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 the main cooking fuel reduces the time burden of cooking activities carried out by Indian rural women and increases the time spent in employment activities. To address the potential endogeneity of LPG, we instrument LPG using 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 that use of LPG does not affect the probability of women participating in cooking activities. LPG use reduces the total time burden of cooking activities; however, the magnitude of the impact remains low compared to the average time spent in the cooking activities. We also find that the use of LPG increases the time spent in employment activities by about eight minutes that constitute a ten percent increase given the very low level of female employment rate in India.

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1 Introduction

In this paper, we examine whether the use of Liquefied Petroleum Gas (LPG) reduces the domestic cooking burden of women in rural India. This is an important question in general as nearly three billion people worldwide use biomass fuels, such as wood, dung, charcoal, and crop residues, for their household cooking needs (World Health Organization, 2016). However, its importance is attenuated in the Indian context where the rural female labor force participation rate among 15-65 age group remains low and has witnessed a decline of 14 percentage points between 1987 and 2011 (Afridi, Dinkelman and Mahajan, 2018). The female labor force participation rate among 25-64 age group was only 35 percentage points in India compared to China's 81 percentage points whereas the male labor force participation rate remains comparable between the two countries (Azam and Han, 2020). Given that rural women (18-60 age group) 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, improved women's labor supply in the developed countries by saving time spent on domestic chores. 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. For example, they may increase the variety of food cooked or increase the frequency of tea/snacks preparation. In addition, since cooking with

LPG is less demanding than the 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 the 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.[1] The health and environmental benefits of using LPG over biomass is well-documented (Agarwal and Bina, 1986; Bruce et al., 2000; Pillarisetti et al., 2019).[2] However, there are only few studies in developing countries context that looks into time-saving aspect of the access to modern cooking energy such as LPG.[3] Moreover, the existing studies are mostly based on small samples or experiments carried out in specific context on limited number of households. For example, William 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. 90 women receive the intervention (treatment). Intervention participants 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 in Central India where they divide randomly selected villages from the one district into three

[1]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 (19 December 2018), "Government expands eligibility criteria to meet Pradhan Mantri Ujjwala Yojana target", CNBC TV18).

[2]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 lead to a significant improvement in women's health, particularly among those who spend most of their time indoors doing housework.

[3]A few studies have investigated whether switching to cleaner stoves can reduce time spent on cooking and collecting fuel. The majority of these studies have focused on improved biomass stoves, which intend to reduce biomass fuel consumption through improved heat transfer efficiency (Rehfuess, Puzzolo, Stanistreet, Pope, and Bruce, 2014).

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 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 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 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 the main source of cooking where the concerned household is excluded in calculating the average. 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 the 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. 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. In addition, our paper also looks at the time spent on total employment activities. A few studies that look at the impact of LPG based on small surveys from selected sites focus mainly on time saving due to decreased time burden of collecting biomass. Since, ours is nationally representative data, we are able to show that time spent on collecting biomass is not a significant channel of time saving as only 5 percent of the women in age 18-60 age group in rural India reported collecting firewood. At the same time, about 90 percent of women not only reported involve-

ment in cooking activities but also spent considerable time in cooking activities. Hence, the cooking activities channel is much more important.

The main findings of the paper are the following. We find that the instrument variable estimates are similar in sign as OLS estimates, and only marginally larger in magnitude. We find that having LPG as 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. We find that having LPG as the main cooking fuel reduces the total time spent by women in food management and preparation by 3.6 minutes. This decline is about 1.6 percent of the average time of 212 minutes spent in food management and preparation by women. When we further investigate the subcategories of food preparation and management, we find no impact of LPG use on actual cooking time, but a significant increase in minutes spent for serving meals/snacks. We find that women residing in households that use LPG as main cooking fuel are likely to spend slightly less time for cleaning (-1.33 minutes on an average of 40.13 minutes spent for cleaning) and storing (-0.78 minutes on average of 3.39 minutes), and other food related activity (-3.18 minutes on an average of 8.25 minutes). Importantly, we find that women residing in household that use LPG as the main cooking fuel are likely to work 8.82 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, Indian women spend around 84.55 minutes on employment activities, this is more than a 10 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 access to LPG on the time spent in cooking activities by women, hence, we estimate the following equation:

$$Y_{ihd} = \alpha + \delta LPG_{ih} + \beta X_{ih} + \eta_d + d_\tau + \varepsilon_{ihd} \tag{1}$$

where Y_{ihd} denotes the time spent in cooking activities by women i, residing in household h, in district d. X_{ih} is a matrix of both women's and household's observed characteristics, while 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_{ihd} is the randomly distributed error. LPG_{ih} is the binary indicator that captures whether household 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. According to Frazis and Stewart (2012), OLS models are preferred in the analysis of time allocation decisions, since estimation techniques for limited dependent variables that assume a nonlinear functional form, such as the Tobit model, will be inconsistent if we want 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.

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), it is difficult to rule out some unobserved factors that may be correlated with both 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.[4] There are many studies that have used similar leave-one-out or spatial instrument, 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; Coen-Pirani et al. 2010; Persson and Tabellini, 2009). Using average village level use of LPG as an instrument, we estimate the following two-stage least square model:

$$LPG_{ih} = \gamma_0 + \gamma_1 . meanLPG_{-ih,village} + \gamma_2 X_{ih} + \eta_d + d_\tau + \vartheta_{ihd} \tag{2}$$

$$Y_{ihd} = \pi_0 + \pi_1 \widehat{LPG_{ih}} + \pi_2 X_{ih} + \eta_d + d_\tau + \sigma_{ihd} \tag{3}$$

where $meanLPG_{-ih,village}$ is the fraction of households in the village that reported LPG as main source of cooking where the concerned household is excluded in calculating average. There are two identifying assumptions here. First, average LPG use in a village must be

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

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_{ihd} only through LPG use.

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, Arcidacono 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 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 can also be expected to hold. The reason is that 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, exclusion restrictions are debatable.

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 (3-digit code) (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).

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 source. Based on the TUS data, about 86.2 percent of urban households reported LPG as main source of cooking compared to only 51.5 percent of rural households. Also, since 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 86,057 non-student women in age group 18-60 residing in rural India.[5] 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. 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.

[5]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.

4 Results

Table 3, Panel A presents the OLS estimates for the impact of LPG use estimated using Eq. (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 on food management and preparation activities. 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, the OLS estimate is not statistically significant at the conventional level. Moreover, the magnitude of the impact remains very small, i.e. 1.4 minutes decline on an average of 212.5 minutes spent in food preparation and management activities that translates into only 0.65 percent decline in time spent on food preparation activities. Hence based on OLS estimate, there is no evidence to suggest that the use of LPG frees up time from the cooking activities. In the literature, one of the potential channels for time saving discussed is through reduced burden of collection of firewood and dungs. 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.[6] The total time spent by women on collection of firewood is only 3.4 minutes in a day that jumps to 66 minutes when we restrict to women who actually spent time in collecting firewood.

In column (3) of Table 3, we consider different subcategories of 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.[7] Perhaps, women with LPG increased the frequency of cooking, or cook more items because of the ease to start and 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. 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 1.4 minutes) and time increased in employment activities are comparable in magnitude.

[6]This is captured by ICATUS code 241: Gathering firewood and other natural products used as fuel for own final use.

[7]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 empirical strategy section, OLS estimates may be biased because of omitted variables. To address the endogeneity concerns, we implement the instrumental variable strategy. Table 4 presents the 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 others 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 7.88 percentage point increase in the probability of LPG use by the household.

In Table 5, 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 time spent in employment activities, and subcategories of food preparation such as time spent in serving meals, storing meals, and other activities of food management, the exogeneity of LPG variable can be rejected at traditional 5% significance level. However, for time spent in total food preparation and management, the exogeneity of LPG cannot be rejected at 10% also, though it can be rejected at 11% significance level. Similarly, for time spent in preparing meals, the exogeneity of LPG can be rejected only at 10% significance level. We fail to reject the null of exogeneity of LPG for time spent in cleaning activities. Thus, for our most important outcome which is the aggregated time spent in food preparation and management, we do not find very strong evidence against exogeneity of our LPG variable, but we report the IV results for all outcomes. Recall that OLS estimates will be efficient in the case LPG variable is exogeneous.

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. 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 LPG

as main cooking fuel source. Recall that, we fail to reject the null of exogeneity of LPG variable in the case of aggregated time spent in food management and preparation, hence, the OLS estimate is preferable. Importantly, the signs of both OLS and IV estimate are similar suggesting a reduction in time spent. Although the magnitude of the IV estimate is larger, qualitatively, both OLS and IV results suggest that LPG use do not reduce the time spent in food preparation and management in economically significant way. The time spent in serving meals/snacks increased by about 3.5 minutes (column 3B, panel B 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. Both OLS and IV estimates are similar for 'cleaning up' outcome suggesting a small decrease in time spent. LPG users spend less time cleaning up than non-users because the pots and pans were no longer covered in soot from cooking over a wood fire (Clancy et al., 2012). The IV result for time spent in employment activities is similar in sign as OLS but larger in magnitude (panel B, column (4) of Table 3). LPG user women are likely to spend 8.8 minutes more in employment activities compared to biomass user women. Although in terms of minutes spent in employment activities, 8.8 minutes do not seem large, but given a very low employment rate in women, this translates into a 10.5 percent increase in time devoted to employment activities on an average time of 84.5 minutes. Overall, the IV results are similar to the OLS results.

4.2 Heterogeneity in LPG impact

The discussion so far looks at the impact of LPG on average time spent without distinguishing among the 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 outcome, zero values only account for about 7 percent of observations. Moreover, since

we fail to reject the exogeneity of LPG previously in the case of total time spent on food management and preparation, we do not instrument for LPG.[8]

In table 6 we present the results of the unconditional quantile regressions. 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 (about 7 percent of the women have reported zero). We find that the time reduced in total time spent on food management because of LPG use increases 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.[9] For example, 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. To allow for LPG impact to vary we introduce interactions of the LPG use with the caste indicators in our Eq (1). 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 outcome variables, the exogeneity of LPG variable can be rejected at

[8]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.

[9]Azam and Bhatt (2015) discussed that Indian society has historically been shaped by a high degree of social class determined by the caste system and this leads to the exclusion of certain groups from certain economic and social areas. At the time of independence, the Constitution of India identified disadvantaged castes and tribes in another register of the Constitution as Scheduled Castes and Scheduled Tribes (SC / ST) and extended affirmative action protection to these groups in the form of higher reserved seats through higher educational institutions, in public sector jobs, in state legislatures and the Indian parliament (Azam and Bhatt, 2015). The Constitution of India also mentions "socially and educationally disadvantaged classes" and the Government of India is called upon to ensure their social and educational development. Unlike the SC / ST listed on another schedule, the Constitution did not identify these backwards classes. The Government of India has used the generic term "Other Backward Class (OBC)" for these classes and has classified many castes as OBC through various committees over the years. The Government of India offered reserved positions for Other Backwards Castes in public sector jobs in 1993 (Azam and Bhatt, 2015).

the traditional 5% significance level (reported in appendix Table A1). Hence, we focus on the IV result Table 7.[10] While LPG access increases the probability of being involved in cooking for higher castes women, it reduces the probability of being involved in cooking for SC and ST women. This is interesting as the higher caste households may have a higher chance to hire help for cooking compared to SC/ST households, the LPG access may involve more women from higher castes cooking, while freeing up some from lower castes. 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 user women from OBC spend more time than non-user in food management and preparation. Although, there is suggestive evidence that LPG access increases time spent in employment more for higher caste women compared to SC and OBC women, we fail to reject the null that the impact is similar across social groups.

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. Table 8 and Table 9 report the results for married women and single-women. 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 5.4 percentage points. Similarly, LPG access reduces time spent in cooking for married women while increasing the time spent in cooking for single women. There is no significant impact of LPG on total time spent in

[10]The OLS regression result is reported in Appendix Table A2.

employment activities for single women. However, married women increase time spent in employment and related activities by 13.6 percent (10.15 minutes on an average of 74.45 minutes spent on employment and related activities).

5 Conclusion

We address the question of whether access to 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 households. The OLS and IV estimates are similar in sign, while magnitude of IV estimates turn out 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.

Our finding of limited impact of LPG on time spent in food management and preparation does not undermine the use of LPG as time saving is only one of many potential benefits of using LPG. As stated earlier, the other benefits such as environmental and health benefit of LPG use is well documented. 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 does not guarantee exclusive use of LPG. It is possible and probably expected that rural households engaged in fuel stacking behavior. 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: Summary Statistics, time spent in different activities (*in minutes*)

	(1)			(2)	(3)
	Mean			Min	Max
Time spent in activity (in minutes)	LPG	Non-LPG	All		
Employment and related activities	89.008	79.645	84.557	0	1,260
Food management and preparation	206.716	218.861	212.490	0	750
(A) Preparing meals/snacks	131.515	141.901	136.453	0	630
(B) Serving meals/snacks	24.535	24.081	24.319	0	390
(C) Cleaning up after food preparation	40.014	40.252	40.127	0	300
(D) Storing, arranging, preserving Food	3.294	3.388	3.338	0	300
(E) Other activities of food management	7.358	9.239	8.252	0	360
Number of Observation	44770	41288	86,058		

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.

Table 2: Summary Statistics of controls

	Mean		
Individual level controls	*LPG*	*non-LPG*	All
Age	37.162	36.568	36.880
Married (1/0)	0.863	0.858	0.861
Primary School (1/0)	0.135	0.136	0.136
Middle School (1/0)	0.157	0.144	0.151
Secondary (1/0)	0.137	0.079	0.110
Higher Secondary (1/0)	0.094	0.046	0.708
Graduate and above (1/0)	0.073	0.024	0.497
self-employed (1/0)	0.127	0.148	0.137
wage or salary employed (1/0)	0.044	0.022	0.034
casual wage labor (1/0)	0.086	0.092	0.088
Household level controls			
Cooking fuel used			
LPG	1	0	0.525
meanLPG(Fraction of household in village with LPG)	0.729	0.274	0.513
Household size	4.354	4.502	4.424
Log of monthly per capita expenditure	8.983	8.772	8.883
Number of age group 0-14	1.132	1.321	1.222
Number of age group 15-64 (male)	1.455	1.421	1.439
Number of age group 15-64 (female)	1.587	1.591	1.589
Muslim (1/0)	0.104	0.136	0.119
Scheduled Tribe (1/0)	0.077	0.169	0.121
Scheduled Caste (1/0)	0.199	0.221	0.210
Other backwards Classes (1/0)	0.457	0.413	0.436
Small family land (1/0)	0.071	0.077	0.742
Medium family land (1/0)	0.051	0.038	0.448
Large family land (1/0)	0.032	0.023	0.028
Semi-pucca house (1/0)	0.259	0.336	0.295
Pucca house (1/0)	0.662	0.435	0.554
Head age	47.226	46.091	46.686
Female head (1/0)	0.143	0.138	0.141
Head education level			
Primary School (head) (1/0)	0.144	0.160	0.151
Middle School(head) (1/0)	0.168	0.167	0.168
Secondary(head) (1/0)	0.150	0.088	0.121
Higher Secondary(head) (1/0)	0.085	0.043	0.649
Graduate and above(head) (1/0)	0.074	0.021	0.491

Self-employed (head) (1/0)	0.476	0.461	0.469
Wage or salary employed (head) (1/0)	0.124	0.072	0.099
Casual wage labor (head) (1/0)	0.239	0.333	0.284
Number of Observation	44770	41288	86,058

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 Regression								
LPG	0.001	-1.402*	-0.116	1.043***	-0.945***	-0.289**	-1.095***	2.031**
	(0.002)	(0.753)	(0.536)	(0.235)	(0.279)	(0.120)	(0.185)	(0.876)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	86,057	86,057	86,057	86,057	86,057	86,057	86,057	86,057
R-squared	0.205	0.340	0.308	0.275	0.169	0.086	0.143	0.599
Panel B: Instrumental Analysis: IV= Fraction of household in village with LPG								
LPG	0.006	-3.601**	-1.775	3.463***	-1.334**	-0.776***	-3.180***	8.815***
	(0.005)	(1.543)	(1.098)	(0.481)	(0.572)	(0.247)	(0.380)	(1.794)
Observations	86,050	86,050	86,050	86,050	86,050	86,050	86,050	86,050
R-squared	0.205	0.340	0.308	0.275	0.169	0.086	0.142	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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: First Stage Regression for IV Estimates

VARIABLES	LPG
Instruments	
MeanLPG	0.788***
	(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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Hausman Test for Endogeneity of IV

H0: the variable under consideration can be treated as exogenous		
IV= Fraction of household in village with LPG		
	Durbin	WU
Food management and preparation	2.660	2.638
	(0.103)	(0.104)
Preparing meals/snacks	2.990*	2.966*
	(0.084)	(0.085)
Serving meals /snacks	33.160***	32.902***
	(0.000)	(0.000)
Cleaning up after food preparation	0.605	0.600
	(0.437)	(0.439)
Storing, arranging preserving Food	5.102**	5.060**
	(0.024)	(0.024)
Other activities of food management	39.487***	39.182***
	(0.000)	(0.000)
Employment and related activities	18.730***	18.580***
	(0.000)	(0.000)

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

Table 6: Unconditional Quantile Regression Estimates

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

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

	(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	0.016**	-12.506***	-1.242	1.282	-5.988***	-1.563***	-4.995***	11.738***
	(0.008)	(2.589)	(1.842)	(0.808)	(0.960)	(0.414)	(0.638)	(3.011)
LPG*ST	-0.032***	3.521	-2.901	1.999	3.757***	-0.339	1.004	5.256
	(0.012)	(3.918)	(2.787)	(1.222)	(1.453)	(0.626)	(0.965)	(4.557)
LPG*SC	-0.021**	3.988	-3.929*	1.102	2.955**	1.052**	2.808***	-5.424
	(0.009)	(3.190)	(2.269)	(0.995)	(1.183)	(0.510)	(0.786)	(3.710)
LPG*OBC	-0.004	16.679***	1.324	3.748***	7.851***	1.322***	2.434***	-5.220
	(0.008)	(2.804)	(1.994)	(0.875)	(1.040)	(0.448)	(0.691)	(3.261)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	86,057	86,057	86,057	86,057	86,057	86,057	86,057	86,057
R-squared	0.205	0.340	0.308	0.276	0.170	0.086	0.144	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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Impact of LPG use on married women's time allocation in different activities (in minutes), Rural India

Panel A: OLS Regression

	(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	0.001	-1.314*	-0.093	1.196***	-1.054***	-0.301**	-1.062***	1.878**
	-0.002	-0.798	-0.567	-0.261	-0.304	-0.13	-0.199	-0.911
Mean	0.93	225.158	144.704	26.49	42.12	3.448	8.397	74.446
Observations	73,758	73,758	73,758	73,758	73,758	73,758	73,758	73,758
R-squared	0.154	0.306	0.279	0.273	0.161	0.091	0.155	0.579
Panel B: Instrumental Analysis: IV= Fraction of household in village with LPG								
LPG	-0.003	-5.291***	-3.346***	3.564***	-1.666***	-0.764***	-3.078***	10.145***
	(0.004)	(1.622)	(1.153)	(0.530)	(0.617)	(0.263)	(0.404)	(1.851)

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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Impact of LPG use on unmarried women's time allocation in different activities (in minutes), Rural India

Panel A: OLS Regression								
	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
VARIABLES	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
LPG	0.002	-3.041	-0.431	-0.547	-0.888	-0.256	-0.919*	2.903
	(0.009)	(2.177)	(1.558)	(0.476)	(0.714)	(0.336)	(0.520)	(2.821)
Mean	0.706	134.180	85.450	10.899	27.813	2.660	7.358	147.054
Observations	12,299	12,299	12,299	12,299	12,299	12,299	12,299	12,299
R-squared	0.254	0.276	0.256	0.235	0.207	0.121	0.166	0.668
Panel B: Instrumental Analysis: IV= Fraction of household in village with LPG								
LPG	0.054***	3.636	5.609*	2.091**	0.205	-1.153	-3.116***	-3.242
	(0.020)	(4.622)	(3.308)	(1.012)	(1.516)	(0.714)	(1.104)	(5.988)

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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A1: 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
Food management and preparation	30.459***	7.555***
	(0.000)	(0.000)
Preparing meals/snacks	9.652**	2.393**
	(0.047)	(0.048)
Serving meals /snacks	38.364***	9.516***
	(0.000)	(0.000)
Cleaning up after food preparation	45.33***	11.245***
	(0.000)	(0.000)
Storing, arranging preserving Food	22.303***	5.531***
	(0.000)	(0.000)
Other activities of food management	46.363***	11.501***
	(0.000)	(0.000)
Employment and related activities	24.056***	5.966***
	(0.000)	(0.000)

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

Table A2: Impact of LPG use on women's time allocation in different activities (in minutes) across castes, Rural India (OLS Regression)

	(1)	(2)	(3)					(4)
			(A)	(B)	(C)	(D)	(E)	
VARIABLES	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
LPG	0.006	-4.179***	0.999	-0.112	-2.651***	-0.631***	-1.783***	2.960*
	(0.004)	(1.423)	(1.012)	(0.444)	(0.528)	(0.227)	(0.350)	(1.655)
LPG*ST	-0.020***	-2.539	-2.997*	0.438	0.104	0.411	-0.496	2.591
	(0.007)	(2.441)	(1.737)	(0.761)	(0.905)	(0.390)	(0.601)	(2.838)
LPG*SC	-0.008	1.458	-2.161	0.266	1.779**	0.443	1.129**	-3.202
	(0.006)	(1.953)	(1.390)	(0.609)	(0.724)	(0.312)	(0.481)	(2.271)
LPG*OBC	-0.002	6.048***	-0.745	2.336***	2.909***	0.450*	1.099***	-1.120
	(0.005)	(1.688)	(1.201)	(0.527)	(0.626)	(0.270)	(0.416)	(1.964)
Mean	0.899	212.490	136.453	24.319	40.127	3.338	8.252	84.557
Observations	86,057	86,057	86,057	86,057	86,057	86,057	86,057	86,057
R-squared	0.205	0.340	0.308	0.276	0.170	0.086	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. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Hausman Test for Endogeneity of IV (Married Women)

H0: the variable under consideration can be treated as exogenous		
IV= Fraction of household in village with LPG		
	Durbin	WU
Food management and preparation	7.913***	7.839***
	(0.005)	(0.005)
Preparing meals/snacks	10.489***	10.391***
	(0.001)	(0.001)
Serving meals /snacks	26.361***	26.119***
	(0.000)	(0.000)
Cleaning up after food preparation	1.293	1.280
	(0.256)	(0.258)
Storing, arranging preserving Food	4.088**	4.050**
	(0.043)	(0.044)
Other activities of food management	32.814***	32.517***
	(0.000)	(0.000)
Employment and related activities	26.262***	26.021***
	(0.000)	(0.000)

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

Table A4: Hausman Test for Endogeneity of IV (Single Women)

H0: the variable under consideration can be treated as exogenous		
IV= Fraction of household in village with LPG		
	Durbin	WU
Food management and preparation	2.643	2.495
	(0.104)	(0.114)
Preparing meals/snacks	4.221**	3.985**
	(0.040)	(0.046)
Serving meals /snacks	8.615***	8.136***
	(0.003)	(0.004)
Cleaning up after food preparation	0.659	0.622
	(0.417)	(0.430)
Storing, arranging preserving Food	1.996	1.884
	(0.158)	(0.170)
Other activities of food management	5.015**	4.735**
	(0.025)	(0.030)
Employment and related activities	1.333	1.258
	(0.248)	(0.262)

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