Timing the Transfer: Liquidity Constraints and the Transition to Clean Fuels*

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Abstract

We study the role of the administrative design of energy subsidy programs aimed at encouraging households' transition to cleaner energy sources. Our context is the universal subsidy for clean cooking gas (LPG) in India - households first purchase LPG at the market price (over-the-counter) and then receive a 'cash-back' subsidy in their bank account. The subsidy varies with the market price such that the effective price (out-of-pocket price net of subsidy) for households does not change. Using exogenous variation in the LPG market price, which varies in tandem with the international price, and administrative data on LPG purchases by one million households, we find that a 1% increase in over-the-counter LPG price causes a 1.4% decrease in LPG purchase by low-income households, even when the effective price remains unchanged. Household survey data show that low-income households substitute away from LPG towards polluting biomass-based solid fuels by 5% in response to a 1% increase in the LPG market price. Consequently, we estimate that the 'cash-back' subsidy design may worsen neonatal mortality and other relevant health outcomes. The adverse impact of the program design on clean fuel usage weakens when households have more cash on hand, suggesting households' short-term liquidity constraint is the key explanation. Our results, thus, show that the design of energy subsidy programs, in particular the timing of transfers, may have significant implications for the energy transition of liquidity-constrained households.

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1 Introduction

Transition to clean energy is an important sustainable development goal (UN). Several countries run household subsidy programs to accelerate the transition to cleaner energy sources that reduce pollution and health externalities.[1] Since access to clean energy has direct implications for environmental justice, energy subsidy programs often include provisions that target low-income households. However, the administrative design of these programs varies significantly, even though they all aim to incentivize households to use cleaner fuels.

Most energy subsidy programs cover either the fixed cost of clean energy transition through a one-time subsidy or the marginal cost of transition with a price subsidy (and, sometimes, both). These subsidies come in various forms – advance price subsidies or vouchers, price subsidies at the point-of-sale, cash-back subsidies, or rebates. Policy-makers usually pay less attention to *how* the subsidy should be provided, as opposed to their focus on *what* the subsidy amount should be. Further, while the choice of administrative design depends on administrative costs and other factors, e.g., potential leakages due to corruption, equity concerns are often overlooked. Consequently, how the administrative design of energy subsidy programs affects efficiency and equity in the take-up of clean energy remains understudied.

This paper examines the consequences of a cash-back energy subsidy, in the context of an at-scale energy subsidy program in India. We empirically investigate how the variation in the subsidy amount, when given as cash-back, affects the take-up of a clean fuel. Particularly focusing on the equity aspect, we estimate the differential impact of the cash-back subsidy design on clean fuel take-up and the substitution towards inferior and more polluting solid fuels by the non-poor versus the poor households. We further explore evidence on the potential mechanisms behind the observed effect. Finally, we quantify the welfare cost of the indoor pollution externality resulting from the cash-back design in terms of the health burden on children.

[1] Some examples include clean fuel subsidies in India, solar panel tax incentives in South Africa, and electric vehicle (E.V.) purchase subsidies in the US.

Three key features of our setting help frame our empirical analysis. First, the Indian government provides universal price subsidy to all households — the poor and the non-poor alike — for purchasing cooking gas (LPG).[2] In addition, poor households receive a one-time 'set-up subsidy' under a nation-wide public program called *Pradhan Mantri Ujjwala Yojana* (PMUY) to cover the fixed cost of their transition from traditional biomass stoves to LPG. Second, households purchase the gas refill by paying the over-the-counter price at the point of purchase, that is regulated by the government based on the international market price of LPG. Third, to insure households against the price risk, the government also adjusts the cash-back-subsidy every month such that the net out-of-pocket price of LPG remains the same for households over time. In other words, the amount households pay as over-the-counter price at the point of purchase depends on the international market price of LPG, but subsequently (in about a week, on average) all households receive a cash-back subsidy into their bank accounts that renders the net out-of-pocket price of LPG effectively unchanged over time. Theoretically, when the effective price of LPG does not change, households' LPG purchase should not respond to changes in the over-the-counter LPG prices.

Our identifying variation utilizes the fact that the LPG over-the-counter price (and the cash-back subsidy amount) varies exogenously, while keeping the net out-of-pocket price unchanged over time. The Indian government regulates the over-the-counter price and the subsidy every month based on Saudi Aramco LPG price in the preceding month. Figure 1 shows a strong, positive correlation between the (domestic) over-the-counter LPG price and the international price of LPG lagged by a month during our study period, underscoring our claim of exogenous variation in LPG prices. Figure 2 depicts graphically the synchronous variation in the over-the-counter LPG refill price and the household LPG refill subsidy such that the net out-of-pocket price of LPG refills is effectively unchanged over time.

[2]Liquified petroleum gas (LPG) has significantly lower carbon and particulate material emissions when compared to alternative biomass fuels like firewood, charcoal, dung cakes, and crop residues, currently used by 2 billion households across the world. Cooking with biomass currently adds to about 2% of global carbon dioxide equivalent emissions (Bailis et al., 2015). Gould et al. (2023) estimate the average PM2.5 exposure for exclusive LPG use to be roughly 35 μgm^{-3}, compared to 250 μm^{-3} for exclusive biomass use.

Our analysis utilizes multiple data sources – administrative, primary surveys as well as secondary survey datasets. First, we use transaction-level data on LPG sold to households through the public distribution system. These data include 24 million LPG refill transactions over 26 months (November 2017 - December 2019) by about one million LPG user households in Indore, a major district in central India. Transaction level panel data allow us to implement a within-household analysis. Second, we use a primary survey that provides information on households' biomass fuel consumption, demographic characteristics and asset ownership over two survey rounds between October 2018 - December 2019. The survey sample includes about 3,000 households from rural Indore. Importantly, we are able to match the households in the survey data to the administrative data. Both data sources contain information on whether the consumer is enrolled under the PMUY program — which we use as a proxy for low-income households.

Third, we use the all-India Demographic and Health Survey (DHS) data that collects information related to pregnancies, births and child-level health outcomes. Since detecting health effects is harder in smaller samples, the scale and timing of the DHS survey allows us to use the same identifying variation as the administrative and primary survey data analyses. We also use additional datasets such as the nationally representative Periodic Labor Force Survey (PLFS) and the Consumer Price Index (CPI), to test for various mechanisms.

Our results indicate large and significant impact of the cash-back subsidy program on LPG purchase by households. First, in contrast to the theoretical expectation of non-responsiveness to variation in market prices, given the design of the cash-back subsidy program, low-income (i.e. PMUY) households decrease their cooking gas purchase by 1.4% when over-the-counter LPG refill price increases by 1%. But no such effect is observed for middle- to high-income households (i.e. non-PMUY households). In levels, an INR 1 per kg of LPG increase in over-the-counter LPG refill price (and cash-back subsidy) results in 0.01 fewer LPG refills per month consumed by low-income households. Second, households respond to higher over-the-counter price for LPG by switching to polluting solid fuels. Specifically,

we find that monthly expenditures on solid fuels increases by more than 5% in low-income households in response to a 1% rise in the over-the-counter LPG refill price. The observed impact is stronger among rural PMUY households who are likely to be poorer and use substitute solid fuels, which are often readily available in rural areas. Replacing PMUY with other proxies for low-income, such as assets, daily wage employment, and socio-economic status (e.g. caste), yields similar results.

Next, we assess the health implications of cash-back subsidy design for households. Using birth and child level outcomes from the Demographic and Health Surveys for India, we estimate the health burden of increases in LPG prices paid upfront between June 2018 and December 2020, overlapping closely with our administrative and survey data periods. Results indicate a significant adverse impact of LPG price increases, and households' sensitivity to it, on child health, measured by neonatal mortality, incidence of child cough, and rapid breathing. Specifically, we estimate that an INR 2.5 per kg increase in over-the-counter price may reduce LPG usage by low-income households by about 10%, which in turn, leads to an increase in neonatal mortality of about 12.5 infants per 1000 births. These effects are more pronounced in rural areas, where the income levels are low and accessibility to alternative fuel is high.

We delve into potential mechanisms that can explain the responsiveness of poor households to variations in the market price of LPG refills despite the cash-back subsidy program. Specifically, we explore whether liquidity constraints are driving the results. First, the observed effects vary significantly with household wealth – richer rural households do not reduce their LPG usage in response to the increase in the over-the-counter price (and cash-back subsidy), while poor households do. We also find qualitatively consistent evidence on socio-economically deprived (lower caste) households and casual laborers, who are more likely to be paid on a daily basis, reducing clean fuel purchase in response to the LPG price increase. Finally, and most importantly, we find that the observed impact of higher LPG refill price (and larger cash-back subsidy amount) decreases when households are likely to

have more cash in hand.

We explore and rule out alternative mechanisms. First, we do not find significant correlation between the overall Consumer Price Index and the over-the-counter domestic price of LPG refills. This rules out general consumer-price inflation as an explanation of our results. Second, it is possible that poor and liquidity constrained households also have lower physical access to banking services. But we do not find any significant effects of multiple measures of the relative remoteness of the household (e.g. distance to nearest ATM or bank) on purchase of gas refills. Third, 'subsidy salience', i.e. understanding of the cash-back nature of the subsidy scheme and awareness of the deposit of the subsidy amount in one's bank account (in line with existing research on tax salience), may be lacking for rural households. However, we do not find any heterogeneity in our results by our survey measures of household awareness and understanding of the subsidy scheme. Furthermore, we test for the possibility that low levels of trust in the government may be driving our results, using both survey responses to trust in government functionaries and restricting the sample to long-term LPG user households. Our estimated effects are robust to controlling for these concerns, reinforcing our claim 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.

Our paper makes three main contributions. First, we contribute to the literature on clean fuel adoption by households in low-income contexts. Recent research shows that households' financial constraints play a critical role in adoption of clean energy. Using LPG sales records, Afridi et al. (2021) underscore the salience of financial constraints in switching to clean fuels inspite of the LPG subsidy program in rural India.[3] Close to our setting, Berkouwer and Dean (2022) find that households' willingness to pay for energy-efficient cooking stoves increases when credit constraints are loosened. Our study provides evidence that liquidity constraints

[3] Afridi et al. (2021) do not find any effect of a health awareness campaign on the purchase of LPG refills. Instead, households adopt measures to reduce indoor smoke inhalation - creating outlets for smoke or a separate kitchen - due to binding budget constraints.

limit households' ability to sustain the transition to clean energy through regular usage of such fuels, even when they have already acquired more efficient cooking technology.

Second, we provide empirical evidence on the implications of even short delays in cash transfers. There are two relevant strands of the literature here: (1) a significant number of subsidy programs, including in developed countries, provide an ex-post rebate for fuel and other essential goods and services. The timing of the transfer becomes an important factor for liquidity-constrained households and may ultimately lead to heterogeneity in the take-up of welfare. Except for a few studies, there exists little research on understanding how timing matters in welfare delivery through income or cash transfers, even in the context of developed countries (Morduch and Schneider, 2021), and less so for energy subsidies;[4] (2) our results, when seen together with recent research on administrative reforms in welfare delivery in developing countries (Barnwal, 2021; Muralidharan et al., 2020; Kishore and Chakrabarti, 2015), highlight the efficiency versus equity trade-off in overhauling public programs to make welfare delivery more efficient, as outlined by Kleven and Kopczuk (2011).

Third, adding to the growing evidence on inequality in exposure to air pollution (WHO), our findings underscore the importance of the administrative design of public programs aiming to encourage transition to cleaner fuel. Despite variations in the administrative designs of public programs, research on their distributional implications in low-income settings is scarce. We specifically show that the clean energy subsidies may work sub-optimally when the administrative design fails to address specific constraints faced by low-income households, which in turn, can have important environmental justice implications (Zhao et al., 2019).[5] There are real consequences if the administrative designs of programs aiming to

[4]Existing evidence from the cash-transfer literature on the role of transfer timing on other outcomes is mixed – Bazzi et al. (2015) find that timing matters for household consumption in a targeted (unconditional) cash transfer program in Indonesia; Duflo et al. (2011) show that time-limited discounts on fertilizer purchases after harvests (when farmers have cash in hand) induce sizeable changes in fertilizer usage in Kenya. Hence synchronizing the timing of conditional transfers with the beneficiary's expenses may be critical. On the other hand, Brune et al. (2017) do not find any impact of experimentally varying the delay in (unconditional) transfer receipt in Malawi on household consumption.

[5]A large share of existing research on environmental justice has primarily considered industrial and commercial pollution, and government policies that regulate such pollution, e.g., allocative inefficiency arising from environmental markets (see Banzhaf et al. (2019) for a review).

reduce pollution exposure fail to address constraints faced by low-income households, as our estimated impact on health outcomes suggests.[6].

On the policy front, the quasi-experimental evidence presented here complements Merfeld and Morduch (2022), who show that accounting for within-year variability in income can "improve targeting of transfers to and reduce poverty most effectively by compensating for imperfect consumption smoothing". The timing of government subsidies is not a concern in low income settings alone but may also matter for households in high-income countries when purchasing expensive products, such as electric vehicles (E.V.s).[7]

The remainder of this paper is structured as follows. In Section 2, we describe the institutional background and context of our study. Section 3 discusses the administrative and survey datasets that we use in our empirical analyses. The estimation strategy is explained in Section 4, while Section 5 discusses the results. The implications of our findings on household welfare, in terms of health outcomes, are in Section 6. We elaborate on the proposed mechanism for explaining our findings in Section 7 and conclude in Section 8.

2 Institutional background

The first step a household has to take in order to use LPG is obtain a "connection" – i.e. register with one of the three state-owned oil marketing companies (OMCs) that are the only suppliers of LPG in India. This is an upfront cost of about INR 3200 (45 USD), about two weeks' worth of household income in rural areas.[8] To expand access to LPG, the

[6]Our study adds to the growing research on health implications of indoor pollution arising from inefficient cooking fuels (Imelda, 2020; Berkouwer and Dean, 2022).

[7]For example, the US offers credit for purchasing E.V.s to accelerate transport electrification. In 2023, the credit was provided ex-post as a tax rebate that would not be realized until the user filed their annual tax return. A delayed credit may not have the same effect on buyers' purchase decisions compared to an immediate discount. Recently the US government changed its income tax credit policy for the purchase of electric vehicles to instant credit at time of purchase (see NPR and Financial Times).

[8]"Connection" is the official term that refers to registration for obtaining a gas pressure regulator, a consumer booklet with unique ID along with the first LPG cylinder refill. To register for a connection, a consumer has to provide proof of identity, residential address and submit a security deposit of 25 USD with her local LPG supplier (henceforth, dealer). The consumer has to pay the market price separately for the gas in the cylinder (10 USD) and a stove (10 USD). Note that the average rural (urban) household income

Government of India launched the *Pradhan Mantri Ujjwala Yojana* (PMUY) in April 2016. The PMUY is the largest program on access to clean fuel in the world, reaching 72 million poor families between April 2016 and June 2019. The program mandates that women, in a socio-economically disadvantaged households, can obtain an LPG connection (henceforth, account) at no upfront cost. The security deposit, along with the administrative charges for an LPG account are borne by the government (USD 25). The beneficiary also receives an interest-free loan (USD 20) to purchase the stove and the gas cylinder.[9]

An LPG account entitled the consumer to a universal subsidy on refills of the LPG cylinder between 2014 and until mid 2020. All residential LPG consumers in India, irrespective of PMUY status, received a subsidy or so-called 'direct benefit transfer' (DBT), for up to 12 LPG cylinder refills a year.[10] To elaborate on how the DBT functioned during this period – the consumer paid the full market price (over-the-counter) to her local LPG dealer (or supplier) at the time of delivery of the refill cylinder she booked. Once the dealer recorded the refill purchase against the consumer's ID in a centralized database, the subsidy amount was directly deposited into the consumer's bank account within 7 days, on average (see Figure A1 in Appendix A). The subsidy program was designed to maintain a stable post-subsidy effective price (net out-of-pocket price) per cylinder of around INR 500 (in current prices) for up to 12 cylinder refills per year per consumer. Since the market price of LPG cylinders moves in tandem with the international market price of LPG, the subsidy delivered via DBT varied monthly with the LPG market price. For instance, if the market price of an LPG cylinder was INR 820, the subsidy amount of INR 320 was directly deposited into the consumer's linked bank account within 7 days of purchase.

was approximately INR 7215 (INR 10000) (1 USD = INR 72) per month in 2011, the latest year for which reliable estimates are available (Desai et al., 2011).

[9]The loan from the OMC to the PMUY consumer was to be recovered from her LPG refill subsidy entitlement, but this recovery was not effectuated during the period of our study.

[10]Throughout, we refer to a cylinder with 14.2 kgs of LPG, the standard size of a cylinder in the Indian market. All registered consumers are assigned a unique consumer ID and a booklet that records, among other details, the date of LPG account creation, LPG dealer, and purchase of every LPG refill. Consumers can purchase refills from the OMC approved dealers. All OMCs offer LPG accounts and cylinder refills at the same, unregulated, market price.

Nationwide, an estimated 79% of the households had LPG accounts in 2018 but with a significant rural-urban gap of almost 40 percentage points (PPAC Report, 2018).[11] The PMUY program has been successful in significantly improving rural households' access to LPG for cooking, but is yet to ensure an increase in LPG usage.[12] In rural India LPG use continues to be much lower than in urban areas with the former having a mean annual consumption of about four LPG cylinders and the latter about eight.[13]

3 Data

Our data come from the second-largest Indian state by area and the fifth largest by population with over 75 million residents, Madhya Pradesh (MP). Over 60% of households (rural and urban) had LPG access in January 2018 (PPAC Report, 2018) in MP. We focus on the district of Indore in MP, with the highest per capita income amongst all districts of MP.

We use two main sources of data - (1) Administrative, consumer-level data from the LPG sales records of all three OMCs for all household-level LPG consumers in Indore and (2) Household-level survey data from approximately 3000 randomly sampled rural households in Indore.[14]

3.1 Administrative sales data

The administrative sales data of the three Oil Marketing Companies (OMCs) covers the LPG refill transactions of all consumers in Indore district of MP during the period 1 November, 2017 - 31 December, 2019.[15] Besides unique consumer IDs, the data contain information on the date of LPG account registration, PMUY status, LPG dealer, residential address of each

[11] Data from the last Census (2011) reveals that 28.5% of households in India had access to LPG with 65% coverage in urban areas and only 11% coverage in rural areas.

[12] Media report.

[13] Media report

[14] We use the term consumer and household interchangeably because each household typically has only one LPG account with their local LPG dealer.

[15] The three OMCs are - IOCL, BPCL and HPCL.

consumer, and date (day, month and year) of every LPG refill transaction of each consumer. Using a machine learning algorithm, we generated the gender variable of the consumer (from PMUY status and the consumer's name) and their rural-urban location (using Google API and address pin-code).

All LPG dealers in the data base were mapped to their corresponding 'LPG market' in the district and thereby the corresponding monthly LPG price (also obtained from OMC administrative data).[16] Thus we have information on the monthly market-level LPG refill price data for all consumers for the entire study period. Apart from monthly market-level price data for refill cylinders, we also have the LPG subsidy per refill in each month during the study period. Hence, we were able to create a database of all customers' purchase of LPG refills, refill market price and subsidy in each month-year for 676 market-months (26 markets x 26 month-years). We drop outliers - consumers who purchased abnormally high number of LPG refills (i.e. 0.024% of the administrative sample who consumed more than 40 refills) in a year.

Note that the administrative data are unbalanced - LPG refill consumption is missing for all months prior to the month the consumer registered for an LPG account in our sample period. In our analysis we balance the sample by recoding the missing values to 0. For instance, if the consumer's account was registered in January 2018, her LPG refill purchase is entered as 0 in November and December 2017. Appendix B reproduces all the main results with an unbalanced panel, where LPG refill consumption is coded as missing for all months before the consumer obtained an LPG account.

3.2 Household-level data

We utilize data from a cluster randomized control trial (RCT) implemented in the rural areas of Indore district in MP by Afridi et al. (2021) between October 2018 - December 2019.

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

150 villages were randomly sampled from four census blocks in Indore district, while, Indore, which is primarily urban, was excluded from the study. In the sampled villages, a household was deemed eligible for the study if it had a currently residing member either less than 10 years or more than 55 years of age or both. Twenty eligible households were randomly sampled in each of these villages by systematic random sampling during a baseline survey in Nov - Dec 2018. Following the completion of a cluster-randomized information campaign on the health benefits of LPG and information on the universal LPG subsidy 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.[17]

Households in the sample were asked whether they currently had 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 in the previous month, PMUY status, health awareness were gathered for all households irrespective of whether they had an LPG account or not. Households with LPG accounts were linked to the OMC's sales data (described above) using the unique consumer ID. The same household level data were gathered at baseline and endline. Our analysis is restricted to the sub-sample of surveyed households who either already had an LPG account or obtained an LPG account between 1 November, 2017 and 31 December, 2019.[18]

3.3 Other datasets

We use individual and household level data from multiple rounds of the nationally representative Periodic Labor Force Survey (PLFS rounds 2017-18, 2018-19 and 2019-20) that overlap

[17] Only 54 of the baseline households could not be re-interviewed at endline, hence attrition is negligible (1.8%).

[18] The earliest LPG account date is July, 1986 while the latest is September, 2019 in our household survey data.

with our study period of November 2017 - December 2019. Data from the rural sample is used to estimate total monthly household income (earned, unearned, self-employment income and other sources of income) and total monthly household expenditure. The difference between the two is our estimate of a household's "cash-on-hand" in a month.

In addition, we use the National Family Survey of India's (Round 5, 2019 - 21) retrospective data on pregnancies, birth history, and child health to estimate the impact of exogenous variation in the over-the-counter-price of LPG on birth (up to 12 months prior to interview – June 2018 to December 2020) and child health outcomes (during month of interview).

3.4 Summary statistics

The domestic, over-the-counter market price of an LPG cylinder is determined by the government, based on the international market price for LPG. Specifically, the domestic price of LPG is expected to be reset by the government every month in tandem with the price in the international markets. This can be seen in Figure 1 - one-month lag of international LPG price (in INR) is strongly correlated with the domestic (over-the-counter) price of LPG with a correlation coefficient of 0.99 (p-value=0.0004) (Barnwal, 2021). Since household consumption of LPG in India is unlikely to affect the international market price for LPG (i.e., India is a price-taker for petroleum and related products in the world market), we argue that the LPG market price paid by the consumer upfront (and the resulting LPG subsidy) varies due to exogenous factors.

The administrative sales data are summarized in Table 1, which show LPG refill consumption from administrative sales records for 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. 7.4% of the consumers are PMUY account holders, while 32% are women and 57.2% rural, as shown in Panel A. Panel B provides statistics on LPG refill transactions, overall and by rural-urban residence. The average number of LPG refills per month is less than one at 0.578 refills, and lower for PMUY consumers (0.252 refills). This PMUY -

non-PMUY consumption gap holds in both rural and urban areas.

The average LPG over-the-counter price and subsidy amount per kg of gas for each of the 26 months in our data are illustrated in Figure 2. Note that while the over-the-counter domestic price of LPG refills varies each month, the LPG refill subsidy tracks the over-the-counter price. Hence the effective or net out-of-pocket price (i.e., over-the counter price minus subsidy) is more or less constant during our study period at approximately INR 25 per unit.[19]

Table 2 summarizes the characteristics of the rural households with an LPG account in Indore in our survey data. Of the 3003 households in the sample, almost 70% had an LPG account during the study period (i.e. 2091 households), of which 39.1% were PMUY consumers. Self-employment or casual labor are the dominant occupations of the household heads, as shown in Panel A. Panel B shows that the explicit, average monthly expenditure on solid fuels (e.g. firewood and dung cakes) purchased by the households is INR 56.8 and INR 151.2 for firewood and dung cakes, respectively. However, monetizing the reported time spent by the household in solid fuel collection/making in the survey data by multiplying the time spent in fuel collection/making with the minimum unskilled wage in rural MP, we find that the implicit monthly household expenditure on solid fuels is more than INR 500 - higher than the average effective price of one LPG refill (see Appendix Table A1).[20] The average LPG refills purchased per month by households with LPG accounts 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), as mentioned in Panel C. PMUY households' annual refill consumption was almost half of the non-PMUY households' consumption.

In Appendix Table A2 we compare the characteristics of the PMUY and non-PMUY consumers using the household survey data. PMUY households have a lower asset index, are

[19] Appendix Table A1 summarizes these prices for a standard 14.2 KG refill cylinder for the 676 market-months in our data.

[20] Households spent almost 4 hours in a typical week in the previous month collecting or making solid fuels, as per our survey data.

less likely to belong to the general caste group (relative to socio-economically disadvantaged Scheduled Caste (SC), Scheduled Tribe (ST) or Other Backward Castes (OBC)), less likely to own or lease land, have lower education and more likely to have precarious, casual labor as their main occupation. These data, therefore, underline the fact that PMUY households are significantly more impoverished and more likely to be liquidity constrained than non-PMUY or the average rural household.[21]

Appendix Figure A2 shows the average per month cash-on-hand (COH) of rural households in India, calculated by taking the difference in monthly total household income (from all sources) and the total household expenditure in the PLFS (2017-18, 2018-19 and 2019-20 survey rounds). The figure indicates that households have less cash-in-hand during the off-agricultural season (summer months of May - June, and August - September, prior to the winter cropping season), suggesting cyclicality of liquidity. Since we did not collect information on households' income or expenditure in our survey, we attribute the cash-on-hand data obtained from the three rounds of the PLFS to our survey households at the occupation-caste-month level for each of the 26 months, for 4 main occupation categories (salaried, self-employed on the farm, self-employed on non-farm and casual labor) and 4 caste groups (SC, ST, OBC and General or higher-caste categories) by merging the PLFS with our household survey collapsed to the occupation-caste-month level. In Appendix Table A3, we summarize the cash-on-hand data that we obtain for these 416 occupation-caste-month groups, which we use later to analyze the effects of variation in over-the-counter price on LPG refill take-up in our sample of households in rural Indore.[22]

[21] We use the first component of a principal component analysis over several indicators measuring the economic status of a household to generate the asset index. These indicators include ownership of land and farm animals, *pucca* house, and a list of consumer durables.

[22] The PLFS data are not representative at the district level. Hence we compute cash-on-hand at the all India levels. COH data for each occupation-caste-month category for all of rural India in the PLFS is a more reliable estimate due to the larger sample sizes by occupation and caste in a month, relative to only rural MP sample.

4 Estimation strategy

Equation 1 shows our main specification to estimate the impact of changes in the over-the-counter price of LPG on our main outcomes pertaining to LPG and solid fuel usage. We estimate the same specification with the cash-back subsidy in place of over-the-counter price, though given the almost perfect correlation between the two, one would expect similar results. For causal interpretation of our estimates, the key assumption is that the over-the-counter price and the cash-back subsidy vary exogenously, and the local supply and demand factors should not influence prices or subsidy. As discussed earlier, that is indeed the case since over-the-counter price of LPG follows the international market price for LPG. Further, our setting uniquely allows for separating the effect of liquidity constraints from any price effect of LPG, since the effective price of LPG refill remains the same over time, while over-the-counter price (and the cash-back subsidy) changes.

$$Y_{imy} = \alpha + \beta Price_{my} + \gamma Price_{my} \times PMUY_i + \mu_i + \delta_m + \tau_y + \epsilon_{imy} \tag{1}$$

Y_{imy} denotes two main outcomes of interest – (1) the number of 14.2kg LPG refills purchased and (2) the expenditure on solid fuels by the household i in the month m in the year y. $Price_{my}$ denotes our main variable of interest - the over-the-counter price for LPG refills (or the cash-back subsidy amount), that varies by month m and year y across LPG markets. In our analysis, we log transform the per unit (real) price (1 kg of gas in INR) to allow for an elasticity interpretation of the estimated coefficients for outcomes related to fuel purchase.

We are primarily interested in estimating the differential effect of changes in over-the-counter price (or cash-back subsidy) for low-income households. The binary variable $PMUY_i$ takes value 1 if the consumer or household has the gas connection under PMUY, thus indicating whether a household belongs to low socio-economic category, and 0 otherwise. On average, a household purchases less than one LPG refill in a month or a single refill every few

months. The estimated regression coefficients of interests (β and γ) can be interpreted as the change in the average number of refills purchased by households due to a one percent increase in the over-the-counter price of LPG. Specifically, the coefficient of interest β denotes the effect of a one percent change in the over-the-counter price (or cash-back subsidy) of LPG refill 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 LPG price (or cash-back subsidy) on the fuel purchase by a PMUY household.

Household's monthly solid fuel expenditure is a continuous variable that includes zeroes denoting no solid fuel purchase or collection/making. We use the Inverse Hyperbolic Sine (IHS) transformation of the household's monthly expenditure on solid fuels to account for non-purchase or collection/making of solid fuels.[23] The estimated regression coefficients (β and γ) can be interpreted as a percentage change in the expenditure on solid fuel due to a one percentage increase in the over-the-counter price of LPG.

Our preferred specification (Equation 1) includes household (μ_i), month (δ_m), and year (τ_y) fixed effects. This approach allows us to account for household-specific time invariable factors, seasonality within a year, and year-specific trends in the analysis. Since the price varies at the month-year level, we can only control for the month and year separately. The specification does not explicitly include PMUY indicator since it is subsumed by household fixed effects. The error term is captured by ϵ_{imy} and is clustered at the market-month-year level.

[23]The transformation is given by $log(y) = log(y + (y^2 + 1)^{1/2})$ (Burbidge et al., 1988). We refrain from log expenditure in order to meaningfully interpret the zeros in the expenditure on solid fuels. The advantage of IHS transformation is that it is defined at zero and provides an elasticity interpretation.

5 Results

5.1 Impact of LPG refill price and subsidy on refill purchase

We first analyze how changes in the over-the-counter price (or cash-back subsidy) affect LPG refill purchases, while the effective price net of the cash-back subsidy remains unchanged. Table 3 shows our main results. PMUY (i.e., low-income) households are highly sensitive to changes in over-the-counter prices when compared to non-PMUY households, despite the fact that the net out-of-pocket price remains constant (Column 1, Panel A). In our preferred specification that controls for household-specific factors, the estimated coefficients on the interaction term suggest that a 1% increase in the over-the-counter price leads PMUY households to purchase 0.00347 fewer LPG refills (Column 2, Panel A) per month. Relative to the mean of 0.25 refills per month purchased by PMUY households, this translates into a 1.39% decrease in LPG purchases with a 1% increase in over-the-counter prices. We see the same consistent pattern – i.e., only PMUY households are sensitive to over-the-counter prices – across rural and urban low-income households in our administrative data when we split the sample by consumer's residential location in Panels B (rural) and C (urban) in Table 3. These effects are more pronounced in rural areas (Column 2 in Panels B and C), likely because PMUY households in rural areas are poorer than PMUY households in urban areas. Further, Columns 3 and 4 show consistent results when we estimate the impact of changes in cash-back subsidy instead of the over-the-counter price. A 1% increase in cash-back subsidy amount leads to 0.0011 fewer LPG refills purchased by PMUY households, decreasing LPG purchases by about 0.44% of the mean value for PMUY households in a month.

As one would expect, since a one INR change in over-the-counter price is mechanically the same as a one INR increase in the cash-back subsidy, their marginal effect should also be the same. Note that our results are consistent when we use price in levels in place of log prices. Specifically, our estimates suggest a 0.009 LPG refills reduction in the purchase of

PMUY households with a one INR per kg increase in over-the-counter price (or cash-back subsidy) (Columns 2 and 4 of Panel A, Appendix Table A4). We prefer to use prices in logs (as shown in Table 3) for easier elasticity interpretation.

In contrast, over-the-counter price and cash-back subsidy do not seem to affect LPG purchase decisions of richer (non-PMUY) households much. The non interacted coefficient is negative but statistically as well as economically insignificant, except in Column 1 (Panel A) of Table 3, which does not control for household-specific factors. Importantly, even in this case (Column 1 of Panel A), the negative coefficient on the non-interacted over-the-counter price is driven by the rural non-PMUY households (Column 1 of Panel B, Table 3) who are likely to have much lower income than urban, non-PMUY households (Column 1 of Panel C, Table 3)

Next, Table 4 shows consistent results using matched rural household survey and administrative data. A key difference, when compared to Panel B (rural sample) in the previous table, is that the effect of over-the-counter price is larger and statistically significant even after controlling for household-specific factors (Column 2). One plausible explanation is that non-PMUY households in the survey sample are relatively poorer than the non-PMUY rural households in the administrative data. The gap in the average monthly LPG refill purchase between the two samples, as shown in Tables 1 and 2, lend some credence to this possibility.

In summary, the estimated elasticity of LPG demand to over-the-counter price and the cash-back subsidy is large. Furthermore, considering it to be the short-term response to over-the-counter price changes, it is probably even more striking. Before going into the potential mechanisms, there are a couple of important points to note here. First, a one INR increase in the effective (out-of-pocket price net of subsidy) and a one INR increase in the upfront over-the-counter price (before subsidy) may have the same effect on demand when households face hard constraints in paying a higher upfront price. Second, overall household income levels are important. Our study area is located in a state that has low

rural household income.[24] Third, the biomass alternatives to LPG are readily accessible in rural and semi-urban areas, hence the cost that households face in temporarily switching away from LPG may not be high.

These results, thus, show that low-income households in rural areas are more likely to reduce their LPG refill purchases when the LPG cash-back subsidy, which moves in tandem with the LPG refill price that households have to pay over-the-counter at the time of purchase, increases. Hence, the purchase and usage of LPG for cooking is likely to fall in these households with an increase in over-the-counter LPG refill price, in spite of the cash-back subsidy program designed to keep the effective price (out-of-pocket price net of subsidy) per unit LPG refill expenditure more or less constant for consumers.

One plausible explanation is that the liquidity constraints of low-income households impede LPG take-up. To validate this interpretation, which we establish later, we test whether the intensive margin of the delay in subsidy disbursal matters. If households do not have sufficient cash-on-hand to pay the over-the-counter price, it is likely inconsequential whether they receive the subsidy soon after the purchase or a few days later. As shown in Appendix Table A5, the observed effect does not vary with the number of days the government took to transfer the subsidy to households' bank accounts. This suggests that having *any* delay between the time of purchase and the subsidy disbursal may be the key factor, not the length of the delay.

5.2 Impact of LPG refill price on solid fuel expenditure

Solid fuels, particularly firewood and dung, are regularly used for cooking in rural India. The motivation behind the LPG subsidy policy and the PMUY program is precisely to discourage solid fuel usage because of its negative health and pollution externalities (Barua and Agarwalla, 2018; Kar et al., 2019) and to encourage energy transition to a clean fuel. In our survey data, although 70% of households have an LPG account, 75% report using

[24] In contrast, using data from one of the richest states in India, Jeuland et al. (2023) estimate the price elasticity of LPG demand to be about 0.33 among PMUY households.

either firewood or dung for cooking in the previous month. Since solid fuels and LPG are substitutes, an increase in the LPG subsidy amount is likely to affect solid fuel usage.[25]

We use two measures of household expenditure on solid fuels - explicit and implicit. Rural households often collect (e.g. firewood) or make (e.g. cow dung cakes) solid fuels themselves, in addition to buying it on the market. Explicit firewood and dung expenditure by the household per month is reported in the survey, while the opportunity cost of time spent on solid fuel collection per month is the "implicit" expenditure. We monetize the time spent on fuel collection/making by multiplying the total number of hours the household spent collecting/making the solid fuel in a typical week (in the previous month) with the minimum hourly wage in MP for unskilled labor (i.e., INR 35 per hour x hours spent on fuel collection/making per week x 4) to get a monthly estimate of the implicit expense on solid fuels.

Table 5 shows the effect of an increase in over-the-counter price on explicit (Column 1), implicit (Column 2) and total (explicit + implicit expenditure, Column 3) monthly solid fuel expenditure by the household.[26] The coefficient on the interaction term in Column 3 indicates that total solid fuel expenditure in PMUY households – including explicit expenditure in the market and implicit expenditure from the time spent on fuel collection – increases by over 5% ($= exp^{(1.799)} - 1 = 5.04$) for each percent rise in the over-the-counter LPG price.[27]

[25]Indeed, when asked whether the household had used either firewood or dung-cakes in the last month, 75% and 88% of all households in the sample, respectively, responded 'yes', even though 74% of the sample had also used LPG for cooking in the previous month. We also asked the household primary cook to list all the fuels used in preparing the last meal. More than half of the households reported using solid fuels exclusively, even though almost two-thirds had LPG connections. Only 29% of households report using LPG exclusively in preparing the last meal.

[26]For conciseness, we do not show the coefficients on the LPG cash-back subsidy from Table 5 onwards. Our results, however, are consistent with the impacts of the over-the-counter price and are available on request.

[27]During the rainy season, it is not only difficult to collect dry firewood and dung, but also more inconvenient to burn them as cooking fuel when the wood/dung is wet. During this season, the price of solid fuels, is also likely to be higher due to limited supply. Hence households are likely to switch to LPG or other non-solid fuels during the wet season. This substitution towards LPG is likely to be easier for economically better-off or wealthier households. Using data on temperature and rainfall for the Indore district from the Indian Meteorological Department during 2010-17, we classify the months of July, August, and September as the wet season (Afridi et al., 2021). We interact Equation 1 with a binary variable that equals 1 for the wet months and 0 otherwise. Appendix Table A6 shows that LPG refill purchase increases for all households in the administrative data – both PMUY and non-PMUY – in the rainy season as shown by the positive

5.3 Robustness

Our results are robust to a host of checks. First, to address any concerns regarding the potential endogeneity of domestic LPG price, we run 2SLS estimation using 1 month lags of the international LPG price as an instrument for over-the-counter price (and cash-back subsidy). Our results are unchanged for both the administrative data (Appendix Table A7) and the household survey data (Appendix Table A8) analyses. Second, we alternatively cluster-bootstrap the standard errors at the LPG market level (26 markets), instead of market-month in our standard analysis, and show that our findings do not change in Appendix Table A9 (administrative data) and Appendix Table A10 (household survey data).

Finally, our results are robust to an alternative model of Poisson pseduo-maximum likelihood estimation (Appendix Table A11). We also recode refills as missing for those consumers who obtained an LPG account later in our study period, (coded as 0 in our standard analysis) and rerun all of our analysis with an unbalanced panel in Appendix B. The results are unchanged.

To summarize, our results so far indicate that poor households are extremely sensitive to increases in the market price of LPG despite the public subsidy program which covers up to 50% of the market price of an LPG refill cylinder during the study period. We hypothesize that the take-up of this clean cooking fuel is adversely affected due to liquidity constraints faced by low-income households. Later we attempt to provide direct evidence on liquidity constraint as the main mechanism and rule out other possible explanations of our results.

coefficients on the interaction terms 'Rainy Month x Over-the-counter price' in Columns 1 (full sample) and 2 (rural sample), as expected. However, while rains effectively make non-PMUY households' LPG purchase indifferent to changes in the over-the-counter price (for instance, the sum of coefficients on 'Over-the-counter price' and 'Rainy Month x Over-the-counter price' is statistically zero), the net impact on PMUY households remains negative. Furthermore, we do not find a significant difference in the effect of the rainy season between the full and rural samples.

6 Impact on health

In this section, we focus on the health rationale for the LPG subsidy program for which relevant data are available from the Demographic and Health Survey or the National Family Health Survey (2019-21) of India, summarized in Appendix Table A12 for the entire country.[28] While the objective of the LPG subsidy program is to protect consumers from increases in the over-the-counter price of LPG refills by keeping the net out-of-pocket expense constant, our analysis shows that the program fails in attaining this goal. Instead, poor consumers are less likely to take-up LPG when there is an increase in LPG refill price and switch to biomass-based solid fuels. Burning of solid fuels, in turn, increases indoor air pollution which leads to adverse health effects, specifically for young children and pregnant women.[29] What is the health burden on households due to their sensitivity to LPG refill price fluctuations inspite of the subsidy program?

We use Equation 2 to estimate the effects of higher, over-the-counter price of LPG refills on infant and child health, as follows:

$$Y_{ids}^{my} = \alpha + \beta Price_{i}^{my} + \mu Child_{ids} + \gamma_d + \delta_m + \tau_y + \phi_s * \theta_{my} + \epsilon_{ids}^{my} \tag{2}$$

Using administrative data on LPG refill prices and quasi-random variation in the households' date of interview in the NFHS survey, we estimate the effects of higher over-the-counter price of LPG refills on infant and child health. Y_{ids}^{my} denotes two main outcomes of interest for infant i born in district d, state s, conceived in month m in year y – (1) weight (in kilo-

[28]There are several economic rationale for providing LPG refill subsidies – namely, to reduce indoor pollution (Gould et al., 2023) and the resulting health burden; to save time spent on using, collecting or making solid fuels (Afridi et al., 2023).

[29]Quoting Afridi et al. (2021): WHO estimates that 3.8 million premature deaths were attributable to household air pollution in 2016, mostly in low and middle-income countries. Furthermore, according to the American Heart Association, "exposure to PM2.5 over a few hours to weeks can trigger cardiovascular disease-related mortality and nonfatal events; longer-term exposure (e.g., a few years) increases the risk of cardiovascular mortality to an even greater extent than exposures over a few days and reduces life expectancy within more highly exposed segments of the population by several months to a few years." Our baseline survey revealed that 87% of the sampled households were unaware of the serious long-term risks to their own or other household members' health.

grams) at the time of birth and (2) an indicator variable that equals 1 for neonatal mortality, for pregnancies conceived within a year prior to the NFHS interview date (reference period of June 2018 to December 2020). $Price_i^{my}$ for infant health outcomes is the average over-the-counter LPG refill price (in levels) during the mother's gestation period (including less than full-term pregnancies) of birth i. Y_{ids}^{my} for child (under 5 years of age) health denotes the other two main outcomes of interest – an indicator variable that equals 1 if there is an incidence of (1) cough and (2) rapid breathing in child i in district d, state s, interviewed in month m in year y (last two weeks prior to the interview date). $Price_i^{my}$ for child health outcomes denotes the over-the-counter LPG price (in levels) in the month-year of the survey interview. We include infant or child ($Child_{ids}$) specific characteristics, (e.g. gender, birth order of child in family, if child is part of a multiple birth and age of child (for child health outcomes)), including mother and household controls, district-level unobservables (γ_{ds}), secular (δ_m, τ_y) and state-specific trends. The error term is captured by ϵ_i^{my} and is clustered at the month-year of conception for infant outcomes and month-year of interview for child outcomes.[30]

Columns 1 and 2 (Panel A) in Table 6 show the effect of the average over-the-counter refill price during the gestation period on birth weight and neonatal mortality, respectively, for births conceived within a year prior to the NFHS survey interview. A one INR higher over-the-counter price (per kg) of LPG refill (about 2.7% of average over-the-counter price) during gestation leads to 15 grams lower infant birth weight, though the estimated coefficient is not significant at the 10% level. Neonatal mortality rises with higher LPG price (Column 2) – a one INR increase in the per kg price of LPG leads to a 0.5% increase in neonatal mortality.

We next turn to the more immediate effects of LPG price increase (in contrast to the

[30]We do not have refill price data for all districts of India. Instead we attribute the refill prices available for the district of Indore (rural and urban) for 2018 - 19 to assess the health impacts at all-India level. There are negligible differences in LPG price levels across districts, and marginal changes in prices occur more or less in tandem across India (Appendix Figure A3). Restricting the NFHS sample to only MP, on the other hand, gives a very small sample of pregnancies, births and children under 5 years of age.

treatment defined over the gestational period) in Columns 3 and 4 (Panel A) of Table 6. A one INR increase in per unit LPG price leads to a 0.2% increase in incidence of coughing and a 0.3% increase in incidence of rapid breathing (Columns 3 and 4, respectively) by a child. Table 6 further shows that these results are primarily driven by rural households (Panel B). Consistent with our main results on the impact of over-the-counter price change on LPG purchase in urban households, we see relatively weaker and statistically insignificant effects (Panel C). We report p-values of the estimates after correcting for multiple hypothesis testing for all the outcomes and samples.[31]

Our results are unchanged when we run household weighted regression analysis, as shown in Appendix Table A14. They are also robust to cluster-bootstrapping the standard errors, as shown in Appendix Table A15, given the small number of month-year clusters for 'cough' and 'rapid breathing' outcomes.[32] Furthermore, we run a falsification exercise to rule out spurious findings by analyzing the effect of LPG refill prices on child height-for-age and weight-for-age Z-scores, outcomes that are less likely to be significantly impacted by exposure to smoke inhalation. We find no detectable effects, as reported in Appendix Table A16.

Overall, our estimated health effects are large and meaningful, and likely a lower bound on the impacts on low-income households.[33] A one INR per kg increase in over-the-counter price of LPG leads to about 4% decrease in LPG purchase by low income households. An INR 2.5 increase in per kg price will correspond to about 10% decrease in LPG usage. Our estimates suggest that this would lead to an increase of about 12.5 infant lives lost per 1000 births. These results complement the findings by Imelda (2020) who shows that switching from dirty kerosene to clean LPG for cooking in Indonesia due to a nation-wide fuel switching program in 2007, reduced infant mortality and incidence of low birth weight.[34]

[31] We do not condition the NFHS sample on whether the household uses LPG or not. Note that our findings are invariant to LPG refill prices in logs or levels. We show additional results on the impact of an increase in the over-the-counter LPG refill price on the probability of adverse gestational outcomes (e.g. pregnancy termination, abortion, miscarriage and still birth) in Appendix Table A13.

[32] We have only 18 clusters for month-year of interview in the NFHS sample.

[33] The NFHS does not provide information on the PMUY status of households or on household income/expenditure. Analysis by households' asset quartiles results in small samples in each quartile.

[34] Imelda (2020) estimates that 10 percentage points increase in switching from kerosene to LPG led a

7 Mechanism - Liquidity constraints

We explore two avenues to understand whether the sensitivity of poor households to fluctuations in LPG refill prices inspite of the subsidy program are attributable to liquidity constraints, which are likely more salient for poor households. First, we test for heterogeneity of our results by household characteristics. Table 7 shows that household wealth, measured on multiple dimensions, primarily explains the observed pattern. We show the impact on refill purchases of changes in over the counter price interacted with the household's asset index (Column 1), dummy for belonging to General or upper caste category (0 if SC/ST or OBC)(Column 2) and dummy for household head being a casual laborer (Coulmn 3). Specifically, the magnitude of the impact of an increase in the over-the-counter price on LPG refill purchase decreases with household assets (Column 1). Since poorer rural households are more likely to be liquidity-constrained, Appendix Table A17 breaks down the analysis by above median and higher asset quartiles. We find consistent results, i.e. the observed effect is significantly higher for households with below median assests and in the lower asset quartiles.

Furthermore, LPG purchase by higher castes (i.e., general caste) households, who are economically better-off on average, exhibit a marginal increase in refill purchase when the over-the-counter price rises (p-value$<$0.10) compared to lower caste households (i.e. SC, ST or OBC), as shown by the interaction term in Column 2 in Table 7. Households that are engaged in more precarious sources of livelihood, daily wage earners from casual labor, are likely to experience greater liquidity constraints. The estimated coefficients in Column 3 support this qualitatively, with a negative interaction coefficient. As Appendix Table A2 shows, while the one-time start-up subsidy under the PMUY program to obtain an LPG account effectively targeted poor and low-caste households, our results here (Table 7) indicate that the variations in the over-the-counter price can reduce the take up of LPG in these

reduction in infant mortality of 1.2 infants per 1000 births in Indonesia. However, she also notes that her estimate is likely a lower bound and "moving away from biomass (i.e., the dirtiest fuel) is expected to lead to even greater health benefits".

same group of households. The impact of changes in the over-the-counter price on liquidity-constrained households is a consequence of the trade-off these households face between the cost and inconvenience of using solid fuel and the costlier but more convenient, clean cooking gas.

Second, we construct a direct measure of household liquidity - cash-on-hand in a month - to test whether households with higher cash on hand are less affected by an increase in the over-the-counter refill price. Using the information on monthly income and expenditure in the PLFS for rural India (as discussed in Section 3 (Data) previously), our constructed measure of household liquidity provides a proxy for cash-on-hand at caste-occupation-month level.[35] Table 8 shows the effect of our measure of log cash-on-hand per month, and its interaction with log over-the-counter price, on monthly refill purchase by caste and occupation of rural households in our sample between November 2017 to June 2019.[36] As hypothesized, more cash on hand significantly increases LPG refill purchases (Column 1). The coefficients on over-the-counter price remain negative across all specifications (Columns 2 and 3). Importantly, the positive coefficient on the interaction of over-the-counter price with cash-on-hand (Column 3) indicates that more cash-on-hand attenuates the negative effect of over-the-counter price increase on LPG purchase.

7.1 Alternative explanations

In this section, we assess and rule out mechanisms other than liquidity constraints that could explain our results above.

7.1.1 General inflation

Increases in the over-the-counter price or the subsidy may be symptomatic of a general increase in prices, which leads households to reduce consumption, which causes them to

[35] Ideally data on a direct measure of household liquidity - cash-on-hand in a month - would allow us to pin down the mechanism in a direct way. Unfortunately, these data are not available in our survey.

[36] In order to allow meaningful interpretation of coefficients on cash-on-hand and over-the-counter price, both variables are mean-centered.

cook less and/or substitute with biomass-based solid fuels. Inflation is likely regressive and will affect poorer households more. In Appendix Table A18 we correlate domestic LPG refill price with each component of the Consumer Price Index (CPI) for each of the 26 months in our study period. Other than a marginally significant coefficient ($p<0.10$) on the 'Fuel and Light' Price Index, all other components (including overall CPI) are uncorrelated with the changes in the over-the-counter price of LPG refill. This is not surprising - since our data capture high frequency, small variations in LPG refill price (standard deviation of INR 62.45 per refill during our study period), it is unlikely to be symptomatic of inflationary trends. We thus rule out income effects, due to general inflation, as an explanation of our results.

7.1.2 Access to financial services

Rural households are more likely to have lower access to physical banking services, which may be the explanation for the observed effects that we attribute to liquidity constraints. Note, however, that the interaction term between PMUY and the over-the-counter LPG refill price is statistically significant in both urban and rural areas. Further, we use Census 2011 data to estimate the relative remoteness of our sampled households in Appendix Table A19. In this analysis, we test for heterogeneity over multiple indicators of access to financial services (e.g., distance to the nearest town, sub-district HQ, nearest ATM, and nearest bank). The triple interaction terms are not statistically significant, suggesting that limited access to financial services is unlikely to explain our findings.

7.1.3 Subsidy salience

An alternative explanation of the observed effects of over-the-counter refill price 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. Afridi et al. (2021) find a 13% increase in the monthly demand for LPG refills when information on the refill subsidy is bundled with improving awareness of the adverse health effects of using

solid fuels. 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 with higher over-the-counter prices when the effective prices net of the subsidy 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. Appendix Table A20 shows estimates on heterogeneity over households' knowledge about the subsidy program. These regressions are carried out using the household's response to a list of five statements on the LPG refill subsidy program in the second round of household survey (October - December 2019). The household was asked to agree of disagree with each statement about the subsidy program, some of which were true and others false in random order.[37] The response to each statement is coded 1 if the household correctly agrees or disagrees with the statement and 0 if incorrect. Thus each variable is an indicator of the household having knowledge or understanding of the LPG subsidy program. We do not find any significant coefficient on the households' understanding about the subsidy program, as shown by the triple interaction terms across all columns in Appendix Table A20. This suggests that subsidy salience is not driving our results.

7.1.4 Trust in government

Another possible explanation of our findings is that households do not trust the government would actually transfer the cash-back subsidy into their bank accounts after they purchase the LPG refill. Consequently, they respond to the market price rather than the effective LPG refill price. The DBT scheme was, however, implemented across the country much before our study period in 2014, while the PMUY program began in 2016. The fact that the government

[37]Conditional on having an LPG account, almost 33% of sampled households disagreed with the statement that the government deposits a subsidy in their bank account after they purchase an LPG cylinder, and only 51% agreed that their net out-of-pocket expenditure was less than the over-the-counter market price of an LPG refill. Over 32% of respondents believed that the refill subsidy is not universal and only PMUY customers are eligible to receive the subsidy. The specific statements are listed in the notes to Appendix Table A20.

was indeed depositing the subsidy into consumers' bank accounts was well-acknowledged.

Nevertheless, we address this issue for our sample in two ways. First, we directly asked our survey households (at baseline) whether they trusted information provided by the government-appointed accredited social health activist (ASHAs) of their village, i.e. community health workers who are responsible for encouraging households to immunize newborns and ensure ante and post-natal care for mothers, among other health information and assistance. We test whether the response to over-the-counter price varies by the household's reported trust in ASHA as a proxy for trust in government. We do not find a significant coefficient on the triple interaction term (PMUY x Trust ASHA x Price) in Appendix Table A21. Second, we restrict the sample in the administrative data to households who had obtained LPG accounts at the beginning or before our study period (November 2017). These households are more likely to be aware of the cash-back subsidy design since they have had a longer exposure to the DBT scheme. If our results are due to lack of trust in government then our main coefficients of interest should be smaller or insignificant for this sample. The coefficients of interest, however, are not different in in either size of significance from those shown in our main table (Appendix Table A22). Lack of trust in the government is, therefore, an unlikely mechanism.

8 Conclusion

This paper underscores the importance of the administrative design of energy subsidy programs. Policy discussions often focus primarily on the rate or amount of energy subsidies. The results presented in this paper highlight that the *method* of delivery of energy subsidies is no less policy-relevant than *how much* subsidy is delivered.

India's large clean fuel subsidy program – where the cash-back subsidy amount varies exogenously while the net out-of-pocket price remains constant – provides a perfect setting. Our results show that clean fuel usage decreases and dirty, solid fuel usage increases, due to

the liquidity constraints amplified by delayed transfer of the subsidy amount. The associated health and environmental externalities, especially for the women and children who spend more time indoors and near the solid-fuel cooking stoves, are likely to be significant, although our analysis is limited (by lack of data) to only two sets of health outcomes – for newborns and children. Overall, our analysis of India's cooking gas subsidy program, highlights the interaction of the cash-back subsidy design with households' liquidity constraints, which is counter to the policy intent behind subsidizing clean fuel take-up of low-income households.

More broadly, our results show that the administrative design of cash transfer programs, especially the *timing* of transfers, matters. While cash transfers are replacing in-kind transfer programs across the world, it is important to understand the welfare implications of their design.[38] While the bank transfer of cash benefits may come with other gains such as lower administrative costs, better targeting, and a reduction in leakages (Muralidharan et al., 2016; Barnwal, 2021), it may also impose an unintended regressive cost on low-income households who are more likely to face liquidity constraints. Specifically, 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. Cash-transfer programs should, thus, be designed with careful attention to constraints faced by low-income households in smoothing income fluctuations, and not just the average level of income.

[38] India, alone, runs 311 public programs where the government provides cash benefits to citizens through direct bank transfers. See https://dbtbharat.gov.in/ for more details.

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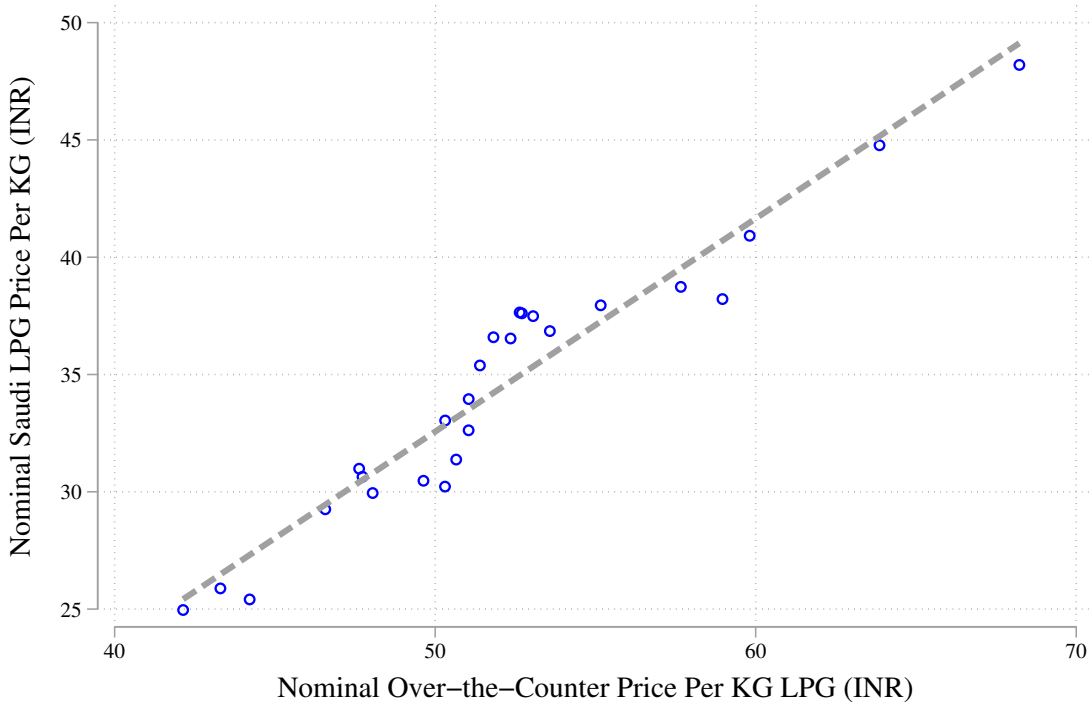
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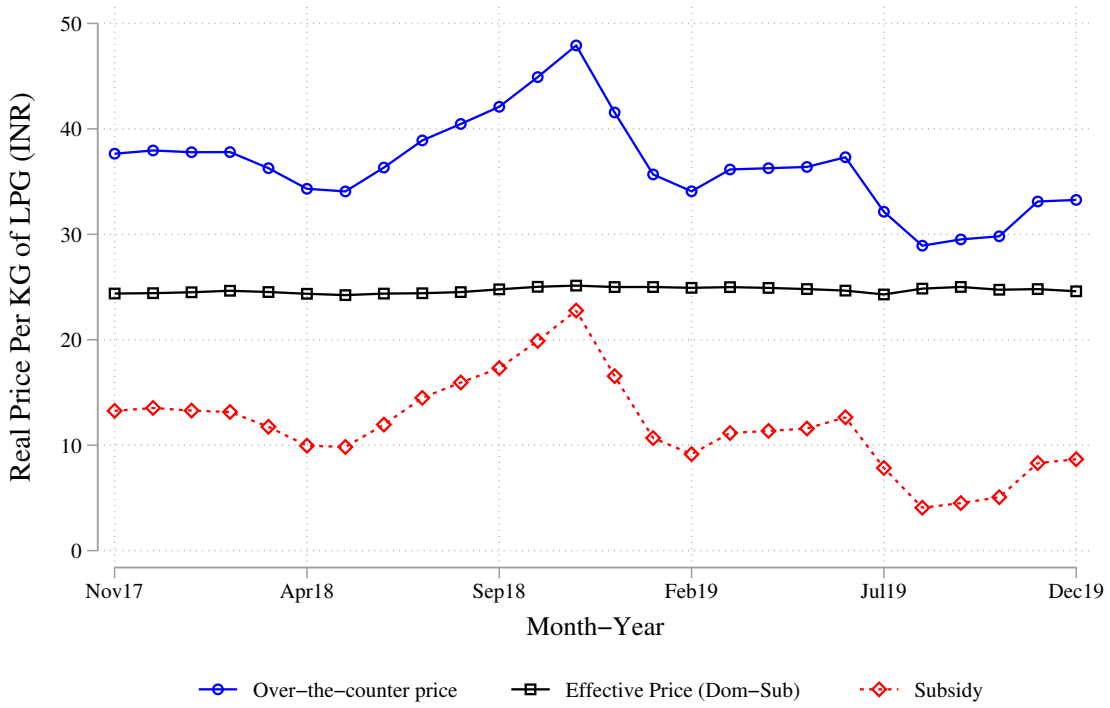
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Figure 1: Correlation between International LPG Price and Over-the-counter Domestic LPG Price (November 2017 - December 2019)



Notes: Saudi Aramco LPG price (defined as price of butane (60%) and price of propane (40%)) obtained from here. The domestic price of LPG obtained from the OMC administrative dataset. Each observation on the Y-axis is the monthly price of Saudi Armco (lagged by 1 period). The X-axis shows the domestic price of LPG spanning 26 months from November 2017 to December 2019. All prices are in nominal INR per KG of LPG. The dashed line shows the coefficient of correlation between the lagged international price and domestic market price, which is 0.99 (p-val = 0.0004).

Figure 2: Over-the-counter Price, Effective Price and Subsidy on LPG
(November 2017 - December 2019)



Notes: LPG prices obtained from the OMC administrative dataset. Over-the-counter price of LPG is the price paid by consumers upfront to purchase LPG. Effective price is over-the-counter price minus the cash-back subsidy to LPG to consumers. The cash-back subsidy floated in tandem with the over-the-counter price. The Y-axis shows all three prices in real (2012) INR for 1 kg of LPG. The X-axis shows the corresponding month, from November 2017 to December 2019 (26 months). All prices are averaged across the 3 OMCs.

Table 1: LPG Consumer Characteristics (Administrative Data)

	Obs	Mean	SD	Minimum	Maximum
		Panel A: Attributes			
PMUY	911,454	0.074	0.262	0.000	1.000
Female	911,099	0.320	0.466	0.000	1.000
Rural	908,650	0.572	0.495	0.000	1.000
		Panel B: LPG Refills			
All	23,697,794	0.578	0.638	0.000	16.000
PMUY	1,754,298	0.252	0.495	0.000	12.000
Non-PMUY	21,943,496	0.604	0.640	0.000	16.000
Rural	13,522,165	0.576	0.643	0.000	16.000
PMUY	1,242,540	0.259	0.503	0.000	12.000
Non-PMUY	12,279,625	0.608	0.646	0.000	16.000
Urban	10,102,717	0.580	0.631	0.000	13.000
PMUY	510,276	0.235	0.475	0.000	11.000
Non-PMUY	9,592,441	0.598	0.633	0.000	13.000

Notes: This table summarizes the OMCs administrative data from Nov 2017 to Dec 2019. **Panel A** summarizes the demographics of all consumers in the district of Indore. PMUY is a dummy which equals 1 if the consumer has a PMUY LPG connection, and 0 otherwise. Female is a dummy which equals 1 if the LPG account is in the name of a woman and 0 otherwise. Rural is a dummy which equals 1 if the consumer resides in a rural area. Some observations could not be classified as female or rural, hence the total observations vary. **Panel B** summarizes LPG refill transactions from Nov 2017 to Dec 2019 overall, by rural/urban, and PMUY status of the LPG consumers.

Table 2: Household Characteristics (Survey Data)

	Obs	Mean	SD	Minimum	Maximum
	Panel A: Household Attributes (Baseline)				
PMUY	2,091	0.391	0.488	0.000	1.000
Asset Index	2,091	1.620	0.748	-0.150	3.965
General Caste	2,091	0.150	0.357	0.000	1.000
Salaried HH Head	2,091	0.106	0.308	0.000	1.000
Agri Self-Employed HH Head	2,091	0.305	0.461	0.000	1.000
Agri Casual Laborer HH Head	2,091	0.391	0.488	0.000	1.000
Land Owner	2,091	0.522	0.500	0.000	1.000
Land Owner/Leaser	2,091	0.535	0.499	0.000	1.000
HH Head Education	2,091	0.411	0.492	0.000	1.000
Latrine in HH	2,091	0.879	0.326	0.000	1.000
	Panel B: Household Solid Fuel				
Baseline					
Explicit firewood expenditure (Rs.)	2,091	71.174	339.208	0.000	6,000.000
Implicit firewood expenditure (Rs.)	2,091	665.798	873.713	0.000	4,480.000
Explicit dung expenditure (Rs.)	2,091	160.841	525.133	0.000	6,000.000
Implicit dung expenditure (Rs.)	2,091	591.769	701.799	0.000	9,800.000
Baseline & Endline					
Explicit firewood expenditure (Rs.)	4,150	56.791	282.530	0.000	6,000.000
Implicit firewood expenditure (Rs.)	4,150	543.258	833.181	0.000	4,480.000
Explicit dung expenditure (Rs.)	4,150	151.177	470.125	0.000	6,000.000
Implicit dung expenditure (Rs.)	4,150	503.106	626.538	0.000	9,800.000
	Panel C: Household Refills Matched to Admin Data				
All Refills	54,366	0.411	0.576	0.000	7.000
PMUY refills	21,268	0.285	0.505	0.000	7.000
Non-PMUY refills	33,098	0.492	0.604	0.000	6.000

Notes: **Panel A** provides information on household characteristics collected in 2018 (at baseline). Asset Index is the first component of a principal component analysis over several indicators measuring the economic status of a household including, ownership of land and farm animals, *pucca* house, and a list of consumer durables. Education of the head of the household is measured by an indicator that takes value one for above primary education and zero otherwise. General Caste is a dummy for household that is neither SC/ST nor OBC category. Salaried, Self-Employed, Casual Laborer, Land Owner, Land Owner/ Leaser are dummies equal to 1 if the household head belongs to the respective category. Latrine in HH is a dummy if the household has a pit or flush toilet built inside house. **Panel B** summarizes the explicit and implicit expenditure on firewood and dung.Implicit expenditure is calculated as total number of hours household spent collecting/making the solid fuel in a week times the minimum hourly wage in Madhya Pradesh for unskilled labor (i.e. INR 35) and then times 4 to get monthly estimate of implicit expense on solid fuels. Explicit firewood and dung expenditure per month is reported in the survey. **Panel C** summarizes the LPG refill transactions for the sampled households over 26 months by matching them to the administrative records.

Table 3: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data)

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.067**	-0.043		
	(0.031)	(0.034)		
PMUY × Over-the-counter price	-0.098***	-0.347***		
	(0.002)	(0.053)		
Cash-back subsidy			-0.005	-0.007
			(0.008)	(0.009)
PMUY × Cash-back subsidy			-0.145***	-0.110***
			(0.004)	(0.013)
Mean of Dependent Var.	0.578	0.578	0.578	0.578
Mean of Dependent Var. for PMUY	0.252	0.252	0.252	0.252
Mean of Dependent Var. for Non-PMUY	0.604	0.604	0.604	0.604
Observations	23,697,794	23,697,794	23,697,794	23,697,794
Panel B: Rural Sample				
Over-the-counter price	-0.080**	-0.046		
	(0.034)	(0.035)		
PMUY × Over-the-counter price	-0.097***	-0.372***		
	(0.002)	(0.046)		
Cash-back subsidy			-0.006	-0.008
			(0.009)	(0.009)
PMUY × Cash-back subsidy			-0.144***	-0.115***
			(0.003)	(0.012)
Observations	13,522,165	13,522,165	13,522,165	13,522,165
Panel C: Urban Sample				
Over-the-counter price	-0.050	-0.041		
	(0.032)	(0.034)		
PMUY × Over-the-counter price	-0.101***	-0.275***		
	(0.004)	(0.074)		
Cash-back subsidy			-0.004	-0.006
			(0.008)	(0.008)
PMUY × Cash-back subsidy			-0.149***	-0.093***
			(0.005)	(0.018)
Observations	10,102,717	10,102,717	10,102,717	10,102,717
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy using the OMC administrative data. **Panel A** shows the estimates for the full OMC administrative sample, **Panel B** shows the estimates for rural sub-sample, and **Panel C** shows the estimates for the urban sub-sample. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year, leading to a total of 23.69 million observations, corresponding to monthly refills for 26 months of the 911,454 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy that equals 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 Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Survey Data)

	(1)	(2)	(3)	(4)
Over-the-counter price	-0.104*	-0.082**		
	(0.060)	(0.041)		
PMUY × Over-the-counter price	-0.249***	-0.254***		
	(0.067)	(0.051)		
Cash-back subsidy			-0.028	-0.015
			(0.018)	(0.012)
PMUY × Cash-back subsidy			-0.078***	-0.078***
			(0.020)	(0.016)
Mean of Dependent Var.	0.411	0.411	0.411	0.411
Mean of Dependent Var. for PMUY	0.285	0.285	0.285	0.285
Mean of Dependent Var. for Non-PMUY	0.492	0.492	0.492	0.492
Observations	54,366	54,366	54,366	54,366
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy using the household survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy which equals 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 Over-the-counter Price on Solid Fuel Expenditure (Survey Data)

	(1) Explicit Expenditure	(2) Implicit Expenditure	(3) Total Expenditure
Over-the-counter price	-5.718	5.206	6.030
	(5.018)	(6.125)	(5.955)
PMUY × Over-the-counter price	0.836**	2.271***	1.799***
	(0.398)	(0.307)	(0.311)
Mean of Dependent Var.	1.952	5.249	6.160
Observations	4,118	4,118	4,118
Month FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table shows the impact on monthly expenditure on solid fuels of changes in log of over-the-counter price using the survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. Dependent variable in columns 1 is the inverse hyperbolic sine transformation (IHS) of explicit expenditure on solid fuel which is the amount household reports to have spent out-of-pocket on firewood and dung (combined) in the previous month. Dependent variable in columns 2 is the IHS of implicit expenditure on solid fuel which 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. Columns 3 show the impact on the IHS of sum of implicit and explicit expenditure on solid fuel. All specifications include month, year and household fixed effects. Unit of observation is consumer-month-year. In the survey each household is asked information on solid fuel collection for only one month, hence this dataset is a panel of 2 month observations (baseline survey in 2018 and endline survey in 2019) for each LPG using household. 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 Over-the-counter Price on Birth and Post-birth Child Health Outcomes

	(1) Birth Weight	(2) Neonatal Mortality	(3) Cough	(4) Rapid Breathing
Panel A: Full Sample				
Over-the-counter price	-0.0155	0.0050*	0.0023*	0.0028**
	(0.0103)	(0.0028)	(0.0012)	(0.0010)
Mean of Dependent Var.	2.7840	0.0302	0.1290	0.0646
Observations	16,801	18,451	223,764	223,862
FDR-adjusted p-value	[0.116]	[0.085]	[0.085]	[0.068]
Panel B: Rural Sample				
Over-the-counter price	-0.0163	0.0057*	0.0022	0.0035**
	(0.0100)	(0.0028)	(0.0014)	(0.0015)
Mean of Dependent Var.	2.7800	0.0325	0.1300	0.0662
Observations	13,566	15,038	177,951	178,035
FDR-adjusted p-value	[0.12]	[0.12]	[0.12]	[0.12]
Panel C: Urban Sample				
Over-the-counter price	-0.0175	0.0006	0.0020	0.0022**
	(0.0174)	(0.0069)	(0.0019)	(0.0010)
Mean of Dependent Var.	2.8000	0.0202	0.1240	0.0588
Observations	3,235	3,413	45,813	45,827
FDR-adjusted p-value	[0.482]	[0.766]	[0.482]	[0.211]
Mother and Child Controls	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
State x Month-Year trend	Yes	Yes	Yes	Yes

Notes: This table shows the impact of changes in per unit over-the-counter LPG price on child health outcomes from June 2018 to Dec 2020. Over-the-counter prices from the administrative dataset for BPCL Indore (June 2018 - Dec 2020); health outcomes from the National Family Health Survey (NFHS) Round 5, 2019-21 (previous 12 months is the reference period for interviews conducted during June 2019 to May 2021) for both rural and urban sample. 'Birth Weight' is weight at birth measured in kilograms. 'Neonatal mortality' equals 1 if the child died within the first month of birth. LPG price for birth weight and neonatal mortality is the average price during the gestation period, with the sample restricted to births whose conception was within a year prior to the NFHS survey (pregnancies conceived from June 2018 to Dec 2020). Gestational length includes both month of conception and month of birth/outcome. 'Cough' is a dummy that equals 1 if the child (under 5 years of age) has been ill with cough in last two weeks and 'Rapid breathing' equals 1 if the child (under 5 years of age) suffered from rapid breathing in last two weeks. LPG price for cough and rapid breathing is as of the month of the interview. Time controls correspond to conception month-year of child in columns 1 - 2 and interview month-year of household in columns 3 - 4. Child controls include gender, whether the child is part of a multiple birth and birth order of the child. In columns 3 and 4, age of child (and age squared) are additional controls. Mother controls include mother's age at birth (including age squared), mother's education level, if household is located in rural/urban area, religion, caste and wealth index. State x Month-Year trend is 'i.state x c.month-year' of conception/interview. p-values of coefficients reported for Multiple Hypothesis Testing using the Anderson's sharpened q-values to control for the false discovery rate. Standard errors clustered at month-year of conception in columns 1 -2 and at month-year of interview in columns 3 - 4. Significant at * 10%, ** 5% and ***1% level.

Table 7: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Household Attributes (Survey Data)

	(1)	(2)	(3)
		Z	
	Asset Index	General Caste	Casual Laborer
Over-the-counter price	-0.300***	-0.197***	-0.152***
	(0.057)	(0.036)	(0.038)
Over-the-counter price × Z	0.073***	0.103*	-0.076*
	(0.026)	(0.058)	(0.039)
Mean of Dependent Var.	0.411	0.411	0.411
Observations	54,366	54,366	54,366
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price interacted with household attributes at baseline using the survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Each estimate comes from a separate regression. Column 1 shows the impact on refills of changes in the log of over-the-counter price interacted with the asset index. Column 2 shows the impact on refills of changes in log of over-the-counter price interacted with a dummy indicating whether household belongs to general (upper) caste. Column 3 shows the impact on refills of changes in log of over-the-counter price interacted with a dummy indicating whether household head is a casual laborer. Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. All specifications include month, year and household 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.

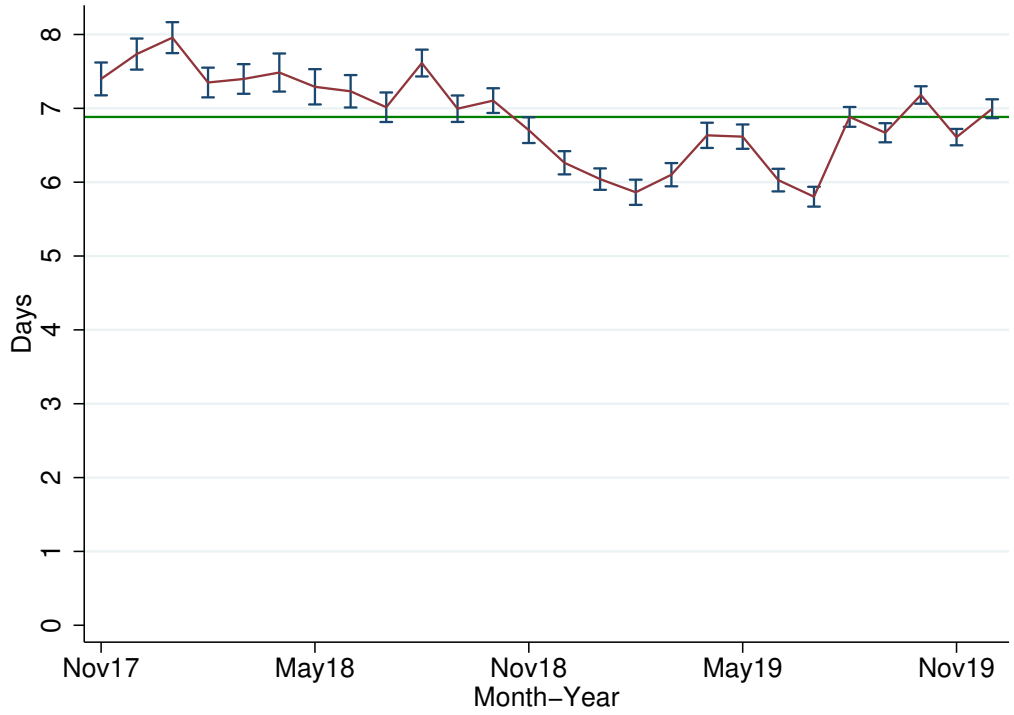
Table 8: Impact of Over-the-counter Price and Cash on Hand (COH) on Monthly Refills (Survey Data)

	(1)	(2)	(3)
COH	0.092***	0.092***	0.092***
	(0.021)	(0.021)	(0.021)
Over-the-counter price		-0.125***	-0.127***
		(0.015)	(0.019)
Over-the-counter price × COH			0.069**
			(0.032)
Mean of Dependent Var.	0.424	0.424	0.424
Observations	416	416	416
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in cash on hand (COH) and log of over-the-counter price using the survey data. COH is constructed from 3 rounds of the Periodic Labor Force Survey (PLFS), 2017-18, 2018-19 and 2019-20. We attribute the COH data to households in the survey data by collapsing the COH and survey data to occupation-caste-month-year level. With 26 months, 4 occupations and 4 caste groups, we have 416 observations. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is caste-occupation-month-year. Standard errors, clustered at the month-year level, are reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

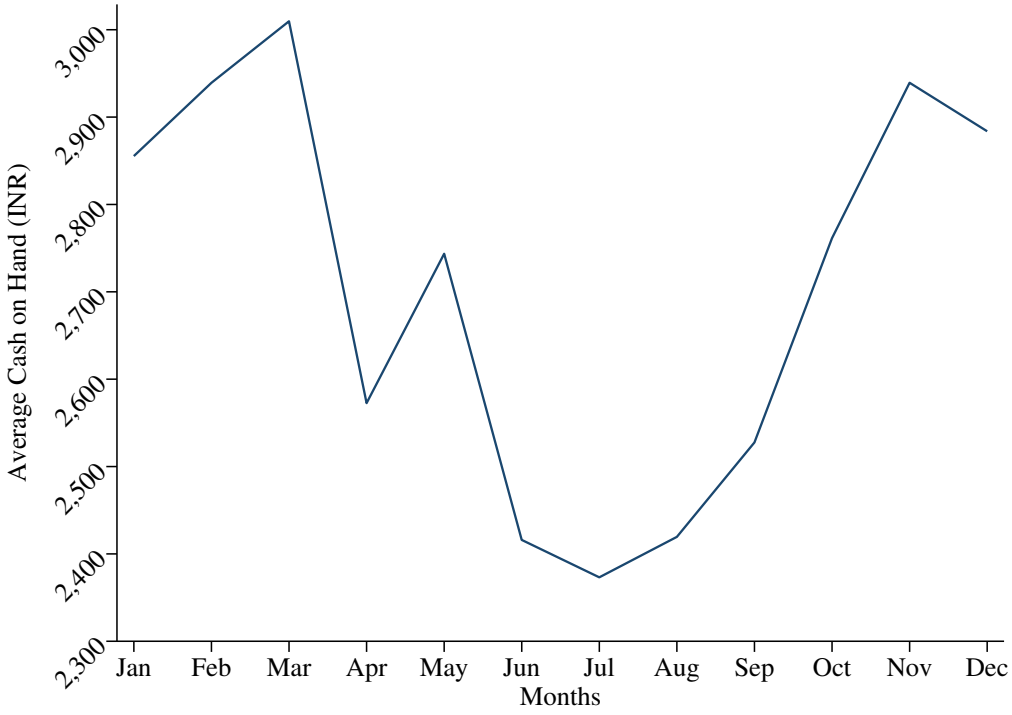
A Appendix: Additional Results

Figure A1: Delay in LPG Subsidy Transfer



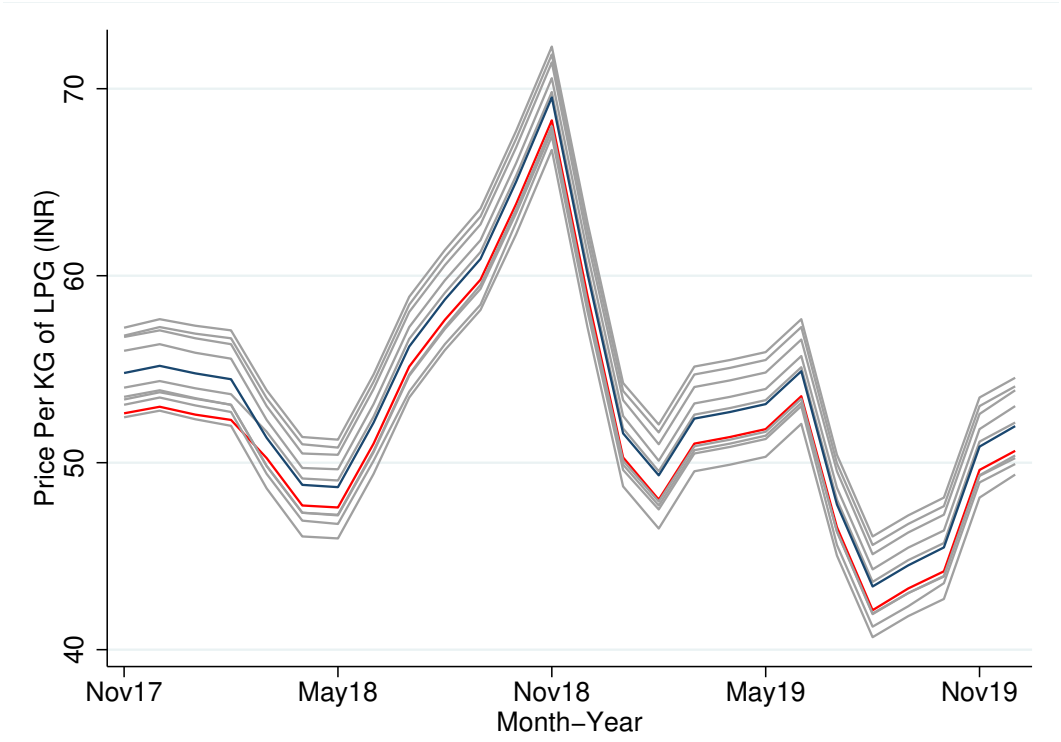
Notes: This figure shows the number of days it takes for the subsidy to be transferred after delivery of cylinder only for the OMC BPCL's refill transactions. 'Days' is defined as the number as the difference between the date of transfer of LPG subsidy to the consumer's bank account and the date of delivery of the LPG cylinder to the consumer. Subsidy date is not available for all transactions, which are restricted to 14.2kg cylinder deliveries between Nov 2017 to Dec 2019 in Indore. The average delay in this period is 6.89 days (green line) while the median delay is 5.

Figure A2: Average Cash on Hand (Rural Households)



Notes: This figure shows how Cash on Hand (COH) varies by month from June 2017 to Oct 2020 for rural households in India, using data from the Periodic Labor Force Survey 2017-18, 2018-19 and 2019-20 rounds. The correlation coefficient of COH for 12 (collapsed) calendar months during this period between rural households in India and Madhya Pradesh is 0.6967 (p=0.0118).

Figure A3: Correlation of Over-the-counter LPG Price Across Districts (November 2017 - December 2019)



Notes: The domestic price of LPG is obtained from the administrative dataset of BPCL for 10 districts across 5 states - Telangana, Andhra Pradesh, Karnataka, Punjab, Madhya Pradesh and Uttar Pradesh (2 districts per state). The X-axis denotes the duration of study period (spanning 26 months from November 2017 to December 2019).The red line represents Over-the-counter LPG Price for Indore. The grey lines represent the Over-the-counter LPG Price for each of the remaining 9 districts. The blue line represents the average Over-the-counter LPG Price for 9 districts (excluding Indore). All prices are in nominal INR per KG of LPG. The coefficient of correlation between the over-the counter domestic per kg price for Indore and the average of the 9 districts (excluding Indore), is 0.9981 (p-val = 0.0000).

Table A1: Average Cash-back Subsidy, Over-the-counter Price, and Effective Price

	Obs	Mean	SD	Minimum	Maximum
Cash-back Subsidy	676	169.31	62.11	46.90	343.32
Over-the-counter 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 the cash-back subsidy, over-the-counter price, effective price in the administrative data. Over-the-counter price of LPG is the price paid by consumers upfront to purchase LPG. The government kept the effective price (over-the-counter price minus cash-back subsidy) of LPG to consumers relatively constant by letting the cash-back subsidy float in tandem with the over-the-counter price. All prices are in real 2012 INR and vary at market-month level. There are 26 months in our sample (November 2017-December 2019), and 26 markets.

Table A2: Characteristics of Non-PMUY and PMUY Households (Survey Data)

	Non-PMUY			PMUY			Difference
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Obs	Mean	SD	Obs	Mean	SD	(PMUY - Non-PMUY)
Asset Index	1,273	1.85	0.74	818	1.27	0.61	-0.580***
General Caste Category	1,273	0.18	0.39	818	0.10	0.30	-0.088***
Salaried Head of HH	1,273	0.12	0.33	818	0.08	0.27	-0.046***
Self Employed Head of HH	1,273	0.36	0.48	818	0.22	0.41	-0.142***
Casual Laborer Head of HH	1,273	0.31	0.46	818	0.51	0.50	0.198***
Land Owning HH	1,273	0.57	0.50	818	0.45	0.50	-0.116**
Land Owning or Leasing HH	1,273	0.58	0.49	818	0.46	0.50	-0.116**
Above Primary Level Edu of HH Head	1,273	0.47	0.50	818	0.32	0.47	-0.151***
Has Latrine in House	1,273	0.93	0.26	818	0.81	0.39	-0.117***

Notes: This table compares Non-PMUY and PMUY households along several dimensions using the household survey data. All the variables are as defined in Table 2. Columns 1 - 3 (4 - 6) show the number of observations, mean and standard deviation of the characteristics of Non-PMUY (PMUY) households. Column 7 is the difference between Columns 5 and 2. Standard errors are clustered at the market-month-year level. Significant at * 10%, ** 5% and ***1% level.

Table A3: Cash on Hand (COH)

	Obs	Mean	SD	Minimum	Maximum
Overall (level)	416	3,677.909	2,134.991	1,033.349	9,579.672
Overall (logs)	416	8.057	0.548	6.941	9.167
Overall (logs, mean-centered)	416	0.000	0.548	-1.116	1.111
Occupation Groups (level)					
Self-employed on farm	104	2,354.889	348.274	1,621.442	3,146.331
Self-employed on non-farm	104	3,736.082	560.424	2,579.580	4,762.813
Casual labor	104	1,746.024	368.519	1,033.349	2,706.314
Salaried	104	6,874.640	1,391.700	4,341.544	9,579.672
Caste Groups (level)					
Scheduled Caste (SC)	104	3,010.946	1,460.813	1,069.227	6,046.346
Scheduled Tribe (ST)	104	4,265.653	2,586.253	1,349.773	9,579.672
Other Backward Caste (OBC)	104	3,372.786	1,732.264	1,033.349	7,147.221
General	104	4,062.250	2,345.418	1,260.421	8,905.957

Notes: This table summarizes the monthly cash-on-hand (COH) in levels (INR), logs and mean-centered (log COH - mean (log COH)) constructed from the Periodic Labor Force Survey (PLFS), rounds 2017-18, 2018-19 and 2019-20. We attribute the COH data to households in the survey data by collapsing the COH and survey data to occupation-caste-month level. With 26 month-years, 4 occupations (Salaried, Self-employed on farm, Self-employed on non-farm, Casual labor) and 4 caste groups (SC, ST, OBC, and General) we have 416 observations.

Table A4: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data)

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.002*	-0.001		
	(0.001)	(0.001)		
PMUY × Over-the-counter price	-0.010***	-0.009***		
	(0.000)	(0.001)		
Cash-back subsidy			-0.000	-0.001
			(0.001)	(0.001)
PMUY × Cash-back subsidy			-0.027***	-0.009***
			(0.001)	(0.002)
Mean of Dependent Var.	0.578	0.578	0.578	0.578
Observations	23,697,794	23,697,794	23,697,794	23,697,794
Panel B: Rural Sample				
Over-the-counter price	-0.002*	-0.002		
	(0.001)	(0.001)		
PMUY × Over-the-counter price	-0.010***	-0.010***		
	(0.000)	(0.001)		
Cash-back subsidy			-0.000	-0.002
			(0.001)	(0.001)
PMUY × Cash-back subsidy			-0.027***	-0.010***
			(0.001)	(0.001)
Mean of Dependent Var.	0.576	0.576	0.576	0.576
Observations	13,522,165	13,522,165	13,522,165	13,522,165
Panel C: Urban Sample				
Over-the-counter price	-0.001	-0.001		
	(0.001)	(0.001)		
PMUY × Over-the-counter price	-0.010***	-0.007***		
	(0.000)	(0.002)		
Cash-back subsidy			-0.000	-0.001
			(0.001)	(0.001)
PMUY × Cash-back subsidy			-0.028***	-0.007***
			(0.002)	(0.002)
Mean of Dependent Var.	0.580	0.580	0.580	0.580
Observations	10,102,717	10,102,717	10,102,717	10,102,717
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: Same as in Table 3 in the main paper but with over-the-counter price and cash-back subsidy in levels.

Table A5: Effect of LPG Subsidy Delay on Refill Demand, by PMUY status (Administrative Data)

	(1)	(2)
PMUY × Over-the-counter price × Delay	-0.003	-0.002
	(0.098)	(0.094)
Mean of Dependent Var.	0.578	0.578
Mean of Median Delay Days	4.808	4.808
Observations	23,697,794	23,697,794
Month FE	Yes	Yes
Year FE	Yes	Yes
Household FE	No	Yes

Notes: "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year, leading to a total of 23.69 million observations, corresponding to monthly refills for 26 months of the 911,454 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy that equals 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Delay (in days) is the month-year median number of days it takes for the cash-back subsidy to be transferred to the consumer (date of subsidy transferred minus date of refill delivery). Delay data available only from BPCL and assigned to each consumer (irrespective of their dealer's OMC) who bought refills in the corresponding month-year. Standard errors, clustered at the market-month-year level, reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A6: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Rainy Season (Administrative Data)

	(1)	(2)
	Full Sample	Rural Sample
Over-the-counter price	-0.080**	-0.084**
	(0.038)	(0.039)
PMUY × Over-the-counter price	-0.321***	-0.348***
	(0.050)	(0.043)
Rainy-Month × Over-the-counter price	0.105***	0.108***
	(0.037)	(0.037)
PMUY × Rainy-Month × Over-the-counter price	0.014***	0.012***
	(0.004)	(0.003)
Mean of Dependent Var.	0.578	0.576
Observations	23,697,794	13,522,165
Month FE	Yes	Yes
Year FE	Yes	Yes
Household FE	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price interacted with PMUY status and rainy month dummy using the administrative data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Rainy month is a dummy which equals 1 if the month is July, August, September and 0 otherwise (based on historical rainfall data for Indore). Column 1 includes the full OMC administrative sample, Column 2 is restricted to only the rural consumers. Columns 1 and 2 show the impact of over-the-counter price interacted with PMUY and rainy month. Unit of observation is household-month-year, and number of observations are as in Table 3. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. All specifications include month, year and household fixed effects. PMUY is a dummy which equals 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 A7: IV Estimation: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data)

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.062**	-0.044		
	(0.030)	(0.033)		
PMUY × Over-the-counter price	-0.098***	-0.346***		
	(0.002)	(0.056)		
Cash-back subsidy			-0.010	-0.014
			(0.010)	(0.010)
PMUY × Cash-back subsidy			-0.146***	-0.102***
			(0.004)	(0.015)
Mean of Dependent Var.	0.578	0.578	0.578	0.578
Observations	23,697,794	23,697,794	23,697,794	23,697,794
Panel B: Rural Sample				
Over-the-counter price	-0.070**	-0.046		
	(0.033)	(0.034)		
PMUY × Over-the-counter price	-0.098***	-0.369***		
	(0.002)	(0.048)		
Cash-back subsidy			-0.011	-0.014
			(0.010)	(0.011)
PMUY × Cash-back subsidy			-0.145***	-0.109***
			(0.003)	(0.013)
Mean of Dependent Var.	0.576	0.576	0.576	0.576
Observations	13,522,165	13,522,165	13,522,165	13,522,165
Panel C: Urban Sample				
Over-the-counter price	-0.051*	-0.042		
	(0.031)	(0.033)		
PMUY × Over-the-counter price	-0.101***	-0.280***		
	(0.004)	(0.082)		
Cash-back subsidy			-0.009	-0.013
			(0.010)	(0.010)
PMUY × Cash-back subsidy			-0.151***	-0.082***
			(0.005)	(0.022)
Mean of Dependent Var.	0.580	0.580	0.580	0.580
Observations	10,102,717	10,102,717	10,102,717	10,102,717
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy. **Panel A** shows the estimates for the full OMC administrative sample, **Panel B** shows the estimates for rural sub-sample, and **Panel C** shows the estimates for the urban sub-sample. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. **1 month lag of international LPG price is used as an IV for over-the-counter price and cash-back subsidy**. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year, leading to a total of 23.69 million observations, corresponding to monthly refills for 26 months of the 911,454 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy which equals 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 A8: IV Estimation: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Survey Data)

	(1)	(2)	(3)	(4)
Over-the-counter price	-0.069	-0.069		
	(0.062)	(0.042)		
PMUY × Over-the-counter price	-0.260***	-0.260***		
	(0.069)	(0.053)		
Cash-back subsidy			-0.022	-0.022*
			(0.019)	(0.013)
PMUY × Cash-back subsidy			-0.078***	-0.078***
			(0.020)	(0.016)
Mean of Dependent Var.	0.411	0.411	0.411	0.411
Observations	54,366	54,366	54,366	54,366
Month FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Household FE	Yes	Yes	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy using the survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. **1 month lag of international LPG price is used as an IV for over-the-counter price and cash-back subsidy**. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy which equals 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 A9: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data with Bootstrapped Standard Errors)

	(1)	(2)	(3)	(4)
Over-the-counter price	-0.049*	-0.043**		
	[0.054]	[0.0360]		
PMUY × Over-the-counter price	-0.344***	-0.347***		
	[0.000]	[0.000]		
Cash-back subsidy			-0.008	-0.007*
			[0.146]	[0.070]
PMUY × Cash-back subsidy			-0.112***	-0.110***
			[0.000]	[0.000]
Mean of Dependent Var.	0.578	0.578	0.578	0.578
Observations	23,697,794	23,697,794	23,697,794	23,697,794
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy for the administrative sample."Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year, leading to a total of 23.69 million observations, corresponding to monthly refills for 26 months of the 911,454 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy which equals 1 if the consumer has a PMUY connection, 0 if it's a regular gas connection. Standard errors are bootstrapped at market level, and significance corresponds to bootstrapped p-values reported in square brackets. Significant at * 10%, ** 5% and ***1% level.

Table A10: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Survey Data with Bootstrapped Standard Errors)

	(1)	(2)	(3)	(4)
Over-the-counter price	-0.104	-0.082***		
	[0.124]	[0.001]		
PMUY × Over-the-counter price	-0.249***	-0.254***		
	[0.000]	[0.000]		
Cash-back subsidy			-0.028	-0.015
			[0.182]	[0.125]
PMUY × Cash-back subsidy			-0.078***	-0.078***
			[0.002]	[0.000]
Mean of Dependent Var.	0.411	0.411	0.411	0.411
Observations	54,366	54,366	54,366	54,366
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy for the survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of an LPG cylinder (which is an indivisible object of 14.2 kg). Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. Columns 1 and 3 include month and year fixed effects, Columns 2 and 4 add household (i.e. customer) 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 are bootstrapped at market level, and significance corresponds to bootstrapped p-values reported in square brackets. Significant at * 10%, ** 5% and ***1% level.

Table A11: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data) - Poisson Pseudo-Maximum Likelihood Estimation

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.110**	-0.062		
	(0.056)	(0.057)		
PMUY × Over-the-counter price	-0.245***	-1.462***		
	(0.009)	(0.183)		
Cash-back subsidy			-0.011	-0.008
			(0.015)	(0.014)
PMUY × Cash-back subsidy			-0.372***	-0.426***
			(0.013)	(0.043)
Mean of Dependent Var.	0.578	0.578	0.578	0.578
Observations	23,697,794	23,667,665	23,697,794	23,667,665
Panel B: Rural Sample				
Over-the-counter price	-0.133**	-0.064		
	(0.062)	(0.057)		
PMUY × Over-the-counter price	-0.239***	-1.540***		
	(0.007)	(0.147)		
Cash-back subsidy			-0.014	-0.008
			(0.017)	(0.015)
PMUY × Cash-back subsidy			-0.365***	-0.437***
			(0.010)	(0.036)
Mean of Dependent Var.	0.576	0.576	0.576	0.576
Observations	13,522,165	13,505,577	13,522,165	13,505,577
Panel C: Urban Sample				
Over-the-counter price	-0.080	-0.059		
	(0.057)	(0.058)		
PMUY × Over-the-counter price	-0.261***	-1.231***		
	(0.015)	(0.313)		
Cash-back subsidy			-0.008	-0.008
			(0.014)	(0.014)
PMUY × Cash-back subsidy			-0.395***	-0.391***
			(0.023)	(0.071)
Mean of Dependent Var.	0.580	0.580	0.580	0.580
Observations	10,102,717	10,089,228	10,102,717	10,089,228
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price and log of cash-back subsidy estimated using Poisson Pseudo Maximum Likelihood Estimation. Panel A shows the estimates for the full OMC administrative sample, Panel B shows the estimates for rural sub-sample, and Panel C shows the estimates for the urban sub-sample. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year, leading to a total of 23.69 million observations, corresponding to monthly refills for 26 months of the 911,454 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. PMUY is a dummy which equals 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 A12: Birth and Post-Birth Child Health Outcomes

	Obs	Mean	SD	Minimum	Maximum
Birth Weight	16,801	2.784	0.568	0.500	9.000
Neonatal Mortality	18,451	0.030	0.171	0.000	1.000
Cough	223,764	0.129	0.335	0.000	1.000
Rapid Breathing	223,862	0.065	0.246	0.000	1.000

Notes: This table summarizes the birth and post-birth child health outcomes from June 2018 to Dec 2020. All health outcomes are from the National Family Health Survey (NFHS) Round 5, 2019-21 (previous 12 months is the reference period for interviews conducted during June 2019 to May 2021). NFHS data used in the analysis is for all India (rural and urban) sample. 'Birth Weight' is weight at birth measured in kilograms. 'Neonatal mortality' equals 1 if the child died within the first month of birth. The sample is restricted to births whose conception was within a year prior to the NFHS survey (pregnancies conceived from June 2018 to Dec 2020). 'Cough' is a dummy that equals 1 if the child (under 5 years of age) has been ill with cough in last two weeks and 'Rapid breathing' equals 1 if the child (under 5 years of age) suffered from rapid breathing in last two weeks.

Table A13: Effect of Over-the counter Price on In-vitro Outcomes during Gestation

	(1) TAMS	(2) MS	(3) S	(4) M
Over-the-counter price	0.0297**	0.0235**	0.0008	0.0236**
	(0.0124)	(0.0110)	(0.0006)	(0.0111)
Mean of Dependent Var.	0.1160	0.0833	0.0056	0.0785
Observations	51,067	49,259	45,410	49,007
FDR-adjusted p-value	0.06	0.06	0.065	0.06
Mother Controls	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
State x Month-Year Trend	Yes	Yes	Yes	Yes

Notes: Over-the-counter LPG prices are obtained from the administrative dataset for BPCL Indore (June 2018 - Dec 2020), while the health outcomes are from the National Family Health Survey (NFHS) Round 5, 2019-21 (previous 12 months is the reference period for interviews conducted during June 2019 to May 2021). NFHS data used in the analysis is for all India (rural and urban) sample. Prices are during the gestation period (from administrative data) of a pregnancy recorded in the NFHS. The sample is restricted to the most recent pregnancy of the mother and pregnancies conceived within a year prior to survey (conception between June 2018 and Dec 2020). In Column 1 the outcome variable is a dummy that equals 1 if the pregnancy ended in a Termination, Abortion, Miscarriage or Still birth (TAMS); Column 2 dummy equals 1 for miscarriages and Still Births (MS); Column 3 dummy equals 1 for Still births (S); and Column 4 dummy equals 1 for Miscarriages (M); each dummy = 0 for live birth or if currently pregnant. Mother controls include mother's age at birth (including age squared), mother's education level, if household is located in rural/urban area, religion, caste and wealth index. All time controls correspond to conception month-year of pregnancy. State x Month-Year Trend is 'i.state x c.month-year' of conception. p-values reported for Multiple Hypothesis Testing using the Anderson's sharpened q-values to control for the false discovery rate. Standard errors clustered at month-year of conception and reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A14: Impact of Over-the-counter Price on Birth and Post-birth Child Health Outcomes (with sampling weights)

	(1) Birth Weight	(2) Neonatal Mortality	(3) Cough	(4) Rapid Breathing
Panel A: Full Sample				
Over-the-counter price	-0.0122	0.0075**	0.0014	0.00146**
	(0.0104)	(0.0034)	(0.0011)	(0.0005)
Mean of Dependent Var.	2.7840	0.0302	0.1290	0.0646
Observations	16,801	18,451	223,764	223,862
FDR-adjusted p-value	[0.142]	[0.057]	[0.142]	[0.043]
Panel B: Rural Sample				
Over-the-counter price	-0.0161	0.0074**	0.0011	0.0021**
	(0.0096)	(0.0031)	(0.0011)	(0.0009)
Mean of Dependent Var.	2.7800	0.0325	0.1300	0.0662
Observations	13,566	15,038	177,951	178,035
FDR-adjusted p-value	[0.075]	[0.075]	[0.161]	[0.075]
Panel C: Urban Sample				
Over-the-counter price	-0.0005	0.0055	0.0007	0.0013
	(0.0186)	(0.0092)	(0.0026)	(0.0009)
Mean of Dependent Var.	2.8000	0.0202	0.1240	0.0588
Observations	3,235	3,413	45,813	45,827
FDR-adjusted p-value	[1.000]	[1.000]	[1.000]	[1.000]
Mother and Child Controls	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
State x Month-Year trend	Yes	Yes	Yes	Yes

Notes: as shown in Table 6 in the main paper. Observations in the regressions are weighted using the DHS household sampling weights.

Table A15: Effect of Over-the-counter Price on Post-birth Child Health Outcomes

	(1) Cough	(2) Rapid Breathing
Over-the-counter price	0.0023*	0.0028***
	[0.0941]	[0.0030]
Mean of Dependent Var.	0.1290	0.0646
Observations	223,764	223,862
Mother and Child Controls	Yes	Yes
District FE	Yes	Yes
Month FE	Yes	Yes
Year FE	Yes	Yes
State x Month-Year Trend	Yes	Yes

Note: This table is analogous to Table 6 (columns 3 and 4) in the main paper. Standard errors are bootstrapped at Month-Year of interview, and significance corresponds to bootstrapped p-values reported in square brackets. Significant at * 10%, ** 5% and ***1% level.

Table A16: Effect of Over-the-counter Price on Child Anthropometric Outcomes

	(1)	(2)
	Height for Age Z-score	Weight for Age Z-score
Over-the-counter price	0.0007	-0.0015
	[0.9169]	[0.7027]
Mean of Dependent Var.	-1.312	-1.395
Observations	206,025	210,524
Mother and Child Controls	Yes	Yes
District FE	Yes	Yes
Month FE	Yes	Yes
Year FE	Yes	Yes
State x Month-Year Trend	Yes	Yes

Notes: Over-the-counter LPG prices are obtained from the administrative dataset for BPCL Indore, while the health outcomes are from the National Family Health Survey (NFHS) Round 5, 2019-21 (June 2019 to May 2021). NFHS data used in the analysis is for all India (rural and urban) sample. Ht for Age and Wt for Age Z-scores are calculated using the new Child Growth Standards released by WHO in 2006, to develop a new international standard for assessing the physical growth nutrition status and motor development in all children from birth to age five. All time controls correspond to interview month-year of household. Standard errors are bootstrapped at Month-Year of interview, and significance corresponds to bootstrapped p-values reported in square brackets. Child controls include sex of child, if child is part of a multiple birth and birth order of the child in the household, age of child (and age squared). Mother controls include mother's age at birth (including age squared), mother's education level, if household is located in rural/urban area, religion, caste and wealth index. State x Year-Month Trend is 'i.state x c.month-year' of interview. Significant at * 10%, ** 5% and ***1% level.

Table A17: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Asset Ownership (Survey Data)

	(1)	(2)
Over-the-counter price	-0.220***	-0.274***
	(0.040)	(0.050)
Asset Above median × Over-the-counter price	0.077**	
	(0.037)	
Asset Quartile 2 × Over-the-counter price		0.108**
		(0.054)
Asset Quartile 3 × Over-the-counter price		0.140**
		(0.055)
Asset Quartile 4 × Over-the-counter price		0.122**
		(0.056)
Constant	1.064***	1.064***
	(0.125)	(0.125)
Mean of Dependent Var.	0.411	0.411
Observations	54,366	54,366
Month FE	Yes	Yes
Year FE	Yes	Yes
Household FE	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price interacted with median asset and asset quartiles for the survey data. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Households are divided into 2 and 4 groups based on their baseline asset index. Asset Half 1 and Asset Quartile 1 (lowest) are the omitted categories. Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. All specifications include month, year and household fixed effects. PMUY is a dummy which equals 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 A18: Correlation of Consumer Price Index with Nominal Over-the-counter Price of LPG

	(1) Food & Beverage	(2) Pan, Tobacco & Intoxicants	(3) Clothing & Footwear	(4) Fuel & Light	(5) All
Over-the-counter LPG price	-0.175	-0.227	-0.001	0.164*	-0.098
(Nominal terms)	(0.139)	(0.158)	(0.046)	(0.081)	(0.086)
Constant	150.658***	172.076***	150.104***	137.670***	109.858***
	(7.303)	(8.300)	(2.429)	(4.256)	(4.502)
Observations	26	26	26	26	26

Notes: This table regresses the monthly rural Consumer Price Index (CPI) on the (nominal) average monthly Over-the counter LPG price (per kg) between November 2017 - December 2019 (26 months). In Column 1 the dependent variable is the food and beverages CPI, in Column 2 it is pan, tobacco and intoxicants CPI, in Column 3 it is clothing and footwear CPI, and Column 4 is fuel and light CPI. Column 5 is a combination of all the four CPIs using on the following weights 0.54, 0.074, 0.0326, and 0.079, respectively as per Goyal et al. (2021). Standard errors reported in parentheses. Significant at * 10%, ** 5% and ***1% level.

Table A19: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Access to Banking Services (Survey Data)

	(1)	(2)	(3)	(4)
		Z		
	Statutory Town	Sub-District Headquarter	ATM	Bank
PMUY × Over-the-counter price × Z	-0.007	-0.000	-0.048	0.001
	(0.004)	(0.005)	(0.061)	(0.055)
Mean of Dependent Var.	0.406	0.409	0.410	0.409
Observations	47,424	49,556	51,220	49,244
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes

Notes: This table shows the impact on monthly refills of changes in log of over-the-counter price interacted with proxies for access to banking services using the survey data. Access to banking services is proxied in 4 ways: (Column 1) distance to nearest statutory town, (Column 2) distance to nearest sub-district headquarter, (Column 3) distance to nearest ATM and (Column 4) distance to nearest bank. The distance data are from the village census abstracts of Census 2011. Z denotes the proxy for banking access. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Each estimate comes from a separate regression. Unit of observation is household-month-year. Number of observations is lower than 54,366 due to missing distance data in Census 2011 for some of the sampled villages. Refill is coded zero if the consumer does not have a gas connection or did not purchase a refill in a given month. All specifications include month, year and household fixed effects. PMUY is a dummy which equals 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 A20: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Knowledge About Subsidy (Survey Data)

	(1)	(2)	(3)	(4)	(5)
Over-the-counter price	-0.102*	-0.110**	-0.083*	-0.090	0.002
	(0.058)	(0.056)	(0.049)	(0.058)	(0.048)
PMUY × Over-the-counter price (OTC price)	-0.211***	-0.244***	-0.286***	-0.230***	-0.335***
	(0.069)	(0.082)	(0.062)	(0.068)	(0.071)
PMUY × Govt. Deposits Subsidy × OTC price	-0.066				
	(0.083)				
PMUY × Subsidy Amt. Same × OTC price		-0.014			
		(0.082)			
PMUY × Out-of-Pocket<Paid × OTC price			0.067		
			(0.077)		
PMUY × Subsidy SMS Alert × OTC price				-0.037	
				(0.082)	
PMUY × Subsidy only for PMUY × OTC price					0.118
					(0.075)
Mean of Dependent Var.	0.412	0.412	0.412	0.412	0.412
Observations	53,534	53,534	53,534	53,534	53,534
Month FE	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the total number of monthly refills of a 14.2 kg LPG cylinder consumed by a household in the survey data. LPG subsidy knowledge equals 1 if the household correctly agreed/disagreed with each of the five statements: (1) 'govt. deposits subsidy' to your bank account (2) deposited 'subsidy amount remains same' every time (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) LPG refill 'subsidy is only for PMUY' customers. Unit of observation is consumer-financial month-financial year. 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 A21: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Trust in ASHA Worker (Survey Data)

	(1)
Over-the-counter price	-0.073
	(0.081)
PMUY × Over-the-counter Price	-0.250**
	(0.103)
Trust info from ASHA × Over-the-counter Price	-0.010
	(0.085)
PMUY × Trust info from ASHA × Over-the-counter Price	-0.004
	(0.108)
Mean of Dependent Var.	0.411
Observations	54,366
Month FE	Yes
Household FE	Yes
Year FE	Yes

Notes: The dependent variable is the total monthly refills of a 14.2 kg LPG cylinder consumed by a household in the survey data. ASHA is an acronym for 'Accredited Social Health Activist', a community health worker. "Trust info from ASHA" is the response to the survey question "Does your household trust information given by ASHA worker in your village", which equals 1 if the household reports saying they do trust the information from ASHA worker, and 0 otherwise. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. Unit of observation is household-month-year, leading to a total of 54,366 observations, corresponding to monthly refills for 26 months of the 2091 unique consumers. Refill is coded zero if the consumer does not have a gas connection or did not purchase in a given month. All specifications include month, year and household fixed effects. PMUY is a dummy which equals 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 A22: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills
(Administrative Data)
(Sample Restricted to LPG Users in November 2017)

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.085**	-0.071**		
	(0.035)	(0.035)		
PMUY × Over-the-counter price	-0.083***	-0.307***		
	(0.001)	(0.038)		
Cash-back subsidy			-0.015	-0.017*
			(0.010)	(0.009)
PMUY × Cash-back subsidy			-0.122***	-0.085***
			(0.002)	(0.011)
Mean of Dependent Var.	0.637	0.637	0.637	0.637
Observations	19,803,108	19,803,108	19,803,108	19,803,108
Panel B: Rural Sample				
Over-the-counter price	-0.099**	-0.078**		
	(0.040)	(0.037)		
PMUY × Over-the-counter price	-0.085***	-0.320***		
	(0.002)	(0.038)		
Cash-back subsidy			-0.018	-0.018*
			(0.011)	(0.010)
PMUY × Cash-back subsidy			-0.126***	-0.088***
			(0.002)	(0.011)
Mean of Dependent Var.	0.637	0.637	0.637	0.637
Observations	11,228,762	11,228,762	11,228,762	11,228,762
Panel C: Urban Sample				
Over-the-counter price	-0.067*	-0.062*		
	(0.034)	(0.035)		
PMUY × Over-the-counter price	-0.075***	-0.223***		
	(0.002)	(0.045)		
Cash-back subsidy			-0.012	-0.014*
			(0.009)	(0.009)
PMUY × Cash-back subsidy			-0.111***	-0.064***
			(0.002)	(0.012)
Mean of Dependent Var.	0.637	0.637	0.637	0.637
Observations	8,508,116	8,508,116	8,508,116	8,508,116
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: This table reproduces Table 3 in the main paper to show the impact of changes in the over-the-counter price and cash-back subsidy on monthly consumption of LPG refills. The sample is restricted to only those consumers who had an LPG account in November 2017, i.e. from the beginning of our study period (Nov 2017 - Dec 2019). **Panel A** shows the estimates for the full OMC administrative sample, **Panel B** shows the estimates for rural sub-sample, and **Panel C** shows the estimates for the urban sub-sample. "Over-the-counter price" is the log of the price paid upfront per kg of LPG. "Cash-back subsidy" is the log of the subsidy per kg of LPG that the consumers get back after purchase. The dependent variable is refills, which is the total monthly refills of a 14.2 kg LPG cylinder. Unit of observation is consumer-month-year. Refill is coded zero if consumer did not purchase in a given month. PMUY is a dummy which equals 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.

B Appendix: Reproduction of analyses in the main paper with LPG Refills recoded as missing until consumer obtains an LPG account during our study period (Nov 2017 - Dec 2019)

Table B1: LPG Consumer Characteristics (Administrative Data)

	Obs	Mean	SD	Minimum	Maximum
Panel A: Attributes					
PMUY	910,778	0.074	0.262	0.000	1.000
Female	910,423	0.320	0.466	0.000	1.000
Rural	907,975	0.572	0.495	0.000	1.000
Panel B: LPG Refills					
All	21,898,168	0.625	0.640	0.000	16.000
PMUY	1,299,503	0.340	0.549	0.000	12.000
Non-PMUY	20,598,665	0.643	0.642	0.000	16.000
Rural	12,468,102	0.624	0.646	0.000	16.000
PMUY	936,682	0.343	0.554	0.000	12.000
Non-PMUY	11,531,420	0.647	0.648	0.000	16.000
Urban	9,360,226	0.626	0.633	0.000	13.000
PMUY	361,737	0.332	0.535	0.000	11.000
Non-PMUY	8,998,489	0.637	0.634	0.000	13.000

Notes: as shown in Table 1 in the main paper.

Table B2: Household Characteristics (Survey Data)

	Obs	Mean	SD	Minimum	Maximum
	Panel A: Household Attributes Baseline				
PMUY	2,085	0.391	0.488	0.000	1.000
Asset Index	2,085	1.620	0.748	-0.150	3.965
General Caste	2,085	0.150	0.357	0.000	1.000
Salaried HH Head	2,085	0.106	0.309	0.000	1.000
Agri Self-Employed HH Head	2,085	0.305	0.461	0.000	1.000
Agri Casual Laborer HH Head	2,085	0.390	0.488	0.000	1.000
Land Owner	2,085	0.522	0.500	0.000	1.000
Land Owner/Leaser	2,085	0.536	0.499	0.000	1.000
HH Head Education	2,085	0.412	0.492	0.000	1.000
Latrine in HH	2,085	0.879	0.326	0.000	1.000
	Panel B: Household Solid Fuel				
Baseline					
Explicit firewood expenditure (Rs.)	2,091	71.174	339.208	0.000	6,000.000
Implicit firewood expenditure (Rs.)	2,091	665.798	873.713	0.000	4,480.000
Explicit dung expenditure (Rs.)	2,091	160.841	525.133	0.000	6,000.000
Implicit dung expenditure (Rs.)	2,091	591.769	701.799	0.000	9,800.000
Baseline & Endline					
Explicit firewood expenditure (Rs.)	4,150	56.791	282.530	0.000	6,000.000
Implicit firewood expenditure (Rs.)	4,150	543.258	833.181	0.000	4,480.000
Explicit dung expenditure (Rs.)	4,150	151.177	470.125	0.000	6,000.000
Implicit dung expenditure (Rs.)	4,150	503.106	626.538	0.000	9,800.000
	Panel C: Household Refills Matched to Admin				
All Refills	50,578	0.442	0.586	0.000	7.000
PMUY refills	18,335	0.331	0.530	0.000	7.000
Non-PMUY refills	32,243	0.505	0.606	0.000	6.000

Notes: as shown in Table 2 in the main paper.

Table B3: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Administrative Data))

	(1)	(2)	(3)	(4)
Panel A: Full Sample				
Over-the-counter price	-0.078**	-0.060*		
	(0.034)	(0.035)		
PMUY × Over-the-counter price	-0.084***	-0.227***		
	(0.002)	(0.035)		
Cash-back subsidy			-0.009	-0.013
			(0.009)	(0.009)
PMUY × Cash-back subsidy			-0.125***	-0.058***
			(0.003)	(0.010)
Mean of Dependent Var.	0.625	0.625	0.625	0.625
Observations	21,898,168	21,894,452	21,898,168	21,894,452
Panel B: Rural Sample				
Over-the-counter price	-0.092**	-0.067*		
	(0.038)	(0.037)		
PMUY × Over-the-counter price	-0.084***	-0.256***		
	(0.002)	(0.033)		
Cash-back subsidy			-0.011	-0.015
			(0.011)	(0.010)
PMUY × Cash-back subsidy			-0.126***	-0.065***
			(0.002)	(0.010)
Mean of Dependent Var.	0.624	0.624	0.624	0.624
Observations	12,468,102	12,466,067	12,468,102	12,466,067
Panel C: Urban Sample				
Over-the-counter price	-0.059*	-0.052		
	(0.034)	(0.034)		
PMUY × Over-the-counter price	-0.084***	-0.146***		
	(0.003)	(0.055)		
Cash-back subsidy			-0.007	-0.011
			(0.009)	(0.008)
PMUY × Cash-back subsidy			-0.125***	-0.036**
			(0.004)	(0.016)
Mean of Dependent Var.	0.626	0.626	0.626	0.626
Observations	9,360,226	9,358,549	9,360,226	9,358,549
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: as shown in Table 3 in the main paper.

Table B4: Impact of Over-the-counter Price and Cash-back Subsidy on Monthly Refills (Survey Data)

	(1)	(2)	(3)	(4)
Over-the-counter price	-0.167***	-0.146***		
	(0.061)	(0.042)		
PMUY × Over-the-counter price	-0.174**	-0.189***		
	(0.067)	(0.052)		
Cash-back subsidy			-0.048**	-0.035***
			(0.019)	(0.013)
PMUY × Cash-back subsidy			-0.048**	-0.053***
			(0.020)	(0.016)
Mean of Dependent Var.	0.442	0.442	0.442	0.442
Observations	50,578	50,577	50,578	50,577
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Household FE	No	Yes	No	Yes

Notes: as shown in Table 4 in the main paper.

Table B5: Impact of Over-the-counter Price on Solid Fuel Expenditure (Survey Data)

	(1) Explicit Expenditure	(2) Implicit Expenditure	(3) Total Expenditure
Over-the-counter price	-5.718	5.206	6.030
	(5.018)	(6.125)	(5.955)
PMUY × Over-the-counter price	0.836**	2.271***	1.799***
	(0.398)	(0.307)	(0.311)
Mean of Dependent Var.	1.952	5.249	6.160
Observations	4,118	4,118	4,118
Month FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: as shown in Table 5 in the main paper.

Table B6: Impact of Over-the-counter Price on Monthly Refills: Heterogeneity by Household Attributes (Survey data)

	(1)	(2)	(3)
		Z	
	Asset Index	General Caste	Casual Laborer
Over-the-counter price × Z	0.069**	0.108*	-0.075*
	(0.028)	(0.060)	(0.040)
Mean of Dependent Var.	0.442	0.442	0.442
Observations	50,577	50,577	50,577
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes

Notes: as shown in Table 7 in the main paper.

Table B7: Impact of Cash on Hand (COH), Over-the-counter Price on Monthly Refills

	(1)	(2)	(3)
COH	0.096***	0.096***	0.096***
	(0.018)	(0.018)	(0.018)
Over-the-counter price		-0.180***	-0.182***
		(0.018)	(0.025)
Over-the-counter price × COH			0.083*
			(0.040)
Mean of Dependent Var.	0.455	0.455	0.455
Observations	416	416	416
Month FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: as shown in Table 8 in the main paper.