

On The Design Of Subsidy Programs: Access To Clean Energy And Liquidity Constraints*

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Abstract

Liquid Petroleum Gas (LPG) for cooking is subsidized by the Indian government in tandem with the international market price of oil to shield consumers from price variation. However, the ‘cash-back’ subsidy reaches households only after they purchase the fuel at a higher unsubsidized price. We study the role of liquidity constraints in access to clean energy among the poor in India. Using exogenous variation in the subsidy amount and data with over 21 million transactions, we find that a 1% increase in the universal cash-back LPG subsidy causes about 0.2% decrease in LPG usage by low-income households, on average. Doubling of the subsidy amount from its mean would lead to LPG usage declining by one-fifth. We further carry out this analysis for a sub-sample of 3000 rural households covered under two rounds of household surveys. While the LPG subsidy increase reduces LPG usage overall, for the poorest households the impact is significantly steeper - when the subsidy doubles these households reduce LPG purchase by more than one-third. We attribute our counterintuitive results to liquidity constraints households face – while the subsidy is deposited to households’ bank account 2-3 days after LPG purchase, poor households may find it difficult to pay the higher unsubsidized price upfront. Instead, we find that an increase in the LPG subsidy raises household expenditure on dirty, solid fuels. Thus, liquidity constraints may deter take-up of welfare by low-income households when cash transfer programs do not smooth household income.

JEL Codes: H26, O17, I38

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1 Introduction

Cash transfers have gradually taken a central role in welfare delivery, replacing traditional welfare programs such as in-kind transfers (World Bank, 2015). Prior studies have focused on consumption distortion, pecuniary effects, and leakages in cash vs. in-kind transfers (see Currie and Gahvari (2008) for a review). An important aspect which is overlooked in the literature so far is the *timing* of transfers.¹ Compared to in-kind programs, cash is rarely provided right at the time when beneficiaries need it. We study this in the context of a large fuel subsidy program in India.

With advances in ‘digital’ state capacity, cash transfer through bank accounts have become the dominant mode for transfers from government to beneficiaries, especially in low-income countries.² But even with the cash transfers through bank accounts, there might be a time-delay between when the beneficiary needs to use the cash and when the cash reaches into her bank account (and into her hands) in practice. Its impact will be particularly salient in conditional cash transfer programs that require the beneficiary to purchase a specific good or service as a condition for subsequent transfer. Some examples include programs which require purchasing subsidized food, fuel and fertilizer or enrolling children in the school to meet the conditionality for subsequent bank transfer of subsidies (e.g. PROGRESA program in Mexico in 1997).³ If the beneficiaries are too liquidity constrained to meet such criteria, they will not be able to fulfil the condition and will lose their benefits. In this paper, we study how subsidy transfer through bank accounts affect welfare take-up among liquidity-constrained beneficiaries in India’s cooking gas subsidy program. In theory, subsidies should improve the welfare of low-income households. In practice, however, any time delay in pro-

¹Leary and Wang (2016) show the importance of timing of social security disbursement on pay-day loan behaviors, showing consumers fail to budget for predictable expenditures.

²The practice of posting checks through mails or disbursing cash by government officials, as common in high-income countries, is rarely practised in low-income countries. Bypassing the old check-via-mail system and enabled by the modern technology and better financial inclusion, many developing countries have adopted electronic bank transfers for welfare delivery. Studies have shown that transferring benefits through digitally directly to the beneficiary have reduced leakages in the public programs (Barnwal, 2021)

³Unconditional cash transfers, e.g., unconditional cash transfers to farmers to purchase inputs, may also observe this impediment when the timing is not synched with the beneficiary’s critical expenses.

vision of subsidies may reduce the take-up. The core thesis of this paper is that liquidity constrained households may find it difficult to pay the full price of a good or service upfront, on which they are going to receive government subsidy through a bank transfer later. Since the extent of the liquidity constraint essentially depends on the amount needed to meet the conditionality (namely, the purchase of a subsidized good or service at the full price) for the subsequent bank transfer, an ironic implication would follow – the higher the subsidy, the lower is the take-up among the liquidity-constrained households.

Our context is India’s Direct Benefit Transfer for Liquefied Petroleum Gas (LPG) - DBTL (commonly referred to as cooking gas) subsidy program. DBTL requires households to purchase cooking gas at the full price (i.e., unsubsidized price) and provides the subsidy amount in a subsequent bank transfer to their verified bank accounts. Cooking gas has been used primarily by middle- to high-income households for decades, which changed since the Indian government started expanding it to low-income households with an additional one-time ‘set-up subsidy’ under the Prime Minister’s Ujjawala Yojana (PMUY) starting in 2016-17. During our study period, each 14.2 kilogram (kg) of cooking gas cylinder refill comes with an average universal subsidy of INR 168, but households have to first pay the full price of more than INR 500, and then receive the subsidy in their bank account as a cash-back with a lag of 2-3 days.

The identifying variation in our analysis comes from the fact that the subsidy amount is determined by the international market prices for cooking gas. The government kept the price net of subsidy (i.e., effective price) mostly constant. Thus, the over-the-counter price of cooking gas (i.e., effective price + subsidy) will vary every month, based on the subsidy amount, which in turn varies in response to the variation in international fuel prices. [Figure 1](#) shows the significant, positive correlation between the over-the-counter, domestic market price of LPG and the international price of crude oil lagged by a month between our study period of Nov 2017 - Dec 2019, underscoring our claim of exogenous variation in LPG prices. [Figure 2](#) depicts graphically the tracking of the domestic market price by the

subsidy such that the effective price is more or less constant across month-years during the same period.

To quantify the demand response of LPG to changes in subsidy, we use both administrative and survey data. Administrative data covers information on LPG refills purchases by about 1 million LPG user households in Indore, a major district in central India. These data are available for 26 months (Nov 2017 - Dec 2019). Administrative data also provided information on whether the household is enrolled under the Pradhan Mantri Ujjwala Yojana (PMUY), that provides a one-time ‘start-up subsidy’ for cooking gas connection to low-income households. The survey data covers two rounds of 3000 randomly sampled rural households in Indore during 2018-19. In addition to basic demography and assets information, the survey also asked detailed questions on solid fuel usage.

We find three main results suggesting the importance of liquidity constraints affecting low-income households’ clean fuel purchase decisions. First, low-income (i.e., PMUY) households decrease their cooking gas purchase when subsidy increases, while there is no such effect on middle-to high-income households (i.e., non-PMUY households). Results suggest aggravation of liquidity constraints with increases in the subsidy amount – as subsidy amount doubles, cooking gas purchase goes down by 20%. The impact is stronger among rural PMUY households who are likely to be poorer and have substitute solid fuels more readily available to them. Second, households start switching to substitute solid fuels in response to high subsidy on cooking gas. We find significant increase in explicit and implicit expenditure on solid fuels by low-income households. Finally, during the rainy period when substitute solid fuels become costlier to access and purchase, the negative impact of subsidy increase on cooking gas purchase weakens.

Overserved effects vary significantly with the household wealth – richer rural households do not reduce their LPG usage in response to subsidy increases, while the poor households do. We also find some qualitatively consistent evidence on lower caste households and casual laborers who are more likely to be paid on a daily basis.

We further explore whether impact of liquidity constraints varies across households based on their investment in health and sanitation, a proxy for health-conscious behavior. Although results are mixed, we find no clear pattern. We also test whether the observed impact can be explained by ‘subsidy salience’, in line with existing research on tax salience (Chetty, Looney and Kroft, 2009), but do not find evidence supporting a behavioral explanation. This reinforces our conclusion that low-income households face hard and binding liquidity constraints in purchasing clean fuel, when they are required to pay for the subsidy amount upfront in lieu of reimbursement later.

Emerging literature on energy access indicates that financial constraints can be binding for poor households. Afridi, Debnath and Somanathan (2021) conduct an RCT in rural India, providing information on long term health hazards of cooking with solid fuels and the benefits from LPG in one treatment arm while in another they combine information on health with explaining the LPG subsidy program. They find a significant, albeit only about 15%, increase in monthly LPG refill consumption in the health + subsidy information treatment only. Berkouwer and Dean (2022) find that households’ willingness to pay for energy efficient cooking stove is low in Kenya, but providing credit doubles it. They conclude that loosening credit constraints of households will be more effective in increasing take-up of fuel-efficient technology than interventions that nudge towards behavioral changes.

This paper makes three main contributions. On a more general level, this paper shows that if the cash-transfer programs fail to adequately smoothen the consumption, low-income households may be adversely affected. Here, our findings add to the literature on the complexity in public program and the resulting targeting vs. exclusion trade off (Kleven and Kopczuk, 2011). Second, our findings highlight that liquidity constraints may be an important reason leading to exclusion in policy-reforms aiming to improve the administration of subsidies in public distribution systems. Prior research has primarily focused on identification verification, leakages, and supply side constraints (Barnwal, 2021; Kishore and Chakrabarti, 2015; Muralidharan, Niehaus and Sukhtankar, 2021). Third, adding to the

growing literature on inequality in exposure to pollution, our findings show that subsidies to reduced pollution and health externalities may be sub-optimal for targeting low-income households facing specific constraints (Banzhaf, Ma and Timmins, 2019; Zhao, Geng, Zhang, Davis, Li, Liu, Peng, Li, Zheng, Huo et al., 2019).

The remainder of this paper is structured as follows. Section 2 discusses the institutional background and context. Section 3 discusses the administrative and survey datasets and describes summary statistics. Section 4 explains the empirical strategy. Section 5 discusses the results, and finally section 6 concludes.

2 Institutional Background

To buy LPG, Indian consumers must obtain a “connection” – register with one of the three state-owned oil marketing companies (OMCs) that are the only suppliers of LPG. A consumer has to pay a connection charge, a deposit for a cylinder and pressure regulator, and purchase a rubber pipe at any OMC’s local distributor or “dealer”. This is an upfront cost of about INR 3200 (45 USD), which could easily be two weeks’ worth of household income in rural areas.⁴

Between 2013 and until about 2020, all residential LPG consumers in India, irrespective of income, received a subsidy, so-called ‘direct benefit transfer’ (DBT), for up to 12 cylinder refills in a year.⁵ This means that when a consumer with an LPG connection buys an LPG cylinder, she pays the market price to the dealer and the subsidy amount is credited to her

⁴“Connection” is the official term that refers to registration for obtaining the pressure regulator and consumer booklet along with the first cylinder. A connection entitles the consumer to the universal LPG subsidy. To register for a connection, a consumer has to provide proof of identity and address and submit a security deposit of 25 USD. The security deposit is for the empty 14.2 kg cylinder plus the pressure regulator. The consumer has to pay the market price separately for the gas in the cylinder (10 USD) and a stove (10 USD). The regulator does not come with the stove (which can be purchased by anyone on the market). It is given only by the LPG dealer, along with the cylinder, when the consumer obtains the “connection”. To recover the 20 USD deposit, the consumer must return the pressure regulator and an empty cylinder. Note that the average rural household income was approximately INR 7215 (100 USD) per month in 2011, the latest year for which these estimates are available (Desai, Vanneman and National Council of Applied Economic Research, 2011).

⁵Throughout this document, we refer to a cylinder with 14.2 kgs of LPG, the standard size of a cylinder in the Indian market.

bank account within the next 2–3 days. The government kept the subsidized price more or less stable at around INR 500 (in current prices) so that responding subsidy delivered by direct benefit transfer varied between INR 159 and INR 376 during our study period.⁶

To expand access to LPG, the Government of India launched the Pradhan Mantri Ujjwala Yojana (PMUY) in April 2016.⁷ The PMUY is the largest program on access to clean fuel in India’s history and the world, reaching 72 million poor families between April 2016 and June 2019. The program mandates that a woman in a rural, socio-economically disadvantaged household, obtaining an LPG connection (giving a right to buy subsidized gas) bears no upfront cost. The security deposit, along with administrative charges for a connection are borne by the government. The woman also receives an interest-free loan from the OMC to purchase the stove and the gas in the first cylinder.⁸ The program has been successful in significantly improving rural households’ access to LPG for cooking, the PMUY program is yet to ensure an increase in LPG usage.⁹

Nationwide, an estimated 79% of the households had an LPG connection in 2018 ([PPAC Report, 2018](#)).¹⁰ In rural India LPG use is much lower than in urban areas with the former

⁶All registered consumers are assigned a unique consumer number and a booklet that records, among other details, the date of LPG connection, LPG dealer, and purchase of every LPG refill. Consumers can purchase refills from the OMC approved dealers serving their village. A consumer with a connection can obtain a cylinder refill by first booking one through a phone call to her local dealer. Typically, the local dealer delivers booked refills in exchange for empty cylinders by mini trucks within a week of booking. All OMCs sell LPG connections and cylinder refills at the same, unregulated, market price. To elaborate on how the DBT functions, if the market price of an LPG cylinder is INR 820, the consumer pays this amount to the LPG dealer at the time of delivery. The dealer enters the refill purchase against the consumer’s ID in a centralized database. The subsidy amount of INR 320 is then directly deposited into the consumer’s linked bank account within 2-3 days of purchase. Since the shift to the DBT system in 2013, corruption through leakages in the LPG subsidy or false reporting of refills is greatly reduced. See [Barnwal \(2021\)](#) for policy changes to stem leakages in the LPG consumption subsidy in India.

⁷This translates as Prime Minister’s Brightening Program.

⁸Under the PMUY program, only those women who belong to socio-economically deprived (based on caste and income) households, are entitled to the subsidy of USD 25 to obtain the connection. While they do not pay the remaining USD 20 at the time of getting the connection, they too have to pay for the gas in the first cylinder at market price and stove eventually. Thus, effectively the USD 20 is a loan from the dealer to the consumer which will be recovered from her refill subsidy at some point by the government. Initially, the loan was to be recovered by paying the direct benefit transfer to the OMC instead of the customer every time a PMUY customer purchases a refill of the cylinder. But from April 2018 the government stopped withholding the direct benefit transfer to the bank accounts of the PMUY beneficiaries to encourage them to increase LPG consumption.

⁹A newspaper article covering the story can be found [here](#).

¹⁰Data from [Census \(2011\)](#) reveals that 28.5% of households in India had access to LPG with 65% coverage

having a mean annual consumption of about four cylinders and the latter about 8.¹¹

3 Data

We use two main sources of data - (1) Administrative Data from the sales records of the three OMCs for all LPG consumers in the district of Indore and (2) Household-Level Survey Data for approximately 3000 randomly sampled households.

3.1 Administrative Sales Data

The administrative sales data was provided by the three Oil Marketing Companies (OMCs) and covers the LPG refill transactions of all consumers in Indore district during the period 1 Nov 2017 - 31 December 2019.¹² Besides unique consumer IDs, the data contain information on the date of initial LPG connection, PMUY status, LPG dealer, residential address of each consumer, and data on every LPG refill transaction of each consumer. Using machine learning algorithm, we generated the gender (from the consumer name) and whether the household is rural or urban (using Google API and address pincode) for each consumer. We also obtained the monthly market-level LPG refill price data for the same period. Apart from monthly market-level price data for refill cylinders, we also have the actual subsidy provided in each month for each refill type during the study period.

The list of LPG dealers was mapped to their corresponding ‘LPG market’ in Indore and the corresponding monthly LPG price based on OMC administrative data.¹³ Hence, we were able to create a database of all customers purchase of LPG refills, refill price and subsidy in

in urban areas and only 11% coverage in rural areas. However, since the launch of PMUY in 2016, access in rural areas has gone up significantly in India.

¹¹Since LPG sales data are not available publicly; these figures are based on authors’ estimates from data shared by OMCs for the study area and [media reports](#).

¹²For BPCL, we also have commercial consumers and their transactions. Apart from giving us the refills by each consumer, for IOCL and BPCL, we also have the quantity purchased by a consumer while making a refill.

¹³Districts are broken into markets by OMCs on the basis of the cost of transportation of LPG refills from the bottling plant. Thus, prices vary between markets by INR 2-3, on average.

each month-year (26 markets x 26 month-year = 676). Since we also have the connection date of the consumer, we were able to replace all those observations with a missing value wherever the consumer was not in the market at that point - if the consumer joined after Nov 2017, all values up to the month of joining were treated as missing. Moreover, domestic consumers who had purchased more than 40 LPG refills in a year were dropped.

3.2 Household-Level Data

We revisit the data from a cluster randomized control trial (RCT) in the rural areas of Indore district in Madhya Pradesh (MP), the second-largest Indian state by area and the fifth largest by population with over 75 million residents (Afridi et al., 2021). Over 60% of households (rural and urban) had an LPG connection in January 2018 (PPAC Report, 2018) in MP. Indore, being the commercial hub with the highest per capita income amongst all districts in MP, is less likely to be subject to supply-side constraints on households' LPG access.

There are four census blocks in Indore district – Indore, Mhow, Sanwer, and Depalpur. Of these, Indore is primarily urban and was, therefore, excluded from the study. The remaining 491 villages were mapped from the three census blocks into their corresponding 250 *Gram Panchayats* (GP) using administrative data.¹⁴ This was to avoid having more than one village from a GP in the sample to reduce spillovers. Twenty-two villages with a population exceeding 5000 (and less than ten households) were excluded, to remove villages that were *de facto* urban or suburban or too small, leaving 239 GPs in the sample. From these, 150 GPs were randomly sampled and the largest village, by population, from each of these GPs was selected for the Afridi et al. (2021) study. All population estimates and other village-level data were based on the 2011 Census of India (Census, 2011).

In the sampled villages, a household was deemed eligible for the study if it had a currently

¹⁴The lowest level of local government in India is the *Gram Panchayat*, usually having 2-3 villages. The data for mapping villages into *Gram Panchayats* was obtained from the Local Government Directory (<https://lgdirectory.gov.in/downloadDirectory.do>)

residing member either less than 10 years or more than 55 years of age or both – demographic groups that are typically more vulnerable to adverse health effects due to indoor air pollution. Twenty eligible households were randomly sampled in each of these villages by systematic random sampling during the baseline survey. The 150 villages were randomly assigned to one of three arms (2 treatment and one control) with 50 villages in each.¹⁵ The baseline was conducted from Nov - Dec 2018. Following the completion of the intervention between Jan - Sept 2019, the endline survey was conducted between October and December 2019. Thus, the households surveyed in the baseline were revisited during the same season approximately a year later. Only 54 of the 3000 households could not be re-interviewed at endline; hence attrition is negligible (1.8%).

Households in the sample were asked whether they currently have an LPG account or not. If they did, details of the account, including the unique consumer ID, number of refills in the past year, were recorded from their consumer booklets accompanied by photographs of the consumer details and refills in the booklet. Detailed information on household composition, socio-economic characteristics, fuel use, and collection, PMUY status, health awareness were gathered for all households irrespective of whether they had an LPG account or not. Households with LPG connection were linked to the OMC data (described above) using the unique consumer ID. The same household level data were gathered at baseline and endline.

3.3 Summary Statistics

Administrative data statistics are described in [Table 1](#), which shows the sample and mean values of LPG refill consumption from administrative sales records all all three OMCs during Nov 2017 - Dec 2019 for the entire district of Indore. The data are at the consumer level, consisting of almost a million customers. 7% of the consumers are PMUY connection holders, while 32% are women and 57% rural. The average number of LPG refills per month is less than one at 0.62, and lower for PMUY consumers (0.34). Panels B and C provide statistics

¹⁵In all our main specifications with the household-level data, we include household fixed effects to ensure that treatment is not driving any of our estimates.

on the same variables for rural (Panel B) and urban (Panel C) consumers.

[Table 2](#) describes the rural household level data from the RCT by [Afridi et al. \(2021\)](#) in Indore. Of the 3003 households in the sample, 74% had an LPG connection, of which 39% were PMUY consumers. The average LPG refills purchased per month by households with an LPG connection was 0.41 (through matching of household Consumer ID with OMC sales data between Nov 2017 - Dec 2019), lower than from the full administrative data ([Table 1](#)) which contains both rural and urban customers. Average monthly expenditure on solid fuels purchased by households (explicit) is INR 70.5 and INR 162.6 for firewood and dung cakes, respectively. However, monetizing the reported time spent by the household in solid fuel collection/making in the survey data in terms of the minimum unskilled wage in MP, we find that the implicit monthly household expenditure on solid fuels is higher than the average domestic and effective price of one LPG refill shown in [Table A1](#), which summarizes the LPG refill domestic market price, subsidy and effective price (domestic market price - subsidy) across 26 LPG refill markets in the 26 months of our study period. Note that henceforth and throughout the analysis we use real prices by deflating current price to 2012 level using the Consumer Price Index.

In [Table A2](#) we compare the characteristics of the PMUY and non-PMUY consumers using the household survey data. PMUY households have lower assets, are less likely to belong to the general caste group (relative to SC-ST or OBC), less likely to own or lease land, have lower education and more likely to have casual labor as main occupation. These data, therefore, underline the fact that PMUY households are significantly more impoverished and more likely to be liquidity constrained.

4 Empirical Specification

We use the exogenous variation in the domestic price of LPG as our main source of identifying variation. Domestic price of LPG is set by the government of India, using as reference the

preceding month's international market price of crude oil (Bank Bazaar, 2022). As can be seen in Figure 1, one month lag of international crude oil price is highly correlated with the domestic price of LPG (with a correlation coefficient of 0.78). Government of India thus resets the price of LPG every month following the oil price in the international oil market (Barnwal, 2021).¹⁶

Equation 1 shows the main empirical specification used to estimate the impact of changes in subsidy on various dependent variables. Y_{imy} , is our dependent variable, which is either total number of refills purchased or expenditure on solid fuel. Number of refills correspond to total number of refills purchased of a 14.2 kg of gas cylinder (an indivisible object containing the LPG). We use the inverse hyperbolic sine transformation of the solid fuel expenditure.¹⁷ The dependent variable, Y_{imy} , varies at the consumer (i), financial-month (m), and financial-year (y) level.¹⁸ X_{my} denotes our main independent variable, which is subsidy, and it varies at the financial-month, financial-year level and market level. In our analysis we standardize subsidy to correspond to the price 1 kg of gas and then use it's log transformation, to get a semi-elasticity interpretation. The dummy $PMUY_i$ takes the value 1 if the consumer or household has the gas connection under the scheme PMUY, thus indicating whether a household belongs to low socioeconomic category. We also include household (μ_i), financial-month (δ_m) and financial-year (τ_y) fixed effects. The error term is captured by ϵ_{imy} term, which is clustered throughout the analysis at the market-financial-month-financial-year level.

$$Y_{imy} = \alpha + \beta X_{my} + \gamma X_{my} \times PMUY_i + \mu_i + \delta_m + \tau_y + \epsilon_{imy} \quad (1)$$

The coefficient β denotes the effect of change in price (subsidy, domestic price, or effective

¹⁶Note that while Government of India sets a price of LPG per month, this price varies at the market level due to cost of transportation from the blotting point as discussed above.

¹⁷We refrain from log expenditure in order to meaningfully interpret the zeros in the expenditure on solid fuel variable.

¹⁸Financial month starts in April (which is coded as month 1, and ends in March (coded as month 12). Similarly, financial year 2018, for instance, starts in April 2018 and ends in March 2019.

price) on the number of refills purchased in a month by a regular (non-PMUY) gas consumer. The coefficient γ denotes the differential effect of change in prices on the PMUY consumer.

5 Results

5.1 Subsidy and LPG purchase

We first analyze the impact of subsidy amount on LPG purchase using administrative data for all household LPG users. [Table 3](#), Panel A (Column 1) shows there is little impact of increase in subsidy on non-PMUY (i.e., medium to high income) households' LPG purchase. However, for PMUY (i.e., low-income) households, the estimated coefficient suggests that 1% increase in subsidy would lead to about 0.19% (i.e., 0.00063 refills per month over the average of 0.34 refills per month for PMUY households) decrease in LPG refills purchased on average. In terms of magnitude, this is an economically meaningful impact since during our study period itself, the subsidy per 14.2 kg LPG refill varied from INR 47 to INR 343. So, when the subsidy doubles from the mean level of INR 169, the LPG purchase of PMUY households would go down by one-fifth for PMUY households. The magnitude of the estimated effect remains stable after accounting for seasonality and year-specific factors (Columns 2-3).

We see a consistent pattern across rural and urban low-income households in our administrative data sample ([Table 3](#), Panel B and C). However, the magnitude of the effect is higher for rural households compared to urban households. Specifically, the decrease among urban households, in response to increase in subsidy, is about half of that in rural households.

We further carry out this analysis for the sample of rural households covered under the two rounds of household surveys. LPG usage rate has been significantly lower in rural areas compared to the urban households in the administrative data. Rural households are not only more likely to have lower income, they are also more likely to use alternative solid fuels such as firewood and dung. In our household survey sample villages, rural households appear to have even lower consumption of LPG than rural households in the administrative

data sample (compare [Table 1](#) and [Table 2](#) for rural households' refills). Specifically, rural households in the survey sample consume two-third of LPG when compared to the rural households in the administrative data, which implies that households in our survey sample are likely to poorer than the average rural households.

[Table 4](#), Column 1 shows that, in general, a subsidy increase leads to reduction in LPG refills purchase among rural households in our survey sample. Even for the non-PMUY rural households, the effect is significant. We attribute to the fact that rural households in our sample are likely to be poorer. Estimated coefficient in Column 1 suggests 1% increase in subsidy may lower refills purchase by 0.096% (i.e., 0.00046 refills per month over the average of 0.48 refills per month for rural non-PMUY households). This implies that when the subsidy doubles, rural non-PMUY households will reduce LPG purchase by more than one-tenth. However, once we account for year fixed effects, the estimated coefficient is no more statistically significant (Column 3). On the other hand, for PMUY rural households in the survey sample, the impact of subsidy increase is significantly steeper and remains robust to time and household fixed effects.

To sum, we see that low-income households in rural area are more likely to reduce their LPG purchase when the subsidy amount increases.

5.2 Impact of subsidy on substitute fuel

Solid fuels, particularly firewood and dung have been prevalent for a long time in rural India. The motivation behind the subsidy policy and the PMUY program is to discourage solid fuel usage because of its health and pollution externalities ([Barua and Agarwalla, 2018](#); [Kar, Pachauri, Bailis and Zerriffi, 2019](#)). Since solid fuels and LPG are substitutes, an increase in the subsidy amount might also affect solid fuel usage.

[Table A3](#) shows that rural households increase the frequency of solid fuel usage. Relatively richer rural households are increasing efforts on dung, while PMUY households go out to collect firewood more frequently. However, not all households collect solid fuel themselves

in rural areas since these fuels are also available in the market. [Table 5](#) shows that overall expenditure – including explicit expenditure in the market and implicit expenditure from the time spent on fuel collection – increases by about half percent for each percentage rise in the subsidy.¹⁹

5.3 Additional evidence on liquidity constraints

We explore two more ways to understand whether the observed effects are indeed due to liquidity constraints. First, we test for heterogeneity over households’ characteristics. [Table 6](#) shows that household wealth primarily explains the observed pattern (Column 1). Specifically, the magnitude of the impact of subsidy increase on LPG purchase decreases with wealth. For the richest households in our sample (with asset index of 3.96), there is basically no gradient in LPG purchase with subsidy amount. But even for households with a mean level of asset ownership (asset index of 1.57), subsidy increase will reduce LPG purchase in a statistically and economically significant way. Furthermore, there is some evidence on heterogeneity across caste – LPG purchase by higher caste (i.e., general caste) households is less affected by subsidy (p-value of 11% on the interaction term) increase compared to lower caste (other backward caste, scheduled caste and scheduled tribe) (Column 2). Households who get paid on a daily basis are likely to experience greater liquidity constraints. The estimated coefficient in Column 3 supports it qualitatively, with an interaction coefficient p-value of 10.4%. We do not find any difference for self-employed households. As [Table A2](#) shows the one-time start up subsidy under the PMUY program effectively targeted poor and low-caste households. In contrast, [Table 6](#) results indicate that increase in subsidy amount has a rather regressive impact on households targeted by PMUY program.

Second, the impact of subsidy increase on liquidity constrained households is a consequence of the trade-off these households face between the cost and inconvenience of using

¹⁹While we do not have data on indoor health pollution and its subsequent health impact, it is expected that negative health externalities may also rise as households substitute LPG with solid fuels in response to higher subsidy amount.

solid fuel and the pricier but convenient, clean cooking gas. Rains may make it difficult to collect firewood and dung, may lead to higher prices for solid fuels, and may make it more inconvenient to burn them as cooking fuel when they are wet (Brouwer and Falcão, 2004). Not cooking food is seldom an option in the rural setting. So, the wet season is likely to have a counteracting impact in this context. To test this, we interact the model presented in Table 3 and Table 4 with a binary variable for rainy months. Table 7 shows that LPG refills purchase increases for all households – PMUY and non-PMUY both – in the rainy season, as expected. However, while rains effectively make non-PMUY households’ LPG purchase indifferent to changes in subsidy, the net impact on PMUY households remains negative.

5.4 Willingness to pay for preventive health and liquidity constraints

Do liquidity constraints, exacerbated by subsidy increase, have a lower impact on clean fuel usage by health-conscious households? If low-income households have low willingness to invest in preventive health (Greenstone and Jack, 2015), they are more likely to prefer solid fuels when accessing cooking gas becomes costlier. Conversely, households who invest in preventive health and make other similar investments are less likely to reduce their gas purchase in response to liquidity constraints exacerbated by subsidy increase.

To test this, we check for heterogeneity over households that have invested in preventive health and sanitation. Table A5 shows some evidence that households who invested in better sanitation and a separate room for cooking respond to subsidy increase differently compared to other households that didn’t (Columns 1-2). Investments in building a latrine in the house and a separate room for cooking impose large costs, and the interpretation of these results is not straightforward since these investment decisions are likely to be correlated with income and PMUY status. However, when we include proactive and relatively low-cost preventive-health behavior such as investment in chimney for kitchen smoke, and preventive test for anemia and diabetes, we do not observe any difference (Columns 3-6).

5.5 Liquidity constraints vs. subsidy salience

An alternative explanation of the observed effects of subsidy increase may be subsidy salience. In other words, it is not hard liquidity constraints, but the rural household’s lack of understanding of how cash-back subsidy works which may be at play in our context, as mentioned in Afridi et al. (2021). Further, Chetty et al. (2009) show that the grocery demand goes down by 8% when tax-inclusive prices are displayed. In our setting, this will translate into LPG demand going down when subsidy-exclusive prices are not salient to consumers.

We explore this alternative explanation using survey data on households’ understanding of the cash-back nature of the LPG subsidy program. Table A6 shows estimates on heterogeneity over households’ knowledge about the subsidy program. These regressions are carried out using the data collected at the second round of survey. There is no observed difference in households’ knowledge about the subsidy program.

6 Conclusion

Cash transfers are replacing in-kind transfer programs across the world. India alone is running 311 public programs where the government provides welfare to citizens through direct bank transfers.²⁰ While the bank transfer of benefits may come with other gains such as lower administrative costs, better targeting, and a reduction in leakages (Barnwal, 2021; Muralidharan, Niehaus and Sukhtankar, 2016), they may also have an unintended regressive impact on low-income households who are more likely to face liquidity constraints. Results presented in this paper show that low-income households’ clean fuel usage decreases and dirtier solid fuel usage increases, due to the liquidity constraints amplified by changes in subsidy amount. The associated health and environmental externalities, especially for the women and children who spend more time indoor near the cooking stoves, are likely to be significant, although our analysis is limited by lack of data on those outcomes. Overall, this

²⁰Information available on <https://dbtbharat.gov.in/>.

paper shows that, in India’s cooking gas subsidy program, the impact of liquidity constraints on clean fuel take-up of low-income households goes counter to the policy intent behind subsidized gas connection and regular gas subsidy.

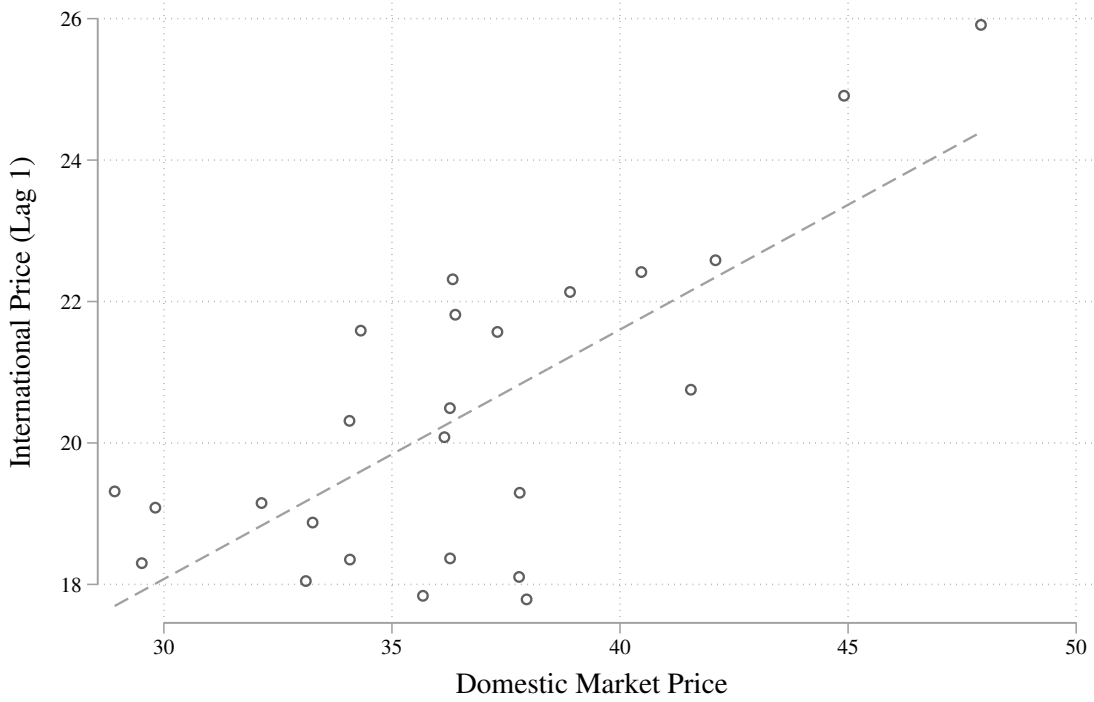
This paper shows that the design of cash transfer programs, especially the *timing* of transfers, matters. Gains in efficiency, leakages and targeting due to policy reforms in welfare delivery may come at the cost of reduced take-up by low-income households, when any time lag embedded in a cash transfer program interacts with households’ liquidity constraints. Our results suggest that cash-transfer programs should be designed with a careful attention to constraints faced by low-income households in income smoothing and not just income levels.

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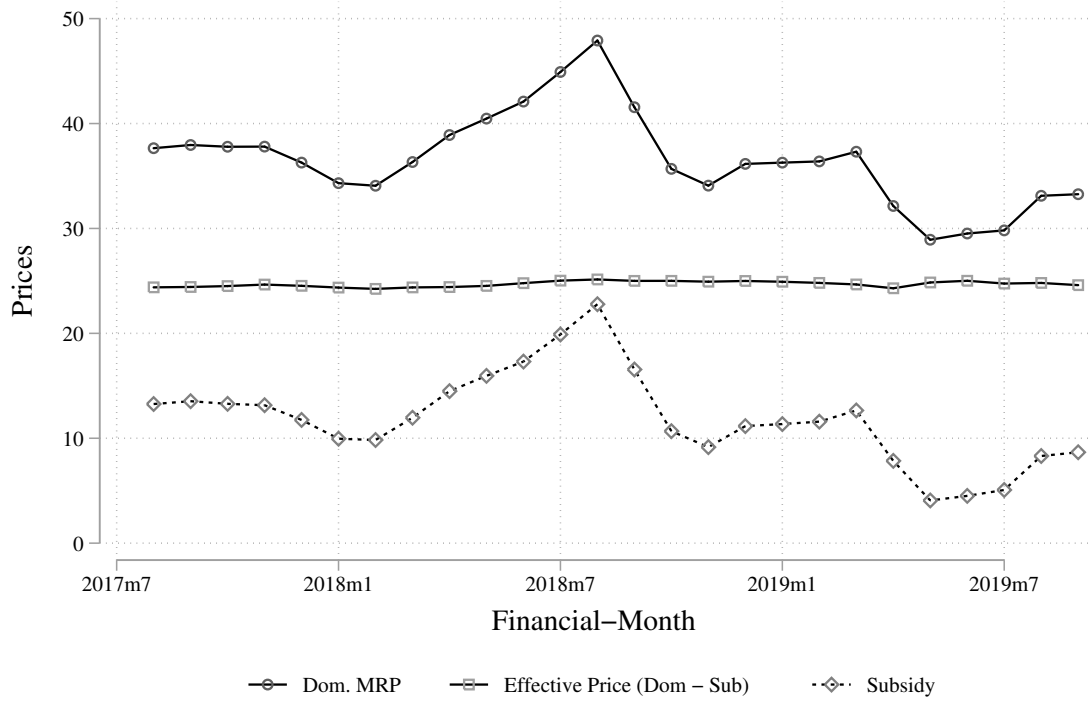
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Figure 1: Correlation Between Domestic Price of LPG and 1-Month Lag of International Crude Oil



Notes: This figure shows a scatter plot between 1-month lagged international price of crude oil ([Organization of the Petroleum Exporting Countries, 2017,1,1](#)) and the domestic price of LPG as obtained from the OMC administrative dataset. Each observation is the monthly price of international crude oil (lagged 1 period) and domestic price of LPG spanning 26 months from November 2017 to December 2019. All prices are in real 2012 INR. Regressing lagged international price on domestic price gives a coefficient of 0.35 with a standard error of 0.06 (correlation coefficient between the lagged international price and domestic market price is 0.78).

Figure 2: Variation in Domestic Price and Effective Price



Notes: This figure shows the variation in Domestic Price, Effective Price and Subsidy. Domestic Price of LPG is defined as the price of LPG as set by the Government of India. Subsidy is set by the Government of India. Effective price is defined as the difference between Domestic Price and Subsidy. Y-axis shows all the three prices in INR for 1 kg of refill. All prices are in real 2012 INR. X-axis shows the corresponding financial month, spanning 26 months from November 2017 to December 2019.

Table 1: Administrative OMC Data Descriptive Statistics

	Obs	Mean	SD	Minimum	Maximum
Panel A: All Consumers					
PMUY	910,755	0.07	0.26	0.00	1.00
Female Connection	910,755	0.32	0.47	0.00	1.00
Rural Connection	910,755	0.57	0.49	0.00	1.00
Average Refills (per month)	910,755	0.62	0.30	0.00	7.80
• PMUY	67,462	0.34	0.24	0.00	2.67
• Non-PMUY	843,293	0.64	0.30	0.00	7.80
Panel B: Rural Consumers					
PMUY	519,679	0.09	0.29	0.00	1.00
Female Connection	519,679	0.33	0.47	0.00	1.00
Average Refills (per month)	519,679	0.62	0.30	0.00	7.80
• PMUY	47,782	0.35	0.23	0.00	2.67
• Non-PMUY	471,897	0.65	0.30	0.00	7.80
Panel C: Urban Consumers					
PMUY	391,076	0.05	0.22	0.00	1.00
Female Connection	391,076	0.30	0.46	0.00	1.00
Average Refills (per month)	391,076	0.62	0.30	0.00	7.80
• PMUY	19,680	0.33	0.24	0.00	2.00
• Non-PMUY	371,396	0.64	0.30	0.00	7.80

Notes: This table summarizes the OMC administrative data. Panel A summarizes information about all (910,755) consumers, Panel B summarizes information on the rural consumers, and Panel C summarizes information on urban consumers. PMUY is a dummy which takes value 1 if the consumer has a PMUY LPG connection. Female is a dummy which takes value 1 if the connection is in the name of a female. Rural in Panel A is a dummy if the connection is that of a rural household. Average refills show the average monthly refills of households divided by PMUY or Non-PMUY categories.

Table 2: Household Survey Descriptive Statistics

	Obs	Mean	SD	Minimum	Maximum
Panel A: Households					
LPG User	3,003	0.74	0.44	0.00	1.00
PMUY	2,217	0.39	0.49	0.00	1.00
Average Refills (per month)	2,217	0.41	0.27	0.00	1.58
• PMUY	858	0.29	0.20	0.00	1.04
• Non-PMUY	1,359	0.48	0.28	0.00	1.58
Panel B: Household Attributes					
Asset Index	3,003	1.57	0.77	-0.15	3.96
General Caste	3,003	0.16	0.37	0.00	1.00
Salaried HH Head	3,003	0.09	0.29	0.00	1.00
Agri Self-Employed HH Head	3,003	0.33	0.47	0.00	1.00
Agri Casual Laborer HH Head	3,003	0.39	0.49	0.00	1.00
Land Owner	3,003	0.54	0.50	0.00	1.00
Land Owner/Leaser	3,003	0.55	0.50	0.00	1.00
HH Head Education	3,003	0.41	0.49	0.00	1.00
Latrine in HH	3,003	0.85	0.35	0.00	1.00
Expenditure (INR): Firewood (explicit)	3,003	70.51	267.98	0.00	5,000.00
Expenditure (INR): Firewood (implicit)	3,003	605.45	667.13	0.00	3,920.00
Expenditure (INR): Dung (explicit)	3,003	162.64	415.28	0.00	10,000.00
Expenditure (INR): Dung (implicit)	3,003	183.37	496.88	0.00	5,390.00

Notes: This table summarizes the household survey dataset. Panel A provides information on connection and refills. LPG User is a dummy that takes value 1 if the surveyed household uses LPG. PMUY is a dummy which is 1 if the LPG using household has a PMUY connection. Average refills show the average monthly refills of households divided by PMUY or Non-PMUY categories. (Refills data comes from the OMC Administrative dataset, matched to households surveyed). Panel B summarizes the various household attributes. Asset Index is the first component of a principal component analysis over several indicators measuring the economic status of a household. These indicators include ownership of land and farm animals, pucca house, and a list of consumer durables. Education of the head of the household and the primary cook is measured by an indicator that takes value one for above primary education and zero otherwise. General Caste is a dummy if the household belongs to any caste group that is ineligible for reservations. Salaried, Self-Employed, Casual Laborer, Land Owner, Land Owner/ Leaser are all dummies equal to 1 if the household head belongs to the respective category. HH Head Education is a dummy equal to 1 if the household head has above primary education. Latrine in HH is a dummy if the household has a pit or flush toilet built inside house. Explicit firewood and dung expenditure per month is reported in the survey. Implicit expenditure is calculated as total number of hours household spent collecting/making the solid fuel in a week into the minimum hourly wage in Madhya Pradesh for unskilled labor (i.e. INR 35 X 4) to get monthly estimate of implicit expense on solid fuels.

Table 3: Impact of Log Subsidy on Monthly Refills: Administrative Data

	(1)	(2)	(3)
Panel A: Full Sample			
Subsidy	0.010 (0.008)	0.008 (0.007)	-0.013 (0.009)
PMUY \times Subsidy	-0.063*** (0.013)	-0.060*** (0.010)	-0.058*** (0.010)
Mean of Dependant Var.	0.625	0.625	0.625
Observations	21,866,270	21,862,577	21,862,577
Panel B: Rural Sample			
Subsidy	0.007 (0.009)	0.006 (0.007)	-0.015 (0.010)
PMUY \times Subsidy	-0.072*** (0.012)	-0.067*** (0.010)	-0.066*** (0.010)
Mean of Dependant Var.	0.624	0.624	0.624
Observations	12,439,541	12,437,529	12,437,529
Panel C: Urban Sample			
Subsidy	0.013* (0.007)	0.010 (0.007)	-0.011 (0.008)
PMUY \times Subsidy	-0.037* (0.019)	-0.038** (0.016)	-0.036** (0.016)
Mean of Dependant Var.	0.626	0.626	0.626
Observations	9,357,132	9,355,455	9,355,455
Financial Month FE	Yes	Yes	Yes
Household FE	No	Yes	Yes
Year FE	No	No	Yes

Notes: This table shows the effect on monthly refills (dependent variable) of changes in log Subsidy (independent variable). Panel A shows the estimates for the full OMC Administrative Sample, Panel B shows the estimates for Rural Administrative Sample, and Panel C shows the estimates for the Urban sample. Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Unit of observation is consumer-financial month-financial year, leading to total of 21.86 million observations, corresponding to monthly refills for 26 months of the 910,755 unique consumers. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). Column 1 shows includes financial month fixed effects, Column 2 adds household (i.e. customer) fixed effects, and Column 3 adds financial year fixed effects. PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table 4: Impact of Log Subsidy on Monthly Refills: Household Survey Data

	(1)	(2)	(3)
Subsidy	-0.046*** (0.017)	-0.044*** (0.010)	-0.019 (0.013)
PMUY \times Subsidy	-0.056*** (0.022)	-0.067*** (0.016)	-0.067*** (0.016)
Mean of Dependant Var.	0.421	0.421	0.421
Observations	54,388	54,388	54,388
Financial Month FE	Yes	Yes	Yes
Household FE	No	Yes	Yes
Year FE	No	No	Yes

Notes: This table shows the effect on monthly refills (dependent variable) of changes in log Subsidy (independent variable). Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Prices and refill data are from the administrative dataset, only the sample is restricted to household survey respondents. Unit of observation is consumer-financial month-financial year, leading to total of 54,388 observations, corresponding to monthly refills for 26 months of the 2,217 unique gas using consumers in the household survey sample. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). Column 1 shows includes financial month fixed effects, Column 2 adds household (i.e. customer) fixed effects, and Column 3 adds financial year fixed effects. PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table 5: Impact of Log Subsidy on IHS of Solid Fuel Expenditure

	(1)	(2)	(3)
	Explicit	Implicit	Total
Subsidy	-0.677 (0.600)	0.081 (0.759)	0.241 (0.667)
PMUY \times Subsidy	0.321** (0.155)	0.719*** (0.155)	0.527*** (0.123)
Mean of Dependant Var.	1.921	5.205	6.126
Observations	3,958	3,958	3,958
Financial Month FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table shows the effect on monthly expenditure on solid fuels (dependent variable) of changes in log Subsidy (independent variable). Subsidy is defined as the log of the price of 1 kg of refill. Column 1 shows the explicit expenditure is the amount household reports to have spent out of pocket on firewood and dung (combined) in the previous month. Column 2 shows the implicit expenditure is defined as number of times person responsible in a households went to collect solid fuel (firewood and dung) in the previous month multiplied by number of hours spent in collection multiplied by the hourly wage of INR 35, to get implicit expenditure per month. Column 3 combines implicit and explicit expenditure. All specifications include financial month and household fixed effects and year fixed effects. Unit of observation is consumer-financial month-financial year. Each household is asked information on solid fuel collection for only one month, hence this dataset is a panel of 2 month observations (once collected during 2018 survey round 1 in 2018, other during 2019 survey round 2) for each LPG using household. A consumer who may not be an LPG user in 2018 could have become and LPG user (PMUY or otherwise) by 2019, hence the panel is unbalance. PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table 6: Impact of Log Subsidy on Monthly Refills: Heterogeneity by Household Attributes

	(1)	(2)	(3)	(4)
Subsidy	-0.075*** (0.018)	-0.049*** (0.012)	-0.037*** (0.012)	-0.046*** (0.012)
Subsidy \times Assets Index	0.019** (0.008)			
Subsidy \times General Caste		0.029 (0.018)		
Subsidy \times Casual Laborer			-0.020 (0.012)	
Subsidy \times Self Employed				0.005 (0.012)
Mean of Dependant Var.	0.421	0.421	0.421	0.421
Observations	54,388	54,388	54,388	54,388
Financial Month FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: This table shows the effect on monthly refills (dependent variable) of changes in subsidy among the LPG users in the household survey data interacted by household characteristics. Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Prices and refill data are from the administrative dataset. Data on asset index, caste, occupation are from the household survey. Asset index, general caste, casual labor, self-employed is defined as in Table 2. Unit of observation is consumer-financial month- financial year, leading to total of 54,388 observations, corresponding to monthly refills for 26 months of the 2,217 unique gas using consumers in the household survey sample. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table 7: Impact of Log Subsidy on Monthly Refills: Heterogeneity by Rainy Season

	(1)	(2)
	Admin (Full)	Admin (Rural)
Subsidy	-0.032** (0.013)	-0.034** (0.013)
PMUY \times Subsidy	-0.054*** (0.011)	-0.063*** (0.010)
Rainy Month \times Subsidy	0.034*** (0.012)	0.036*** (0.012)
PMUY \times Rainy Month \times Subsidy	0.017*** (0.006)	0.013*** (0.005)
Mean of Dependant Var.	0.625	0.624
Observations	21,891,265	12,464,279
Financial Month FE	Yes	Yes
Household FE	Yes	Yes
Year FE	Yes	Yes

Notes: This table shows the effect on refills (dependent variable) of changes in subsidy among the LPG users in the administrative data. Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Prices and refill data are from the administrative dataset. Rainy month is a dummy which is 1 if the month is July, August, September. Column 1 includes the full OMC administrative sample, Column 2 is restricted to only the rural consumers of the administrative data. Unit of observation is consumer-financial month- financial year. All specifications include financial month, household, and year fixed effects. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

A Appendix A

Table A1: Summary of Domestic Price, Subsidy, and Effective Price

	Obs	Mean	SD	Minimum	Maximum
Subsidy	676	169.31	62.11	46.90	343.32
Domestic Price	676	520.82	62.45	410.43	702.60
Effective Price	676	351.51	4.98	338.59	374.01

Notes: This table summarizes Domestic Price, Effective Price and Subsidy. Domestic Price of LPG is defined as the price of LPG as set by the Government of India. Subsidy is set by the Government of India. Effective price is defined as the difference between Domestic Price and Subsidy. All prices are in real 2012 INR. All prices vary at market-month level. There are 26 months in our sample (November 2017-December 2019), and 26 markets. Market is the point from where consumer buys the LPG cylinder.

Table A2: Covariate Comparison Between Non-PMUY and PMUY - Household Survey

	Non-PMUY			PMUY			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Obs	Mean	SD	Obs	Mean	SD	Diff
Assets Index	33,956	1.86	0.74	20,432	1.26	0.60	-0.597***
General Caste	33,956	0.20	0.40	20,432	0.09	0.29	-0.109***
Salaried Head of HH	33,956	0.12	0.33	20,432	0.08	0.27	-0.040***
Self Employed	33,956	0.37	0.48	20,432	0.21	0.41	-0.155***
Land Owner	33,956	0.57	0.50	20,432	0.45	0.50	-0.114***
Land Owner or Leaser	33,956	0.58	0.49	20,432	0.47	0.50	-0.115***
HH Head Edu. Above Primary	33,956	0.47	0.50	20,432	0.32	0.47	-0.154***
Has Latrine in House	33,956	0.93	0.26	20,432	0.81	0.39	-0.111***
Casual Laborer	33,956	0.30	0.46	20,432	0.52	0.50	0.210***

Notes: This table compares Non-PMUY and PMUY households along several covariate dimensions. Total number observations across both groups is 54,388 (same Table 4). All the variables are as defined in Table 2. Standard errors are clustered at the market-month-year level. Difference is significant at * 10%, ** 5% and ***1% level.

Table A3: Impact of Log Subsidy on Solid Fuel Collection

	(1)	(2)
	Firewood	Dung
Subsidy	-0.212 (2.588)	14.311*** (2.442)
PMUY=1 \times Subsidy	3.963*** (0.948)	0.578 (0.725)
Mean of Dependant Var.	6.986	7.031
Observations	3,958	3,958
Financial Month FE	Yes	Yes
Household FE	Yes	Yes
Year FE	Yes	Yes

Notes: This table shows the effect on monthly collection of solid fuels (dependent variable) of changes in log Subsidy (independent variable). Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is defined as number of times person in the household responsible for solid fuel collection went to collect solid fuel in the previous month. Two most common solid fuels are firewood, and dung. Subsidy data is from the administrative dataset, collection of solid fuel data is from household survey. All specifications include financial month, household and year fixed effects. Each household is asked information on solid fuel collection for only one month, hence this dataset is a panel of 2 month observations (once collected during 2018 survey round 1 in 2018, other during 2019 survey round 2) for each LPG using household. A consumer who may not be an LPG user in 2018 could have become and LPG user (PMUY or otherwise) by 2019, hence the panel is unbalance. PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A4: Impact of Log Subsidy on IHS of Solid Fuel Expenditure: Firewood and Dung

	(1)	(2)	(3)	(4)
	<u>Explicit</u>		<u>Implicit</u>	
	Firewood	Dung	Firewood	Dung
Subsidy	-1.104*** (0.312)	0.040 (0.543)	-1.557* (0.912)	0.661 (0.827)
PMUY=1 \times Subsidy	0.052 (0.122)	0.269* (0.138)	1.486*** (0.289)	-0.092 (0.193)
Mean of Dependant Var.	0.609	1.644	3.067	3.930
Observations	3,958	3,958	3,958	3,958
Financial Month FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: This table shows the effect on monthly expenditure on solid fuels (dependent variable) of changes in log Subsidy (independent variable). Subsidy is defined as the log of the price of 1 kg of refill. Column 1 and 2 show effects on the amount household reports to have spent out of pocket on firewood and dung in the previous month respectively. Column 3 and 4 shows the implicit expenditure is defined as number of times person responsible in a households went to collect firewood and dung, respectively, in the previous month multiplied by number of hours spent in collection multiplied by the hourly wage of INR 35, to get implicit expenditure per month. All specifications include financial month and household fixed effects and year fixed effects. Unit of observation is consumer-financial month-financial year. Each household is asked information on solid fuel collection for only one month, hence this dataset is a panel of 2 month observations (once collected during 2018 survey round 1 in 2018, other during 2019 survey round 2) for each LPG using household. A consumer who may not be an LPG user in 2018 could have become an LPG user (PMUY or otherwise) by 2019, hence the panel is unbalance. PMUY is a dummy which is 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A5: Impact of Log Subsidy on Monthly Refills: Heterogeneity Analysis by Health Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
Subsidy	-0.073*** (0.020)	-0.079*** (0.015)	-0.047*** (0.017)	-0.047*** (0.014)	-0.041*** (0.012)	-0.050*** (0.013)
Subsidy \times Has Latrine in House	0.032* (0.019)					
Subsidy \times Have Separate Cooking Room		0.049*** (0.015)				
Subsidy \times Have Chimney outlet			0.003 (0.015)			
Subsidy \times Got Hemoglobin Check-up					-0.023 (0.016)	
Subsidy \times Got Diabetes Check-up						0.000 (0.000)
Mean of Dependant Var.	0.422	0.422	0.422	0.419	0.422	0.416
Observations	51,138	51,138	51,138	45,352	51,138	41,398
Financial Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the effect on monthly refills (dependent variable) of changes in subsidy among the LPG users in the household survey data interacted with various preventive health outcomes. Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Each heterogeneity variable is a dummy indicating whether 1) household has latrine, 2) household has separate cooking room, 3) household has chimney outlet, 4) anyone in the house got a hemoglobin check-up last month, and 5) anyone in the house got a diabetes check-up last month. Unit of observation is consumer-financial month-financial year, leading to less than 54,388, due to random missings in responses, corresponding to monthly refills for 26 months of the 2,217 unique gas using consumers in the household survey sample. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A6: Impact of Log Subsidy on Monthly Refills: Heterogeneity Analysis by Knowledge About Subsidy

	(1)	(2)	(3)	(4)	(5)
Subsidy	-0.023 (0.018)	-0.017 (0.014)	-0.020 (0.015)	-0.016 (0.018)	-0.029** (0.014)
PMUY \times Subsidy	-0.054** (0.022)	-0.066*** (0.017)	-0.080*** (0.020)	-0.065*** (0.021)	-0.057*** (0.018)
Govt. Deposits Subsidy \times Subsidy	0.005 (0.018)				
PMUY \times Govt. Deposits Subsidy \times Subsidy	-0.020 (0.026)				
Subsidy Amt. Same \times Subsidy		-0.007 (0.017)			
PMUY \times Subsidy Amt. Same \times Subsidy		-0.001 (0.026)			
Out-Of-Pocket < Paid \times Subsidy			0.001 (0.016)		
PMUY \times Out-Of-Pocket < Paid \times Subsidy			0.029 (0.023)		
Subsidy SMS Alert \times Subsidy				-0.004 (0.017)	
PMUY \times Subsidy SMS Alert \times Subsidy				-0.004 (0.026)	
Subsidy Only for PMUY \times Subsidy					0.032** (0.015)
PMUY \times Subsidy Only for PMUY \times Subsidy					-0.030 (0.023)
Mean of Dependant Var.	0.422	0.422	0.422	0.422	0.422
Observations	50,914	50,914	50,914	50,914	50,914
Financial Month FE	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the effect on monthly refills (dependent variable) of changes in subsidy among the LPG users in the household survey data interacted by household's knowledge about how the subsidy works. Subsidy is defined as the log of the price of 1 kg of refill. The dependent variable is refills, which is the total monthly refills of a cylinder (which is an indivisible object of 14.2 kg). Each heterogeneity variable is an agree or disagree statement. The statements are: 1) govt. deposits subsidy to your bank account 2) subsidy deposited remains the same everytime 3) out-of-pocket expense on LPG cylinder is less than the market price paid 4) govt. sends an SMS alert about subsidy once deposited 5) subsidy is only for PMUY customers. Unit of observation is consumer-financial month- financial year, leading to 50,914 observations (instead of 54,388, due to random missings in responses), corresponding to monthly refills for 26 months of the 2,217 unique gas using consumers in the household survey sample. Refill is missing if consumer does not have a gas connection, and refills are non-missing once the consumer avails the connection (hence, the panel is unbalanced). Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.