NSS data collected in 1987-88 and 2009-10, and find that stacking of LPG and traditional biomass has grown rapidly in India over 1987 and 2010. In the absence of exclusive use of LPG, the impact of LPG on time saved will be an underestimation.

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Table 1: Time spent in different activities (*in minutes*)

	(1)			(3)	(4)
				min	max
	LPG	*non-LPG*	All		
Employment and related activities	89.008	79.631	84.556	0	1,260
	(170.895)	(162.023)	(166.806)		
Food management and preparation	206.716	218.910	212.506	0	750
	(109.155)	(114.294)	(111.790)		
Preparing meals/snacks	131.515	141.968	136.479	0	630
	(75.351)	(79.830)	(77.689)		
Serving meals/snacks	24.535	24.050	24.305	0	390
	(33.953)	(32.509)	(33.275)		
Cleaning up after food preparation	40.014	40.243	40.123	0	300
	(36.585)	(37.386)	(36.967)		
Storing, arranging, preserving Food	3.294	3.389	3.339	0	300
	(14.360)	(16.066)	(15.194)		
Other activities of food management	7.358	9.259	8.261	0	360
	(22.372)	(25.991)	(24.177)		
Number of Observation	44770	41200	85,970		

Note: Source: Indian Time Use Survey, 2019. Averages are constructed using sample of women aged 18-60 residing in rural India and accounting for survey weights. Standard deviations are in parenthesis.

Table 2: Summary Statistics

	Mean					
	(1)		(2)		(3)	
Individual level controls	*LPG*	*SD*	*non-LPG*	*SD*	All	SD
Age	37.16	11.678	36.57	12.110	36.88	11.863
Married (1/0)	0.86	0.343	0.86	0.349	0.86	0.346
Primary School (1/0)	0.13	0.342	0.14	0.343	0.14	0.342
Middle School (1/0)	0.16	0.364	0.14	0.352	0.15	0.358
Secondary (1/0)	0.14	0.344	0.08	0.269	0.11	0.312
Higher Secondary (1/0)	0.09	0.291	0.05	0.209	0.71	0.257
Graduate and above (1/0)	0.07	0.259	0.02	0.154	0.50	0.217
self-employed (1/0)	0.13	0.333	0.15	0.355	0.14	0.344
wage or salary employed (1/0)	0.04	0.204	0.02	0.148	0.03	0.180
casual wage labor (1/0)	0.09	0.280	0.09	0.288	0.09	0.284
Household level controls						
LPG	1.00	0.000	0.00	0.000	0.53	0.499
meanLPG (Fraction of household in village with LPG)	0.73	0.270	0.27	0.258	0.51	0.349
Household size	4.35	1.818	4.50	1.996	4.42	1.906
Log of monthly per capita expenditure	8.98	0.521	8.77	0.519	8.88	0.530
Number of age group 0-14	1.13	1.206	1.32	1.352	1.22	1.281
Number of age group 15-64 (male)	1.45	0.875	1.42	0.902	1.44	0.888
Number of age group 15-64 (female)	1.59	0.780	1.59	0.800	1.59	0.790
Muslim (1/0)	0.10	0.305	0.14	0.343	0.12	0.324
Scheduled Tribe (1/0)	0.08	0.267	0.17	0.375	0.12	0.326
Scheduled Caste (1/0)	0.20	0.399	0.22	0.415	0.21	0.407
Other backwards Classes (1/0)	0.46	0.498	0.41	0.492	0.44	0.496
Small family land (1/0)	0.08	0.267	0.07	0.256	0.07	0.262
Medium family land (1/0)	0.05	0.220	0.04	0.191	0.05	0.207
Large family land (1/0)	0.03	0.175	0.02	0.151	0.03	0.165
Semi-pucca house (1/0)	0.26	0.438	0.34	0.472	0.30	0.456
Pucca house (1/0)	0.66	0.473	0.44	0.496	0.55	0.497
Head age	47.23	12.999	46.10	13.246	46.69	13.129
Female head (1/0)	0.14	0.350	0.14	0.345	0.14	0.347
Head education level						
Primary School (head) (1/0)	0.14	0.351	0.16	0.366	0.15	0.358
Middle School(head) (1/0)	0.17	0.374	0.17	0.373	0.17	0.373
Secondary(head) (1/0)	0.15	0.357	0.09	0.283	0.12	0.326
Higher Secondary(head) (1/0)	0.09	0.279	0.04	0.202	0.07	0.246
Graduate and above(head) (1/0)	0.07	0.262	0.02	0.145	0.05	0.216

Self-employed (head) (1/0)	0.48	0.499	0.46	0.498	0.47	0.499
Wage or salary employed (head) (1/0)	0.12	0.329	0.07	0.258	0.10	0.299
Casual wage labor (head) (1/0)	0.24	0.426	0.33	0.471	0.28	0.451
Village Level Controls						
Average log of monthly per capita expenditure	2131.98	816.420	1804.74	658.696	1976.60	763.391
Employment rate	0.38	0.124	0.36	0.119	0.37	0.122
Proportion of high caste in population	0.25	0.302	0.22	0.300	0.23	0.301
Proportion of population with higher secondary or above education	0.14	0.103	0.10	0.080	0.12	0.095
Proportion of population living in mud house	0.11	0.181	0.20	0.248	0.15	0.220
Proportion of households with salaried member	0.19	0.184	0.14	0.164	0.17	0.176
Number of Observation	44770		41200		86,970	

Table 3: Impact of LPG use on women's time allocation in different activities (in minutes), Rural India

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
	Involved in cooking (1/0)	Food management and preparation	Preparing meals/snacks	Serving meals /snacks	Cleaning up	Storing, arranging preserving Food	Other activities of food management	Employment and related activities
Panel A: OLS								
LPG	0.001	-1.837**	-0.351	0.980***	-0.981***	-0.303**	-1.111***	1.992**
	(0.002)	(0.755)	(0.537)	(0.235)	(0.280)	(0.121)	(0.186)	(0.878)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	85,969	85,969	85,969	85,969	85,969	85,969	85,969	85,969
R-squared	0.205	0.340	0.308	0.276	0.170	0.088	0.144	0.599
Panel B: IV								
LPG	0.002	-5.730**	-2.419***	2.672***	-1.907**	-0.618***	-3.457***	8.065***
	(0.005)	(1.535)	(1.092)	(0.479)	(0.569)	(0.245)	(0.379)	(1.786)
Observations	85,962	85,962	85,962	85,962	85,962	85,962	85,962	85,962
R-squared	0.206	0.340	0.309	0.276	0.170	0.088	0.143	0.599

Note: The instrument variable used is the fraction of households in village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The OLS/IV regressions control for women' age, marriage status, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Hausman Test for Endogeneity of IV

H0: the variable under consideration (LPG) can be treated as exogenous		
IV= Fraction of household in village with LPG		
	Durbin	WU
Involvement in cooking activities (1/0)	0.063	0.062
	(0.802)	(0.803)
Food management and preparation	8.461***	8.392***
	(0.004)	(0.004)
Preparing meals/snacks	4.718**	4.680**
	(0.030)	(0.031)
Serving meals /snacks	17.849***	17.705***
	(0.000)	(0.000)
Cleaning up after food preparation	3.478*	3.449*
	(0.062)	(0.063)
Storing, arranging preserving Food	2.172	2.154
	(0.141)	(0.142)
Other activities of food management	50.648***	50.260***
	(0.004)	(0.004)
Employment and related activities	15.227***	15.105***
	(0.000)	(0.000)

Note: *p*-values are in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Unconditional Quantile Regression

	(1)	(2)
Quantile(percentile)	Food management and preparation	Food management and preparation (non-zero)
10th	1.975	-7.025***
	(1.704)	(1.214)
25th	-11.530***	-11.317***
	(1.086)	(0.913)
50th	-12.208***	-13.096***
	(0.915)	(0.959)
75th	-15.908***	-14.315***
	(1.101)	(1.090)
90th	-15.506***	-15.360***
	(1.391)	(1.371)

Note: The first Column considered all observations. The second column drops the observations where the reported total time spent in food management and preparation is zero (About 7 percent of the women have reported zero). Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 Impact of LPG use on women's time allocation in different activities (in minutes) across Castes, Rural India, IV estimates

IV= Fraction of household in village with LPG and its interaction with Caste indicators

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
VARIABLES	Involved in cooking (1/0)	Food management and preparation	Preparing meals/snacks	Serving meals /snacks	Cleaning up	Storing, arranging preserving Food	Other activities of food management	Employment and related activities
LPG	0.009	-14.659***	-2.048	0.643	-6.623***	-1.439***	-5.192***	10.767***
	(0.008)	(2.587)	(1.840)	(0.806)	(0.960)	(0.413)	(0.638)	(3.008)
LPG*ST	-0.028**	4.388	-2.284	1.837	4.163***	-0.175	0.915	5.324
	(0.012)	(3.925)	(2.792)	(1.224)	(1.456)	(0.627)	(0.967)	(4.564)
LPG*SC	-0.019**	3.953	-3.953*	1.042	2.932**	1.154**	2.652***	-5.140
	(0.009)	(3.198)	(2.275)	(0.996)	(1.186)	(0.511)	(0.788)	(3.719)
LPG*OBC	-0.002	16.713***	1.577	3.581***	7.974***	1.315***	2.361***	-4.901
	(0.008)	(2.813)	(2.001)	(0.876)	(1.044)	(0.450)	(0.693)	(3.272)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	85,962	85,962	85,962	85,962	85,962	85,962	85,962	85,962
R-squared	0.206	0.340	0.309	0.276	0.169	0.087	0.143	0.599

Note: The instrument variable used is the fraction of households in village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household and its interaction with Castes. The IV regressions control for women' age, marriage status, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Impact of LPG use on time allocation in different activities, Rural India, IV estimates

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
	involved in cooking	Food management and preparation	Preparing meals/snacks	Serving meals /snacks	Cleaning up	Storing, arranging preserving Food	Other activities of food management	Employment and related activities
Panel A: Married Women								
LPG	-0.005	-6.988***	-3.625***	2.718***	-2.096***	-0.584***	-3.401***	10.002***
	(0.004)	(1.612)	(1.146)	(0.526)	(0.613)	(0.262)	(0.402)	(1.841)
Mean	0.93	225.158	144.704	26.49	42.12	3.448	8.397	74.446
Observations	73,678	73,678	73,678	73,678	73,678	73,678	73,678	73,678
R-squared	0.155	0.306	0.280	0.274	0.161	0.093	0.154	0.579
Panel B: Single Women								
LPG	0.043***	0.702	4.862	1.472	-1.216	-1.382*	-3.034***	-4.893
	(0.020)	(4.620)	(3.308)	(1.011)	(1.517)	(0.715)	(1.105)	(5.990)
Mean	0.706	134.18	85.45	10.899	27.813	2.66	7.358	147.054
Observations	12,284	12,284	12,284	12,284	12,284	12,284	12,284	12,284
R-squared	0.255	0.277	0.256	0.235	0.208	0.120	0.166	0.668

Note: The instrument variable used is the fraction of households in village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The IV regressions control for women' age, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.

Table A1: Distribution of households by cooking fuels

	Rural	Urban	Total
Firewood and chips	42.82	6.62	31.35
LPG	51.53	86.18	62.51
Other natural gas	0.23	1.14	0.51
Dung cake	3.83	0.23	2.69
Kerosene	0.19	0.74	0.36
Coke or coal	0.25	0.34	0.28
Gobar gas	0.07	0	0.05
Other biogas	0.01	0	0.01
Charcoal	0.21	0.22	0.21
Electricity	0.03	0.17	0.08
No cooking	0.46	3.63	1.47
Others	0.38	0.73	0.49

TableA2: First Stage Regression for IV Estimates

VARIABLES	LPG
Instruments	
MeanLPG	0.835***
	(0.005)

Note: The first stage regression controls women' age, marriage status, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Regression Results for the Cooking Time

	(1)	(2)	(3)
	Number of times cooked per day	Cooked more than 3 times per day	Average time spent per cooking activity
Panel A: OLS			
LPG	0.039***	0.013***	-1.247***
	(0.008)	(0.003)	(0.176)
Mean	2.726	0.208	57.566
Observations	77,117	77,117	77,117
R-squared	0.243	0.209	0.365
Panel B: IV			
LPG	0.062***	0.019***	-3.005***
	(0.016)	(0.003)	(0.359)
Observations	77,110	77,110	77,110
R-squared	0.243	0.209	0.364

Note: The instrument variable used is the fraction of households in village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The IV regressions control for women' age, marriage status, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.

Table A4 Hausman Test for Endogeneity of IV (Castes)

H0: The variable under consideration can be treated as exogenous		
IV= Fraction of household in village with LPG		
	Durbin	WU
Involvement cooking activities	4.293	1.064
	(0.368)	(0.372)
Food management and preparation	36.188***	8.975***
	(0.000)	(0.000)
Preparing meals/snacks	11.470**	2.844**
	(0.021)	(0.022)
Serving meals /snacks	22.216***	5.509***
	(0.000)	(0.000)
Cleaning up after food preparation	50.031***	12.411***
	(0.000)	(0.000)
Storing, arranging preserving Food	17.267***	4.282***
	(0.002)	(0.002)
Other activities of food management	56.880***	14.111***
	(0.000)	(0.000)
Employment and related activities	20.344***	5.045***
	(0.000)	(0.000)

Note: *p*-values in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Impact of LPG use on women's time allocation in different activities (in minutes) across castes, Rural India, OLS

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
VARIABLES	Involved in cooking (1/0)	Food management and preparation	Preparing meals/snacks	Serving meals /snacks	Cleaning up	Storing, arranging preserving Food	Other activities of food management	Employment and related activities
LPG	0.005	-4.523***	0.721	-0.181	-2.684***	-0.652***	-1.727***	2.798*
	(0.004)	(1.426)	(1.015)	(0.444)	(0.529)	(0.228)	(0.351)	(1.658)
LPG*ST	-0.019***	-2.420	-2.877*	0.331	0.255	0.423	-0.552	2.711
	(0.007)	(2.442)	(1.738)	(0.761)	(0.906)	(0.390)	(0.602)	(2.841)
LPG*SC	-0.008	1.274	-2.258	0.315	1.719**	0.473	1.026**	-3.023
	(0.006)	(1.955)	(1.391)	(0.609)	(0.725)	(0.313)	(0.482)	(2.274)
LPG*OBC	-0.002	5.917***	-0.630	2.198***	2.897***	0.450*	1.002**	-0.958
	(0.005)	(1.691)	(1.203)	(0.527)	(0.627)	(0.270)	(0.417)	(1.967)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	85,969	85,969	85,969	85,969	85,969	85,969	85,969	85,969
R-squared	0.206	0.341	0.309	0.277	0.170	0.088	0.144	0.599

Note: The OLS regressions control for women' age, marriage status, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A6: Impact of LPG use on women's time allocation in different activities (in minutes), OLS

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
	involved in cooking (1/0)	Food management and preparation	Preparing meals/snacks	Serving meals /snacks	Cleaning up	Storing, arranging preserving Food	Other activities of food management	Employment and related activities
Panel A: Married Women								
LPG	0.000	-1.705**	-0.307	1.067***	-1.078***	-0.313**	-1.074***	1.898**
	(0.002)	(0.801)	(0.569)	(0.261)	(0.305)	(0.130)	(0.200)	(0.914)
Mean	0.93	225.158	144.704	26.49	42.12	3.448	8.397	74.446
Observations	73,684	73,684	73,684	73,684	73,684	73,684	73,684	73,684
R-squared	0.155	0.307	0.280	0.274	0.162	0.093	0.156	0.580
Panel B: Single Women								
LPG	0.000	-3.670*	-0.703	-0.711	-1.015	-0.305	-0.936*	2.675
	(0.009)	(2.185)	(1.564)	(0.478)	(0.717)	(0.338)	(0.522)	(2.833)
Mean	0.706	134.18	85.45	10.899	27.813	2.66	7.358	147.054
Observations	12,285	12,285	12,285	12,285	12,285	12,285	12,285	12,285
R-squared	0.256	0.277	0.257	0.237	0.208	0.121	0.167	0.668

Note: The instrument variable used is the fraction of households in village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The IV regressions control for women' age, education level, employment status; household demographic composition, religion and caste of household, amount of land owned by household, type of house construction, and monthly per capita consumption expenditure; household head' education, gender, and employment status and day of the week when survey was conducted, village characteristics, and district fixed effects. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A7: Hausman Test for Endogeneity of IV (Married & Single Women)

H0: the variable under consideration can be treated as exogenous				
IV= Fraction of household in village with LPG	*Married Women*		*Single Women*	
	Durbin	WU	Durbin	WU
Involvement cooking activities	2.030	2.011	6.126**	5.781**
	(0.154)	(0.156)	(0.013)	(0.016)
Food management and preparation	14.214***	14.080***	1.136	1.071
	(0.000)	(0.000)	(0.287)	(0.301)
Preparing meals/snacks	11.107***	11.002***	3.590	3.387
	(0.001)	(0.001)	(0.058)	(0.066)
Serving meals /snacks	13.041***	12.918***	5.923**	5.589**
	(0.000)	(0.000)	(0.015)	(0.018)
Cleaning up after food preparation	3.644*	3.609	0.022	0.021
	(0.056)	(0.057)	(0.881)	(0.885)
Storing, arranging preserving Food	1.417	1.403	2.876	2.713
	(0.234)	(0.236)	(0.090)	(0.010)
Other activities of food management	44.420***	44.020***	4.580**	4.321**
	(0.000)	(0.000)	(0.032)	(0.038)
Employment and related activities	25.681***	25.443***	2.025	1.910
	(0.000)	(0.000)	(0.155)	(0.167)

Note: *p*-values in parentheses *** p<0.01, ** p<0.05, * p<0. 1.