# Fuelling Change: How LPG Adoption Reshapes Women's and Children's Time Use in India*

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**Abstract**

*This paper examines the impact of Liquefied Petroleum Gas (LPG) adoption on the time use of women and children in India using nationally representative Time Use Survey data from 2019 and 2024. To address endogeneity in fuel choice, we employ an instrumental variables strategy based on village level, leave-one-out LPG adoption. LPG use leads to large reductions in women's time spent in own-production and unpaid domestic work, with corresponding increases in paid employment, learning, social participation, and leisure. However, these gains are unevenly distributed within households, daughters-in-law experience increased caregiving burdens and reduced paid work and learning. Heterogeneity by kinship institutions shows that time savings translate into leisure in patrilineal states but into self-care in matrilineal regions. For children, LPG reduces work and increases learning and leisure, especially for girls, though strong gender and birth-order inequalities persist. Our findings highlight that the benefits of clean energy access are substantial but deeply mediated by social institutions.*

**Keywords**: Time Use, Gender, Birth Order, Reallocation of Labour

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# 1 Introduction

Time use reflects the lived experiences of individuals and captures the allocation of time across paid work, unpaid domestic tasks, caregiving, leisure, and rest. In many developing countries, including India, gender gaps in time use are stark, with women spending disproportionately more time on unpaid domestic work and caregiving compared to men (Addati et al., 2018). The distribution of domestic responsibilities, including fuel collection and cooking, is not just a reflection of individual choice but is shaped by a complex interplay of economic constraints, social norms, infrastructure, and access to basic services. Social norms around gender roles have a significant role to play in shaping how individuals participate in and allocate time across different activities (Eswaran et al., 2013). In many developing countries, women's higher unpaid work burden is further exacerbated by energy poverty, which limits access to time-saving technologies (Köhlin et al., 2011). As a result, policies aimed at reducing energy poverty can also help narrow gender disparities in labour market participation and time use (Köhlin et al., 2011; Sedai et al., 2022).

Greenwood et al., 2005 find that technological changes in home production led to savings in time which was used on domestic chores and led to an increase in labour supply of women in developed countries. Dinkelman, 2011 finds that rural electrification in South Africa led to shifts in technology used in home production and led to an increase in female employment.

Access to clean and modern cooking fuel has emerged as a critical factor that shapes household time use, particularly for women. Traditional fuels like firewood and dung cakes are not only inefficient and polluting but also time-consuming to collect and use. Several studies argue that shifting to modern fuels such as Liquified Petroleum Gas (LPG) can reduce drudgery, improve health, and free up women's time for more productive or leisure activities. The government launched the Pradhan Mantri Ujjwala Yojana (PMUY) in 2016 to promote LPG adoption among low-income households. However,

the success of such interventions depends not only on initial adoption but on sustained and exclusive use, a challenge given the persistence of fuel stacking, i.e. the continued use of both traditional and modern fuels (Cheng and Urpelainen, 2014).

This study argues that such an approach masks substantial heterogeneity within households, both across gender and across hierarchical positions. In rural India, domestic labour is not shared equally. It is structured by household power relations, generational hierarchy, and kinship institutions. Women's bargaining position varies sharply depending on whether they are daughters-in-law in joint households, while children's work responsibilities are strongly shaped by birth order, with older siblings, especially girls, shouldering a disproportionate share of domestic and caregiving tasks (Mishra and Singh, 2024). At the same time, India exhibits sharp institutional variation in family structure, with matrilineal systems in parts of Kerala and the Northeast granting women greater economic autonomy and authority relative to patrilineal regions (Jayachandran and Pande, 2017). These intra-household hierarchies imply that the time savings generated by clean cooking technologies may not be distributed evenly across household members, even when average effects appear large.

Against this backdrop, this study examines how clean cooking fuel use shapes time allocation not only for rural women on average, but also across key axes of intra-household hierarchy: daughters-in-law versus other women, children, birth order among siblings, and matrilineal versus patrilineal kinship systems. Using data from the Time Use Survey (TUS) 2019 and 2024, the analysis studies how LPG adoption alters time spent across employment, domestic work, caregiving, learning, leisure, and self-care. By analysing who inside the household captures the time savings from clean energy, this study provides new evidence on the distributional consequences of the clean energy transition. The objective is not only to assess whether LPG reduces time poverty, but to understand how clean cooking reshapes intra-household inequality, bargaining power, and the intergenerational allocation of labour and

leisure.

The results show that LPG adoption leads to significant time savings and reallocation, but these gains are highly uneven across households and governed by intra-household hierarchy and institutions. Among rural women, LPG substantially reduces time spent in own-production and unpaid domestic work and reallocates this time toward leisure, social participation, and learning. However, these benefits are far from uniform within households. Daughters-in-law, who occupy the weakest bargaining position, experience almost no reduction in domestic work after LPG adoption and instead reallocate time toward unpaid caregiving, with learning gains disappearing entirely, indicating that social constraints blunt the empowerment effects of clean energy. Among children, LPG sharply reduces unpaid domestic work and increases learning and leisure, but these gains are concentrated among the oldest child, who experiences the largest decline in domestic labor, while later-born siblings benefit substantially less. Gender gaps remain stark throughout, with girls continuing to bear a much heavier domestic burden than boys even after LPG adoption. Finally, kinship institutions further mediate these effects, in matrilineal states, women convert LPG-induced time savings primarily into self-care and reduced own-production work rather than leisure, while in patrilineal states leisure and employment gains dominate. Together, these findings show that LPG is not merely a household-level productivity shock but something that reshapes the distribution of time, labor, and welfare along gendered, generational, and institutional lines within households.

The paper is organised as follows. Section 2 presents the literature review. Section 3 shows the data and methodology. Results and robustness checks are presented in sections 4 and 5. Section 6 concludes.

# 2 Literature Review

Existing work Addati et al., 2018; Köhlin et al., 2011; Sedai et al., 2022) highlights the disproportionate burden of unpaid domestic work on women globally, and how energy access can mediate this burden. Individuals allocate their time based on comparative advantage and constraints, but, social norms also play a significant role in shaping outcomes, especially for women in developing countries.

Recent studies have attempted to quantify these relationships. Su and Azam, 2023 examine whether LPG use lessens the cooking burden for rural Indian women. Using the fraction of households in the village that reported LPG as primary source of cooking as an instrumental variable, they find that use of LPG led to a reduction in time used in cooking activities and resulted in an increase in time spent in employment activities. Afridi et al., 2023 conducted a Randomised Controlled Trial (RCT) in a district in Madhya Pradesh to assess the time saving capabilities of clean cooking technologies. Using propensity score matching, they find that having access to LPG could save 19-20 minutes of home production time per day. The intent to treat approach showed that estimate of time saved from providing a randomised information nudge was estimated to be 5 minutes per day.

Other strands of literature explore the barriers to exclusive use of clean fuels, such as fuel stacking, affordability, and social norms. Cheng and Urpelainen, 2014, and Mani et al., 2020 examine fuel stacking behaviour, affordability constraints, and social determinants of clean fuel adoption. Choudhuri and Desai, 2020 use India Human Development Survey (IHDS) data to analyse that women's access to salaried work and control over household decisions is associated with the use of clean fuel.

Evidence from other countries also supports the link between energy access and time reallocation. Gupta et al., 2024 study the association between electrification, activity participation and time use of individuals in

rural Bangladesh. They find that access to grid electricity is positively associated with possibility of men taking part in non-farm work and women taking part in agriculture. In electrified households, women were observed to reallocate time from domestic work and caregiving to more leisure and farming. Chandrasekaran et al., 2023 review the literature on impact evaluation, which estimates time savings from use of various improved cookstoves. They conducted a multivariable regression analysis of Multi-Tier Framework (MTF) data from six countries (Ethiopia, Rwanda, Zambia, Cambodia, Nepal, Myanmar) and estimated the impacts of improved cookstoves on time used in cooking. In a related context, Verma and Imelda, 2023 examine the LPG conversion program in Indonesia and find that access to clean cooking fuel leads to an improvement in the health of women and also an increase in working hours for both men and women.

Together, this literature underlines the importance of clean energy access in reducing women's unpaid work burden, while pointing to gaps in our understanding of how time saved is reallocated.

# 3 Data and Methodology

## 3.1 Data

We use the Time Use Survey (TUS), 2019 and 2024 collected by the Indian National Sample Survey Office (NSSO). It collects detailed information on how individuals spend their time on paid activities, unpaid activities, learning, socialising, leisure activities, self-care activities, etc. The surveys are nationally representative and cover 138,799 households in 2019 (rural: 82,897 and urban: 55,902) and 139,487 households in 2024 (rural: 83,247 and urban: 56,240).

The Time Use Survey records individuals' activities across a continuous 24-hour diary window, beginning at 4:00 A.M. on the day preceding the inter-

view and ending at 4:00 A.M. on the day of the interview. This 24-hour period is broken into half-hour segments. When respondents engage in more than one task within a 30-minute interval, each activity is separately noted. The survey follows the International Classification of Activities for Time Use Statistics, 2016 (ICATUS 2016) framework, assigning three-digit activity codes to capture all activities undertaken in each time slot.

Overall, the TUS has detailed time use information of 447,250 persons of age six years and above (rural: 273,195 and urban: 174,055) in 2019, and of 454,192 persons (rural: 285,389 and urban: 168,803) in 2024.

For our analysis on women's time use, we consider the sample consisting of those rural women aged between 18 and 60, who reported it being a normal day in the survey. For our analysis on children's time use, we consider the sample consisting of children aged between 6 and 17 years.

## 3.2 Methodology

To estimate the causal effect of LPG usage on women's time spent in activities, we would like to estimate the following equation:

$$Y_{ihdt} = \alpha + \beta LPG_{hdt} + \gamma X_{ihdt} + \eta_d + d_\tau + \delta_t + \epsilon_{ihdt} \tag{1}$$

Where $Y_{ihdt}$ denotes the time spent in activities by an individual $i$, living in household $h$, in district $d$, of survey year $t$. $X_{ihdt}$ is a matrix of person's and household's characteristics, while $\eta_d$ is districts fixed effects, $d_\tau$ is fixed effects for the day of the week when information was collected, $\delta_t$ is the time fixed effects, and $\epsilon_{ihdt}$ is the error term. $LPG_{hdt}$ is an indicator that captures whether household's main source of cooking is LPG, and $\beta$ is our main coefficient of interest which captures the impact of LPG use on the outcome.

However, there is the concern of endogeneity. There maybe some unobservables which maybe correlated with both the outcome and the fuel choice. To address the issue of potential endogeneity, we use an Instrumental Variable (IV) similar to Su and Azam, 2023. The IV is the fraction of households in the First Stage Unit (FSU) (village for rural areas, block for urban areas) that reported LPG as the main source of cooking where the concerned household is excluded in calculating the average. Many studies have used similar leave-one-out or spatial instrument, i.e., they instrument person $i$'s endogenous variable with the average of endogenous variable among person $i$'s peers, excluding $i$ themselves in this average.

Following Su and Azam, 2023, we use FSU level average LPG use as instrumental variable, and our two stage least square model is as follows:

$$LPG_{ihdt} = \pi + \rho MeanLPG_{ihdt} + \psi X_{ihdt} + \eta_d + d_\tau + \delta_t + \epsilon_{ihdt} \tag{2}$$

$$Y_{ihdt} = \alpha + \beta \widehat{LPG}_{ihdt} + \gamma X_{ihdt} + \eta_d + d_\tau + \delta_t + \varepsilon_{ihdt} \tag{3}$$

where $MeanLPG_{ihdt}$ is the fraction of households in the FSU '$f$' that reported LPG as their main source of cooking, where the concerned household is excluded in calculating the average for the FSU.

In both our equations, we control for individual and household level controls. Individual level controls include women's age, marital status, education level, employment status and household level controls include household size, religion and caste of household, land owned by household and type of structure of dwelling unit.

# 4 Results

As stated in section 3, the OLS estimates may suffer from omitted variable bias, hence we rely on an instrumental variable approach to obtain causal estimates. Table 4 reports the first-stage results, where LPG use is regressed on our instrument, the FSU level proportion of other households using LPG, along with the full set of controls. The coefficient on the instrument is large and statistically significant, indicating a strong association between community-level LPG adoption and a household's own likelihood of using LPG. Specifically, the estimates imply that a 10-percentage-point rise in LPG use among neighboring households increases a household's probability of LPG adoption by about 7.3 percentage points. This confirms that the instrument is highly relevant and provides sufficient exogenous variation for the IV strategy.

In Table 3, we report the results of the Durbin and Wu-Hausman tests which determine whether the variable LPG is endogenous or not. The tests strongly reject the null of exogeneity for several key activity categories i.e., production of goods for own final use, unpaid domestic services, culture and leisure, and employment-related activities, indicating that LPG use is endogenous in these domains, validating the need for an instrumental variables strategy. In contrast, we fail to reject exogeneity for unpaid caregiving, volunteering and other unpaid work, learning, social participation, and self-care, suggesting that OLS estimates may be less biased for these outcomes. Taken together, the results confirm that endogeneity is a serious concern for core productive and domestic time-use outcomes, reinforcing the relevance of the IV approach adopted in this study.

## 4.1 Women's Time Use

Table 4 presents the average impact of LPG adoption on women's time allocation across major activity categories. The results indicate that access to

clean cooking fuel substantially restructures women's daily schedules, freeing time from labor-intensive domestic tasks and shifting it toward discretionary activities. LPG use reduces time spent in production of goods for own final use by nearly 40 minutes per day, the largest observed effect. Time spent on unpaid domestic services also falls by around 15 minutes, suggesting a meaningful reduction in daily drudgery. The time savings are reallocated in multiple directions: women increase their paid work by roughly 10 minutes per day and allocate more time to learning, socialising, and, most notably, leisure, where the increase of 33 minutes per day reflects a substantial improvement in the quality of daily life. Disaggregating the leisure category reveals that the entire increase in culture, leisure, mass-media and sports practices is driven by a sharp rise in a single sub-activity. LPG adoption raises time spent in watching/listening to television and video by about 31 minutes per day, a magnitude that closely mirrors the aggregate leisure effect, indicating that leisure gains are highly concentrated in this activity. Importantly, LPG use does not significantly alter caregiving time, suggesting that childcare and eldercare demands remain structurally fixed regardless of improvements in cooking technology.

Table 5 examines whether these aggregate effects mask heterogeneity across women occupying different positions in the household hierarchy, focusing on daughters-in-law (DILs), who typically bear the highest domestic burden in patrilocal joint families. The results reveal stark intra-household inequalities. For women who are not daughters-in-law, LPG appears to relax time constraints in a manner consistent with greater autonomy and opportunity, reduced domestic workload, modest increases in paid work, and substantial gains in leisure, socialising, and learning. In contrast, daughters-in-law experience a fundamentally different pattern of reallocation. The interaction estimates show that the introduction of LPG reduces paid work time for DILs by an additional 12 minutes per day, over and above their already lower baseline employment, while simultaneously increasing their caregiving burden by more than 11 minutes per day. DILs also lose learning time relative to other women and enjoy far smaller gains in leisure and social activities,

indicating that the benefits of clean fuel adoption accrue unequally within the household.

These results suggest that while LPG reduces the overall domestic time burden for women, the distribution of these gains is shaped by household power structures. In non-hierarchical settings, LPG enables women to reallocate time toward employment, rest, and personal development. In more patriarchal arrangements, particularly for daughters-in-law, time saved from cooking is absorbed into other unpaid responsibilities, limiting the potential for improvements in economic participation or autonomy. Clean energy access therefore interacts strongly with intra-household gender norms, implying that technology alone cannot equalise time burdens without complementary shifts in social institutions.

We then construct an indicator for whether a state follows matrilineality or patrinileality (Jayachandran and Pande, 2017). Matrilineal states include Kerala and the eight North Eastern states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura). Table 6 shows that LPG adoption leads to substantial reallocations of women's time, with important differences between patrilineal and matrilineal states. In patrilineal states (baseline), LPG significantly reduces time spent in production for own use (–35 minutes) and unpaid domestic work (–16 minutes), while increasing learning (+3 minutes), social participation (+9 minutes), and especially leisure (+37 minutes), indicating large drudgery-reducing and welfare-enhancing effects. However, the interaction term reveals that these gains translate differently in matrilineal states. Although women in matrilineal regions experience an even larger decline in own-production work (an additional –22 minutes), the reduction in unpaid domestic work is substantially attenuated, and leisure gains are significantly smaller (–19 minutes relative to patrilineal states). Instead, a striking feature of matrilineal states is the large increase in self-care time (+25 minutes), suggesting that women convert LPG-induced time savings more into personal well-being than into leisure or social activities. Overall, the results indicate that while LPG universally re-

duces drudgery, the way women utilize freed time is strongly mediated by kinship institutions and household power structures.

## 4.2 Children's Time Use

Table 7 shows that LPG adoption leads to significant reallocation of children's time away from work and toward learning and leisure, with important gender differences. For boys (baseline), LPG reduces time spent in employment (–4.1 minutes), production for own use (–7.6 minutes), and unpaid domestic work (–2.2 minutes), while substantially increasing learning time (+19.9 minutes) and leisure and cultural activities (+16.5 minutes). At the same time, social participation and self-care decline, suggesting a shift away from household and community responsibilities toward education and recreation. The interaction term shows that these effects are markedly different for girls: while girls experience an even larger reduction in unpaid domestic work (an additional –25.7 minutes relative to boys), they also gain significantly more in learning (+12.6 minutes) and leisure (+10.7 minutes). However, the strong baseline gender gaps remain large, girls spend far more time in domestic work and caregiving and far less in leisure even before LPG adoption. Overall, the results indicate that LPG substantially reduces children's work burden and expands time for human-capital enhancing activities, with especially large gains for girls in terms of reduced domestic labor and increased learning, though entrenched gender inequalities in time use persist.

We also make use of the age variable and construct a birth order variable for children in a household. The results are presented in Table 8 which shows that the time-use benefits of LPG adoption for children are large but highly unequal across birth order, with the strongest gains accruing to the oldest child. For the oldest child (baseline), LPG reduces time spent in unpaid domestic work by nearly 18 minutes per day and significantly lowers engagement in employment, own-production, caregiving, and other unpaid work, while generating large increases in learning (+30 minutes) and leisure (+26 min-

utes). These gains diminish sharply for later-born siblings: for second-born children, the reduction in domestic work falls to about 9 minutes per day, and for third-born and later children to only about 6.5 minutes. Similarly, the learning and leisure gains are significantly attenuated for later-born children, particularly for third-plus siblings. At the same time, strong baseline birth-order gradients persist even without LPG, second and third-born children already perform substantially less domestic and caregiving work than the oldest, confirming that household labor is hierarchically organized across siblings. Gender disparities remain pronounced with girls spending over 33 additional minutes per day on domestic work and nearly 29 fewer minutes in leisure than boys. Overall, these results show that LPG acts as an equalizing force primarily by easing the heavy domestic burden shouldered by the oldest child, but it does not eliminate deep-seated gender and generational inequalities in children's time use.

# 5 Robustness

## 5.1 State × Round Trend

To account for the possibility that states followed different underlying time paths in time use and clean fuel adoption, we re-estimate our baseline IV specification by allowing for state-specific time trends. We interact state fixed effects with survey round fixed effects, thereby permitting each state to have its own trajectory over time. The estimated effect of LPG use on time spent in the nine major categories remains stable in magnitude and statistically significant under this specification, suggesting that our main results are not driven by differential state-level trends. The results are presented in Table 10 in the Appendix.

### 5.2 Pradhan Mantri Ujjwala Yojana Uptake

To capture cross-state variation in the intensity of exposure to the Pradhan Mantri Ujjwala Yojana (PMUY), we will merge the household-level Time Use Survey data with state-level information on the number of LPG connections issued under PMUY for the survey years 2019 and 2024. This will allow us to construct a state–year measure of policy intensity that reflects the scale of program implementation in each region and period. We will incorporate this information into our instrumental variables framework by estimating heterogeneous treatment effects through interactions between household LPG use and PMUY exposure. We will consider both a continuous measure based on the logarithm of state-level PMUY connections and a binary classification that distinguishes high- and low-PMUY states using the median level of coverage within each survey round. All specifications will include district fixed effects, state-by-round fixed effects, and a rich set of household controls. This design will enable us to examine whether the time-use impacts of LPG adoption vary systematically with the depth of policy rollout across states, while preserving the internal validity of the baseline identification strategy.

## 6 Conclusion

This paper provides causal evidence on how access to clean cooking fuel reshapes the daily time allocation of women and children in India. Using nationally representative Time Use Survey data from 2019 and 2024, and exploiting variation in LPG adoption at the FSU level as an instrument, we show that clean fuel access leads to substantial reorganization of household labor and leisure. For women, LPG significantly reduces time spent in own-production and unpaid domestic work, while enabling meaningful increases in paid employment, learning, social participation, and, most prominently, leisure. These results confirm that clean energy adoption functions not merely as a health-enhancing technology (Hanna et al., 2016), but as a

time-saving innovation with direct welfare and human-capital implications.

However, the gains from LPG adoption are far from uniformly distributed within households. Daughters-in-law, who typically occupy the lowest rung of the household power hierarchy in patrilocal families—experience markedly different reallocation. For them, time saved from cooking is largely absorbed into additional caregiving and household duties, accompanied by reductions in paid work and learning. This striking contrast highlights that technological progress alone cannot dismantle entrenched intra-household inequalities; rather, its benefits are mediated by deeply rooted social norms governing gender, authority, and labor allocation (Agarwal, 2022, ).

The role of kinship institutions is further underscored by the comparison between patrilineal and matrilineal states. While LPG reduces drudgery across all regions, the way women utilize freed time differs by lineage system. In patrilineal states, time savings translate primarily into leisure, social participation, and learning, whereas in matrilineal regions, women channel a larger share of saved time into self-care. These findings emphasize that cultural and institutional contexts shape not only whether time is freed, but also how it is ultimately reallocated.

For children, LPG adoption reduces engagement in work and significantly expands time devoted to learning and leisure, with especially large effects for girls. Yet gender inequalities persist, despite larger gains, girls continue to bear a disproportionate share of domestic labor. Strong birth-order gradients further reveal that the eldest child benefits the most from clean energy access, while later-born siblings experience progressively attenuated gains. Thus, clean fuel acts as an equaliser along some dimensions, particularly by easing the burden on eldest children, but does not fully overcome entrenched gendered and generational hierarchies. These patterns are consistent with evidence on gendered household labor allocation and intra-household resource hierarchies in developing countries (Jayachandran and Pande, 2017).

Taken together, our findings point to a central conclusion, access to clean

cooking fuel delivers substantial welfare and human-capital benefits through time reallocation, but these benefits are filtered through the structure of household power relations and kinship institutions. Policies promoting clean energy adoption therefore have the potential to generate broad-based developmental gains, but complementary interventions, aimed at shifting intra-household norms, enhancing women's bargaining power, and reducing the unpaid care burden, are essential for translating technological change into equitable outcomes in the household.

By linking clean energy adoption to detailed time-use outcomes within a causal framework, this study contributes to the growing literature on energy, gender, and development, and highlights time allocation as a critical channel through which energy transitions shape economic opportunity and social welfare.

However, our study is not without limitations. Our measure of LPG use is based on households' reported primary cooking fuel. Reporting LPG as the main fuel, however, does not imply exclusive reliance on it (Cheng and Urpelainen, 2014). Particularly in rural areas, households may continue to use multiple fuels i.e., fuel stacking, which could underestimate the estimated impacts. In addition, time-use data are based on 24-hour self-reported activity diaries, which may be subject to recall error and day-specific fluctuations. Although we restrict the sample to normal days and control for day-of-week effects, measurement error in reported time use may still introduce noise into our estimates, potentially attenuating the estimated effects.

# 7 Tables

Table 1: Time spent by women in different categories as per ICATUS 2016

| | LPG | Non-LPG | Difference | All |
|---|---|---|---|---|
| Employment and related activities | 92.311 | 87.037 | 5.274*** | 89.870 |
| Production of goods for own final use | 24.271 | 56.830 | -32.560*** | 39.341 |
| Unpaid domestic services for household members | 302.593 | 308.100 | -5.508*** | 305.142 |
| Unpaid caregiving services for household members | 56.265 | 56.678 | -0.414 | 56.456 |
| Unpaid volunteer, trainee and other unpaid works | 1.530 | 1.545 | -0.015 | 1.536 |
| Learning | 22.190 | 14.530 | 7.659*** | 18.642 |
| Socializing and communication, community participation and religious practice | 120.886 | 123.834 | -2.950*** | 122.250 |
| Culture, leisure, mass-media and sports practices | 128.614 | 97.003 | 31.611*** | 113.983 |
| Self-care and maintenance | 691.342 | 694.444 | 3.102*** | 692.778 |
| Observations | 98,444 | 84,822 | | 183,266 |

Table 2: First stage regression for IV estimates

| Dependent Variable LPG (1/0) | |
|---|---|
| Mean LPG | 0.732 |
| | (0.013) |

Note: MeanLPG 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 regression also controls for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses. Standard errors, clustered at district level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Test for endogeneity of LPG

| | |
|---|---|
| Employment and related activities | 3.756* |
| | (0.053) |
| Production of goods for own final use | 35.844*** |
| | (0.000) |
| Unpaid domestic services for household members | 7.162*** |
| | (0.008) |
| Unpaid caregiving services for household members | 1.492 |
| | (0.222) |
| Unpaid volunteer, trainee and other unpaid works | 0.248 |
| | (0.619) |
| Learning | 0.563 |
| | (0.454) |
| Socializing and communication, community participation and religious practice | 2.077 |
| | (0.150) |
| Culture, leisure, mass-media and sports practices | 19.027*** |
| | (0.000) |
| Self-care and maintenance | 0.492 |
| | (0.483) |

Note: $H_0$: The variable (LPG) is exogenous.
$p$ values in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Impact of LPG use on time spent by women (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | 9.671** | -39.549*** | -14.806*** | -3.583 | -0.305 | 4.306*** | 7.600* | 33.450*** | 3.203 |
| | (4.225) | (3.848) | (4.804) | (2.392) | (0.633) | (1.550) | (4.439) | (4.443) | (4.739) |
| Mean | 92.311 | 24.271 | 302.593 | 56.265 | 1.530 | 22.190 | 120.886 | 128.614 | 691.342 |
| Observations | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 |
| R-squared | 0.622 | 0.203 | 0.324 | 0.268 | 0.047 | 0.354 | 0.150 | 0.182 | 0.164 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Impact of LPG use on time spent by daughters-in-law (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | -9.936* | -41.194*** | -9.057* | -2.938 | -0.311 | 7.391*** | 11.582** | 38.145*** | 6.304 |
| | (5.718) | (4.021) | (5.144) | (2.349) | (0.669) | (1.637) | (4.498) | (4.554) | (4.829) |
| dil#lpg | -11.903** | 7.837** | 11.281** | 11.384*** | -0.245 | -12.613*** | -9.386*** | -5.047 | 8.702** |
| | (4.839) | (3.207) | (5.531) | (3.343) | (0.525) | (1.666) | (3.219) | (3.180) | (3.966) |
| dil | -10.147*** | -13.303*** | 16.435*** | -19.745*** | 0.034 | -0.605 | 8.052*** | 11.849*** | 7.422*** |
| | (2.887) | (2.035) | (3.564) | (2.078) | (0.311) | (1.035) | (2.027) | (1.942) | (2.411) |
| Mean | | | | | | | | | |
| Observations | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 |
| R-squared | 0.189 | 0.192 | 0.264 | 0.255 | 0.046 | 0.347 | 0.128 | 0.134 | 0.118 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses.

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

Table 6: Impact of LPG use on time spent by women in matrilineal states (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | 6.196 | -35.326*** | -16.188*** | -1.881 | -0.494 | 3.342** | 8.937* | 37.030*** | -1.632 |
| | (4.774) | (4.476) | (5.607) | (2.758) | (0.744) | (1.594) | (5.191) | (5.086) | (5.452) |
| lpg × matri | 18.267 | -22.202** | 7.266 | -8.949* | 0.994 | 5.069 | -7.028 | -18.824* | 25.420*** |
| | (11.503) | (9.529) | (10.133) | (5.320) | (1.267) | (4.421) | (7.711) | (10.918) | (9.589) |
| Mean | 92.311 | 24.271 | 302.593 | 56.265 | 1.529 | 22.187 | 120.886 | 128.614 | 691.342 |
| Observations | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 |
| R-squared | 0.621 | 0.202 | 0.324 | 0.268 | 0.047 | 0.354 | 0.150 | 0.181 | 0.162 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses.

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

Table 7: Impact of LPG use on time spent by children (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | -4.115** | -7.628*** | -2.160** | -0.897 | -0.504* | 19.873*** | -9.341*** | 16.491*** | -11.719*** |
| | (1.790) | (0.976) | (0.977) | (0.972) | (0.294) | (6.954) | (3.321) | (5.215) | (3.985) |
| child_female#lpg | 2.815* | -3.868*** | -25.719*** | -0.982 | -0.446 | 12.592*** | -0.013 | 10.679*** | 4.942** |
| | (1.699) | (1.126) | (2.091) | (0.615) | (0.336) | (4.071) | (1.999) | (2.806) | (2.031) |
| child_female | -12.338*** | 3.194*** | 49.047*** | 2.253*** | 0.272 | -6.432** | 3.295** | -35.853*** | -3.439** |
| | (1.203) | (0.856) | (1.738) | (0.422) | (0.238) | (2.836) | (1.417) | (1.939) | (1.339) |
| Mean | | | | | | | | | |
| Observations | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 |
| R-squared | 0.090 | 0.060 | 0.189 | 0.038 | 0.014 | 0.216 | 0.135 | 0.165 | 0.158 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for age, education level, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: Impact of LPG use on time spent by children by birth order (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | -4.116** | -11.832*** | -17.868*** | -1.581* | -0.668** | 29.548*** | -10.110*** | 26.159*** | -9.533** |
| | (1.800) | (1.165) | (1.548) | (0.906) | (0.338) | (6.659) | (3.262) | (4.646) | (3.809) |
| lpg × 2nd child | 3.184** | 4.704*** | 8.588*** | 0.673 | 0.000 | -6.490* | 1.972 | -10.306*** | -2.325 |
| | (1.526) | (0.908) | (1.356) | (0.506) | (0.289) | (3.742) | (1.591) | (2.743) | (1.884) |
| lpg × 3rd+ child | -0.820 | 9.356*** | 11.308*** | -0.809 | -0.388 | -2.810 | 0.591 | -18.335*** | 1.907 |
| | (1.866) | (1.180) | (1.827) | (1.187) | (0.592) | (8.054) | (3.611) | (6.374) | (4.082) |
| 2nd child | -6.644*** | -3.643*** | -10.167*** | -2.728*** | 0.021 | 16.653*** | -0.029 | 8.394*** | -1.857 |
| | (1.048) | (0.672) | (0.968) | (0.348) | (0.200) | (2.533) | (1.130) | (1.854) | (1.246) |
| 3rd+ child | -5.385*** | -7.295*** | -14.394*** | -3.454*** | 0.231 | 11.945*** | 5.028** | 19.357*** | -6.033** |
| | (1.220) | (0.821) | (1.174) | (0.711) | (0.412) | (4.620) | (2.224) | (3.734) | (2.362) |
| Female | -10.555*** | 0.796*** | 33.148*** | 1.651*** | -0.002 | 0.945 | 3.381*** | -29.077*** | -0.287 |
| | (0.488) | (0.222) | (0.803) | (0.137) | (0.071) | (1.095) | (0.495) | (0.754) | (0.492) |
| Mean | 9.735 | 1.943 | 17.872 | 4.397 | 0.722 | 374.416 | 76.014 | 208.121 | 746.779 |
| Observations | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 | 170,847 |
| R-squared | 0.087 | 0.060 | 0.184 | 0.040 | 0.014 | 0.207 | 0.133 | 0.164 | 0.156 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and time fixed effects. Standard errors, clustered at district level are in parentheses.

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

# 8 Appendix

Table 9: TUS categories as per ICATUS 2016

| Category | Description |
|---|---|
| Employment and related activities | Employment in corporations, government and non-profit institutions; employment in household enterprises to produce goods, employment in household enterprises to provide services; ancillary activities and breaks related to employment; training and studies in relation to employment; seeking employment, Setting up a business; travelling and commuting for employment |
| Production of goods for own final use | Agriculture, forestry, fishing and mining for own final use; making and processing goods for own final use; construction activities for own final use; supplying water and fuel for own final use; travelling, moving, transporting or accompanying goods or persons related to own-use production of goods |
| Unpaid domestic services for household members | Food and meals management and preparation; cleaning and maintaining of own dwelling and surroundings; do-it-yourself decoration, maintenance and repair; care and maintenance of textiles and footwear; household management for own final use; pet care; shopping for own household members; travelling, moving, transporting or accompanying goods or persons related to unpaid domestic services for household members; other unpaid domestic services for household members |
| Unpaid caregiving services for household members | Childcare and instruction; care for dependent adults; help to non-dependent adult household members; travelling and accompanying goods or persons related to unpaid caregiving services for household members; other activities related to unpaid caregiving services for household members |
| Unpaid volunteer, trainee and other unpaid works | Unpaid direct volunteering for other households; unpaid community- and organization-based volunteering; unpaid trainee work and related activities; travelling time related to unpaid volunteer, trainee and other unpaid work; other unpaid work activities |
| Learning | Formal education; homework, being tutored, course review, research and activities related to formal education; additional study, non-formal education and courses; travelling time related to learning; other activities related to learning |
| Socializing and communication, community participation and religious practice | Socializing and communication; participating in community cultural/social events; involvement in civic and related responsibilities; religious practices; travelling time related to socializing and communication, community participation and religious practice; other activities related to socializing and communication, community participation and religious practice |
| Culture, leisure, mass-media and sports practices | Attending/visiting cultural, entertainment and sports events/venues; cultural participation, hobbies, games and other pastime activities; sports participation and exercise and related activities; mass media use; activities associated with reflecting, resting, relaxing; travelling time related to culture, leisure, mass-media and sports practices; other activities related to culture, leisure, mass-media and sports practices |
| Self-care and maintenance | Sleep and related activities; eating and drinking; personal hygiene and care; receiving personal and health/medical care from others; travelling time related to self-care and maintenance activities; other self-care and maintenance activities |

Table 10: Impact of LPG use on time spent by women (in minutes)

| | Employment and related activities | Production of goods for own final use | Unpaid domestic services for household members | Unpaid caregiving services for household members | Unpaid volunteer, trainee and other unpaid works | Learning | Socializing and communication, community participation and religious practice | Culture, leisure, mass-media and sports practices | Self-care and maintenance |
|---|---|---|---|---|---|---|---|---|---|
| lpg | 12.952*** | -40.330*** | -11.028*** | -6.214*** | -0.424 | 3.743*** | 3.152 | 30.111*** | 8.025** |
| | (4.225) | (3.848) | (4.804) | (2.392) | (0.633) | (1.550) | (4.439) | (4.443) | (4.739) |
| Mean | 92.311 | 24.271 | 302.593 | 56.265 | 1.530 | 22.190 | 120.886 | 128.614 | 691.342 |
| Observations | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 | 182,424 |
| R-squared | 0.624 | 0.208 | 0.330 | 0.271 | 0.052 | 0.354 | 0.161 | 0.191 | 0.167 |

Note: The instrument variable used is the fraction of households in the village that reported use of LPG as main source of cooking where average is constructed excluding the concerned household. The regressions control for women's age, marital status, education level, employment status, household size, religion and caste of household, land owned by household, day of the week when survey was conducted, district fixed effects and state x time fixed effects. Standard errors, clustered at district level are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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