FOR ONLINE PUBLICATION
APPENDIX

Curbing Leakage in Public Programs: Evidence from India's Direct Benefit Transfer Policy

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Appendix A: Additional Institutional Details

A1. Cooking Gas Public Distribution System and Gas Subsidy

This section provides additional institutional details on the gas public distribution system and the Direct Benefit Transfer policy. The PDS for gas is controlled by the central government in India through three OMCs, in contrast to the PDS for food which is controlled by the respective state governments. These three OMCs are the Indian Oil Corporation Ltd. (IOCL), Bharat Petroleum Corporation Ltd. (BPCL), and Hindustan Petroleum Corporation Ltd. (HPCL). The government deliberately maintains the OMCs' market share in gas sales - IOCL at about 50%, and BPCL and HPCL at about 25% each. All three OMCs are simultaneously present across the country through a local franchise system known as the gas distributorship. While the Indian government allows gas marketing by private firms, household subsidies are available through OMCs only, which effectively eliminates any private sector participation in gas sales to households. According to LPG Regulation of Supply Distribution Order 2000, "No person other than a Government Oil Company, a parallel marketeer or a distributor shall be engaged in the business of selling gas to the consumer." Using gas cylinders meant for household consumption in any other way is a non-bailable offense. This provides a unique advantage to gas distributors and their delivery teams in carrying out black market transactions.

OMCs supply both 19kg commercial and 14.2kg household gas cylinders to local distributors on an as-needed basis from bottling plants located across the country. Gas distributors are local OMC franchisees with a predefined catchment area. A total of 13,896 distributors delivered both household and commercial gas refills as of March 31, 2014 (Ministry of Petroelum and Natural Gas, 2015). New distributors are regularly appointed as the demand for gas refills increases in an area, though the process from the start of the need assessment for a new distributorship in an area to the opening of the new gas distributorship is a slow one often taking months. Distributors maintain a warehouse and keep a team of deliverymen, commonly known as "gas hawkers," who deliver gas-filled cylinders to both household and commercial accounts and collect empty ones. Empty household-use cylinders are rationed (up to two 14.2kg cylinders per household account), though empty cylinders can also be potentially bought in the black market.

The Indian government regulates the price of gas sold through OMCs in tandem with the international market price. Local demand and supply factors and supply-chain issues do not affect the over-the-counter price for gas at distributorships. The gas subsidy has been provided to encourage usage and to shield households from international price fluctuations since the nationalization of OMCs in the 1960s and 70s. However, the subsidy has been universally provided to household accounts without an explicit quota for a long time. In September 2012, an annual cap of six subsidized 14.2kg gas refills per household gas account was introduced for the first time; this was later increased to nine refills in January 2013 and 11 refills in February 2014. Starting in April 2014, the annual cap was raised to up to 12 refills in a year. The middle- to upper-income urban population has been the primary beneficiaries of household gas subsidies for a long time (Lahoti, Suchitra and Goutam, 2012). As per the 2011 Census, about 65% households in urban areas were using gas as the primary fuel for cooking, compared to only 11% in rural areas (Registrar General of India, 2011). The government faced political and administrative challenges in targeting gas subsidies to needy households only. Before 2015-16, the subsidy was available universally to all households, but only middle and high-income households used gas and received subsidies. A policy change in 2015 introduced an income criterion for excluding very high-income households. In 2016, the Indian government started a countrywide program called Pradhan Mantri Ujjwala Yojana which seeks to expand gas usage among low-income households by providing an additional startup subsidy (Kar et al., 2019).

The net cost of opening a new household account for gas, called 'gas connection', is relatively low

(about USD 6-7). However, after including the refundable security deposit for the steel cylinder and the cost of required accessories such as gas pipe, valve, and burners, it may go up to USD 60-100 for a new gas connection. Hoarding multiple household accounts and more than two gas cylinders is not allowed.

A2. Subsidy Diversion

The Essential Commodities Act, 1955, and subsequent orders allow for high penalties and even prison terms for black marketing and diversion of household gas. However, for any critical irregularity carried out by a gas distributor, the stipulated penalty terms are significantly less severe than the general penalty for operating in the black market (Ministry of Petroleum and Natural Gas, 2014*a*). Further, a degree of tolerance for irregularity is embedded in the regulatory framework and staunchly defended by distributors. For example, a news report mentioned that "dealers find it terrible that the sale of more than 50 'unaccounted' [household gas] cylinders is regarded as a 'critical irregularity' ...[T]hey want the limit to be increased to 300 cylinders." (Jai, 2013). Gas distributors have strong national- and state-level unions who regularly threaten to strike when reforms aimed at curtailing the subsidy diversion are announced. For example, in 2012, gas distributors went on strike when an annual household cap on gas refills was introduced for the first time in India (Kumar, 2012). In 2013, in response to the DBTL policy, the deliverymen started unionizing to threaten the government with a strike aimed at raising their stipulated per-delivery compensation (TNN, 2013). The government also has raised compensation for distributors and deliverymen multiple times in recent years, which is consistent with their being employed at below-market-level wages due to the extra compensation from fuel diversion activities.

A3. DBTL policy roll out and termination

The DBTL policy was introduced in about half of the districts in India, staggered over six phases and more than six months beginning in June 2013 (for the timeline, see Figure 3). In each phase, selected districts entered a voluntary DBTL enrollment period first, and once the transition period was over, DBTL enrollment became mandatory for households to receive the subsidy. Voluntary enrollment meant household gas account holders could either enroll in DBTL for direct transfer of the subsidy or access the over-the-counter subsidy as before. This provided a transition phase to minimize any short-term exclusion from benefits. DBTL was first introduced for voluntary enrollment in 20 districts in Phase 1 in June 2013. After three months of the transition phase, DBTL became mandatory in 18 Phase 1 districts starting from September 2013 (or soon thereafter, since two districts, Mysore and Mandi, observed a one-month and two-month delay, respectively, due to by-elections.) The remaining two districts, both from Kerala state, did not make it mandatory due to the state government's opposition. In Phase 2, the policy was introduced on a voluntary basis in 34 districts on September 1, 2013, and was made mandatory in 22 districts on January 1, 2014. The remaining 12 districts were from Kerala.

In total, the DBTL policy was introduced in 291 districts by January 2014, out of which 40 districts in nine states made DBTL mandatory by January 2014. The selection of districts in early phases was based on Aadhaar coverage. A number of states had low Aadhaar coverage due to slow implementation by the assigned ministry. This includes most of the 360 districts not scheduled for DBTL in 2013, located in Bihar, Chhattisgarh, Jammu and Kashmir, Orissa, Tamil Nadu, Uttarakhand, Uttar Pradesh, and the northeastern states.[20]

[20]The Indian government's decision to make Aadhaar mandatory for availing subsidies has been controversial for privacy as well as exclusion reasons (Khera, 2011*b*). A public interest litigation was filed against this decision by the civil society organizations in the Supreme Court of India. In September 2018, the Court ruled in favor of using Aadhaar for providing subsidy benefits.

The outright policy termination transpired after continued political lobbying in the run-up to the general elections in April-May 2014. While implementation-related issues were cited as the reason for DBTL's termination in a closed door meeting, that explanation did not fit with the Petroleum Minister's assertion a few days prior to January 30$^{\text{th}}$ that the policy was a success. The use of Aadhaar for subsidy delivery was challenged in the Indian Supreme Court (TNN, 2014), but this was not cited by the government as a reason for termination. Later, the Supreme Court ruled in favor of using Aadhaar to identify PDS beneficiaries. The outright policy termination transpired after continued political lobbying in the run-up to the general elections in April-May 2014. High global prices in early 2014 may have also further encouraged lobbying efforts and influenced households' perception of the policy due to historically large price gaps between the regulated and subsidized gas prices.

Close to the election, special interest groups may have tried to obstruct policy reforms in order to ensure the survival of the traditional rent-seeking structure.[21] Such efforts were likely encouraged by politicians who held interests in gas distributorships. A former minister in Karnataka state, himself a gas distributor, explained, "As a politician, I am telling you that 90% of the LPG dealers and black-marketeers in the state are either politicians, bureaucrats, or their kin" in response to the uncovering of 2.4 million fake gas subsidy beneficiaries in Karnataka (Aji, 2012). Media may have also selectively highlighted problems with instituting a new policy during the election period. Research shows evidence of electoral calendars affecting the timing of policy reforms (Bussell, 2010; Shleifer and Treisman, 2001).

The newly elected government began planning the relaunch of DBTL shortly after the general elections in May 2014, and the DBTL policy was re-implemented in November 2014. It was now renamed PAHAL, after "Pratyaksh Hanstantrit Labh", the Hindi translation of Direct Benefit Transfer. It was introduced throughout the country in two quick phases over three months, in contrast to the previous staggered and gradual roll-out. Eligibility was slightly modified by an alternative reliance on a gas consumer ID (a unique customer ID number across OMCs) for account verification, allowing Aadhaar enrollment to be voluntary. This facilitated a quick roll-out and minimized concerns about exclusion errors in districts where Aadhaar enrollment was not yet complete. The mandatory Aadhaar requirement was reinstated in 2016. Consistent with the observation from 2014 that vested interests may lobby for reverting back to dual pricing before elections, a new campaign to terminate DBTL resurfaced in the media in the period leading up to the 2019 general elections (Ministry of Petroleum and Natural Gas, 2018).

Prior to the DBTL policy, households were unable to opt out of purchasing gas at the subsidized price. This meant that all household accounts faced the subsidized price up to the point that they reached the annual cap. The new policy indirectly provided a convenient way for wealthier households to opt out of subsidies by not enrolling in DBTL. Based on this observation, in March 2015, the government invited well-off households to voluntarily give up gas subsidies under a program called "Give It Up," which allowed households to indicate that they did not want the gas subsidy transfer (Troncoso and da Silva, 2017; The Economic Times, 2016). In one year, more than 10 million households signed up for Give It Up, accounting for more than 6% of household gas user accounts. Data obtained from OMCs in 2018 show that about half of households not enrolled in DBTL have signed to Give It Up. This self-exclusion suggests that a large proportion of households may have voluntarily abstained from the DBTL program when it was first implemented.

[21] On policy manipulation by politicians seeking re-election, see Nordhaus (1975); Alesina (1997). Some related contexts of corruption are discussed in Cole (2009); Kapur and Vaishnav (2011); Burgess et al. (2012); Sukhtankar (2012); Foremny and Riedel (2014).

Appendix B: Data

Data and code for this study are available through the American Economics Association repository (Barnwal, 2024).

- **Administrative Data on Cooking Gas Sales**
  - **Distributor-month level data:** Distributor-month level data on gas sales are obtained from the Ministry of Petroleum and Natural Gas, India. This data includes household and commercial gas sales during the period from January 2013 to August 2015. The dataset covers distributors from all three government-controlled oil marketing companies (OMCs): HPCL, BPCL, and IOCL. For BPCL, data from two months (March and April 2013) is missing. In any month between April 2013 and March 2014, a maximum of 15,220 distributors were recorded in the administrative data. New distributors are gradually added by OMCs, especially in rural areas, but there was a large increase of 10.1% from July to August 2014. Overall, the number of distributors increases from 14,835 in January 2013 to 19,378 distributors in August 2015, though almost all of this expansion in gas distributorship happened after DBTL's termination. This dataset provides information on household subsidized and unsubsidized gas sales (14.2kg units) at the distributor-month level. It also provides monthly details of commercial gas refills (19kg units) sold by the same distributors who sell household gas. This data does not include information on gas sold for commercial and transport usage through other channels.
  - **Household Gas refill Transactions Data:** This dataset provides details on all gas refills purchased by a sample of customers during one financial year (April 2013- March 2014). The number of subsidized gas refills purchased against the annual cap is reset on April 1 every year for all household accounts. The data is obtained from HPCL Transparency Portal during April-July 2014 which was publicly accessible at the time of data extraction. HPCL claims a 25% gas market share. It is uniformly present in about 80% districts in the country. For each gas distributor, this portal provided details of customers (20 household accounts per page) and their gas refills transaction details with a web link. Given the large amount of data, 10% of pages for each distributor available were randomly chosen for data extraction. This provides a sample of 4 million household customers,i.e., about 2.5% of all household gas accounts in India during this period. This dataset includes complete gas refill histories for all household accounts in the sample. It provides information on the number of refills purchased by household customers, the gas refill order dates, the gas refill delivery dates, and enrollment in the DBTL program.
- **Survey data on black market prices:** Surveys using two separate instruments were conducted during December 2013 and March 2014 to collect data from the supply side in the black market (i.e., gas deliverymen) and the demand side in the black market (i.e., small businesses). Two-side price surveys were implemented to address concerns about strategic misreporting by either set of respondents. The approach used in this fieldwork leverages the fact that fuel-price information is readily revealed by unsuspecting agents in the local black markets, in part because gas is a ubiquitous commodity. The survey was designed for gas black markets in urban areas and was tested in a pilot round. Districts were randomly selected across DBTL phases. There are 10 districts in Phases 1 and 2 (i.e., treated districts), 50 districts in Phases 3 through 6 (i.e., voluntary DBTL districts), and 29 districts in the non-policy group where DBTL implementation was not yet scheduled. At the time of termination, the DBTL policy was fully enforced only in Phase 1 and 2 districts, while it was available

for voluntary enrollment in Phase 3-6 districts. DBTL termination was not anticipated when surveys were designed. Three rounds of surveys were conducted starting in December 2013. However, Phase 1 and 2 districts were included in the second and third rounds only and so, data collected in only these two rounds are used in this study. Specifically, I use data from the period when DBTL policy was enforced in Phase 1 and 2 districts and from after DBTL termination. Some districts (10 districts in Phase 1 and 2, and 4 districts in the non-policy group) were surveyed after the announcement of policy termination, but before the actual termination on March 10, 2014. In the post-termination round, all districts in the sample were surveyed simultaneously within a three-week period. Potentially erroneous black-market price values reported by respondents, namely, prices below the average OMC price for subsidized 14.2kg household gas refills or above the average OMC price for 19kg commercial gas refills, are dropped.

- Small Business survey: In each survey round, about 15 small businesses were surveyed per district, leading to a total sample of 1,452 small businesses from 89 districts. First, an area roster was created by listing the main market areas in a district, from which three local areas were randomly selected. Small businesses in these selected local markets were listed and sampled. Due attention was given to ensuring the inclusion of small businesses with similar production functions, such as snack counters and restaurants.[22] For example, more than 60% of the sampled small businesses sell 'samosa' (a popular North Indian snack) and 'chai' (hot tea). About 20% attrition was observed in the post-termination round and replacement businesses were surveyed from the same local markets. By asking a number of questions on gas prices in different ways, the survey instrument was designed to collect gas refill price information without confronting the business owner about their participation in the black market. This business survey collects data on ongoing black-market prices as well as on gas refill purchase history for up to the last five refills.
- Deliverymen survey: Up to seven gas deliverymen were surveyed in each district using an audit format. Enumerators were unable to find a sufficient number of deliverymen in all the areas. The same local market areas were surveyed as in the small business survey, and on the same day. Enumerators approached every other deliveryman that they saw in the market. A deliveryman, as part of his regular job, usually carries empty and filled gas cylinders of both types (household 14.2kg and commercial 19kg). This also makes it convenient to identify them. The enumerator asked for a quote for a 14.2kg household gas refill. Specifically, as per the script provided, the enumerators told the deliverymen that they did not have a gas connection and wanted to buy a gas refill on the same day *in black* which is a commonly used phrase for purchasing black-market refills. In the DBTL and post-termination rounds, the percentage of deliverymen who refused to entertain a black market transaction inquiry was 18.2% and 4.2%, respectively. One round of bargaining was embedded in the script to elicit the true offer price for gas refills in the black market.

- **Additional datasets used**
  - Center for Monitoring of Indian Economy (CMIE) Household Expenses Details database: CMIE collects information from households on all types of expenses, including monthly expenditure on cooking fuel for the preceding four months. This data covers a large

[22] Metal-cutting shops, other small industrial firms, and commercial automobile users may be other potential buyers on the black market.

number of districts across the country and allows for the construction of a household-month panel with three survey rounds per year. These survey rounds were conducted between January 2014 and December 2014, a period overlapping two full months of the DBTL policy being mandatory in Phase 1 and 2 districts (i.e., January and February 2014). Data from November 2014 is dropped because it contains less than 20% of the total number of households in the sample. CMIE data covers 440 districts in total, sampled uniformly across the country. Two districts in DBTL Phase 1 and four districts in DBTL Phase 2 are not available in the CMIE data.

– National Sample Survey (NSS): NSS round 68 Household Consumption and Expenditure survey was conducted in 2011-12, one year before the DBTL policy implementation. NSS round 66 was conducted in 2009-10. These surveys ask households about gas consumed in the last 30 days. The reported gas consumption presents an upward-biased estimate as households are more likely to report gas purchases only when they have bought it in the last 30 days. In the analysis, the gas refills purchased by households are adjusted using the mean gas refills purchased in the administrative data. NSS Surveys also provide information on households' total monthly expenditure by aggregating itemized consumption information.

Appendix C: Model

Here I describe a simple model to guide the interpretation of the empirical results. I consider three types of actors interacting in three markets: genuine households, commercial users, and agents. Genuine households and agents (ghost accounts) buy gas at the subsidized price, while commercial users may buy gas at the unsubsidized price or from agents on the black market.

Assume a per-unit regulated price of gas p (that is the same as the unsubsidized household gas price) and a subsidy s. Households buy gas refills at the subsidized price $p-s$ up to an annual cap. The price p varies with the international petroleum price each month, while $p-s$ does not change during the study period. This means p and s both vary on a monthly basis, but the subsidized household fuel price $p-s$ remains fixed. I omit time subscripts for p and s. For commercial users, the formal price is $p+t$, where t is the commercial gas tax. For brevity, I ignore the fact that t is proportional to p.

I make two assumptions for simplicity here. First, the data shows that 95% of household gas users did not exceed their annual gas refill cap. I, therefore, assume that this cap is not binding. Because gas prices for household accounts are lower on the regulated (subsidized) market, it follows that only commercial users purchase gas on the black market. Secondly, I assume that genuine households do not resell their excess gas on the black market in response to DBTL. A baseline level of diversion by legitimate household accounts, if it remains balanced across DBTL and non-DBTL districts, would not pose a concern for our results. In the main body of the paper, I show evidence that DBTL did not increase gas purchases by genuine households, indicating that any household-level diversion is minimal, at least in the short term. This assumption implies that commercial users do not purchase gas refills diverted by genuine households in the black market.

Households' gas demand is a function of the subsidized price they face $p-s$ and other household characteristics x such as income and family size.

$$\text{Genuine household demand}: D_{hh} = D_{hh}(p-s, x) \tag{1}$$

Agents active in diverting gas to the black market purchase gas meant for household usage at the same unit price as households. Prior to DBTL, this means black market agents purchase at price $p-s$, and at price p after DBTL when the subsidy s is directly transferred to genuine household beneficiaries. Assuming the equilibrium black-market price to be p_b, then the agent receives p_b for each unit of gas sold on the black market. Diversion involves costs in terms of potential penalties, carrying and selling in the black market, and bribing the gas distributor or enforcement agencies if needed, which I combine together as c_a. Agents' demand for household fuel for diversion to the black market will depend upon the potential pay-off. For simplicity, I assume the marginal cost of dealing in the black market c_a remains constant.

$$\text{Black-market agent's demand}: D_a = D_a(p, p_b, s, c_a, \mathbb{1}_{\text{dual price}}) = D_a(p_b - (p - s \times \mathbb{1}_{\text{dual price}}) - c_a) \tag{2}$$

Under DBTL, the dual price system due to over-the-counter subsidy is eliminated, which I indicate as $\mathbb{1}_{\text{dual\_price}} = 0$. It is important to note that, unlike lump sum transfers, the DBTL policy did not change the marginal price net of the subsidy transferred to household bank accounts; households continued to face the same subsidized price $p-s$ per unit of fuel purchased. $\mathbb{1}_{\text{dual price}} = 1$ denotes the status quo policy of providing the subsidy to households over the counter, leading to a low price for households and a high price for commercial users.[23] Since all the household gas purchased by agents is for sale on the black market, I can safely assume that D_a will be the same as the supply

[23] 'Dual pricing' here indicates two over-the-counter prices for household fuel i.e. $p-s$ and p, which were collapsed to one price p under the direct benefit transfer policy. Fuel available to commercial accounts continued to be priced at $p+t$, due to tax t on commercial usage.

in the black market, denoted by S_b.

I next turn to the demand side in the black market. Fuel diverted to the black market is ultimately purchased by commercial users and small firms at the black-market price p_b. The alternative for commercial users is to purchase the same fuel formally at the much higher, tax-inclusive price $p+t$. However, purchasing household fuel for commercial usage may be costly in terms of potential penalties if caught by enforcement agencies. These costs, denoted c_f, can vary heterogeneously across users. We assume c_f to be non-negative. Thus, a commercial user has to choose between buying gas from the formal market at price $p+t$ or from the black market at price p_b+c_f. A marginal commercial customer would be indifferent between purchasing fuel in the black market and purchasing it through the formal channel, meaning they face cost $\hat{c_f} = p+t-p_b$.

Let the c.d.f. of c_f be denoted by $F(c_f)$, and let $q(.)$ indicate the amount of fuel purchased as a function of price, with $q'(.) < 0$.

Total black-market fuel demand of commercial users:

$$\int_0^{\hat{c_f}} q(p_b+c_f)dF(c_f) = \int_0^{p+t-p_b} q(p_b+c_f)dF(c_f) \tag{3}$$

Total formal fuel demand of commercial users:

$$\int_{\hat{c_f}}^{\infty} q(p+t)dF(c_f) = q(p+t)[1-F(\hat{c_f})] \tag{4}$$

Definition: A black-market equilibrium is a price p_b^* such that the supply in the black market $S_b : D_a(p_b^* - (p - s \times \mathbb{1}_{\text{otc}}) - c_a)$ equals the demand in the black market $D_b : \int_0^{p+t-p_b^*} q(p_b^* + c_f)dF(c_f)$ (Eq. 5).

$$D_a(p_b^* - (p - s \times \mathbb{1}_{\text{dual price}}) - c_a) = \int_0^{p+t-p_b^*} q(p_b^* + c_f)dF(c_f) \tag{5}$$

Without loss of generality, assuming that $D_a(.)$ is increasing in p_b and $D_a(.) = 0$ if $(p_b - (p - s \times \mathbb{1}_{\text{duel price}}) - c_a) \leq 0$, then any equilibrium must have $p_b \geq p - s$. Similarly, since black-market demand is zero at $p_b = \infty$ (because all commercial users will opt to purchase gas through the formal channel at the price $p+t$), any equilibrium must have $p_b < \infty$. Thus, the equilibrium black-market price $p_b^* \in [p-s, \infty)$.

In Eq. 5, the left-hand side (supply) is increasing in p_b since $D_a^{'}(.) > 0$. On the right-hand side, demand decreases in p_b since $\frac{d(D_b)}{dp_b} = -q(p+t) + \int_{-\infty}^{p+t-p_b} q^{'}(p_b+c_f)dF(c_f)$, where the first term on the right-hand side is obviously less than 0 and the second term is negative since $q^{'}(.) < 0$. This implies uniqueness. Note that, since at the minimum value of p_b, the supply will be lower than the demand, this rules out the no solution case. Hence, a unique black-market equilibrium price p_b^* exists.

Comparative static: The black-market equilibrium price is lower when $\mathbb{1}_{\text{dual price}} = 1$. If $p_{b,dual}^*$ is the black-market equilibrium price for $\mathbb{1}_{\text{dual price}} = 1$, then the black-market equilibrium price under direct benefit transfer $p_{b,dbtl}^*$ (i.e. when $\mathbb{1}_{\text{dual price}} = 0$) is higher.

Proof: In Eq. 5, the right-hand side is invariant to $\mathbb{1}_{\text{dual price}}$, while the left-hand side $p_b - (p - s \times \mathbb{1}_{\text{dual price}}) - c_a$ is increasing with $\mathbb{1}_{\text{dual price}}$. In other words, while black-market demand is invariant to $\mathbb{1}_{\text{dual price}}$, the policy regime $\mathbb{1}_{\text{dual price}} = 0$ reduces supply compared to $\mathbb{1}_{\text{dual price}} = 1$. Hence, the equilibrium black-market price is higher when $\mathbb{1}_{\text{dual price}} = 0$, all else equal. This means, if p_b

remains at $p^*_{b,dual}$ at $\mathbb{1}_{\text{dual price}} = 0$, there would be excess demand. So, the black-market equilibrium price for $\mathbb{1}_{\text{dual price}} = 0$, $p^*_{b,dbtl}$ is greater than $p^*_{b,dual}$. On the other hand, the black-market equilibrium price $p^*_{b,dbtl}$ will be less than $p^*_{b,dual} + s$, otherwise, at this price, there would be excess supply with the supply unchanged and the demand lower in the black market.

Definition: An equilibrium is a black-market price p^*_b such that the black market clears and a quantity q^*_h such that the regulated market clears at the regulated price p.

Comparative static: Total purchase of household gas $q^*_{h,dbtl}$ under the direct benefit transfer policy will be lower than $q^*_{h,dual}$ under dual pricing.

Proof: Supply in the regulated market is perfectly elastic, which means with a fixed price $p-s$ or p, household gas quantity purchased q^* will vary as per the demand. Total household gas purchase is $D_{hh} + D_a$. The first term (household gas purchased by genuine households) is invariant to the policy change. The second term (household gas purchased for resale in the black market) depends on both p_b and $\mathbb{1}_{\text{dual price}}$, and the former depends on the latter. Employing the result above that $0 < p^*_{b,dbtl} - p^*_{b,dual} < s$ delivers the prediction that $D_a(p^*_{b,dual} - p + s - c_a) > D_a(p^*_{b,dbtl} - p - c_a)$. Thus, the policy change from over-the-counter dual pricing to direct subsidy transfer to households will reduce the equilibrium quantities purchased by black-market agents.

Comparative static: Total purchase of commercial fuel $q^*_{f,dbtl}$ under the direct benefit transfer policy will be higher than $q^*_{f,dual}$ under dual pricing.

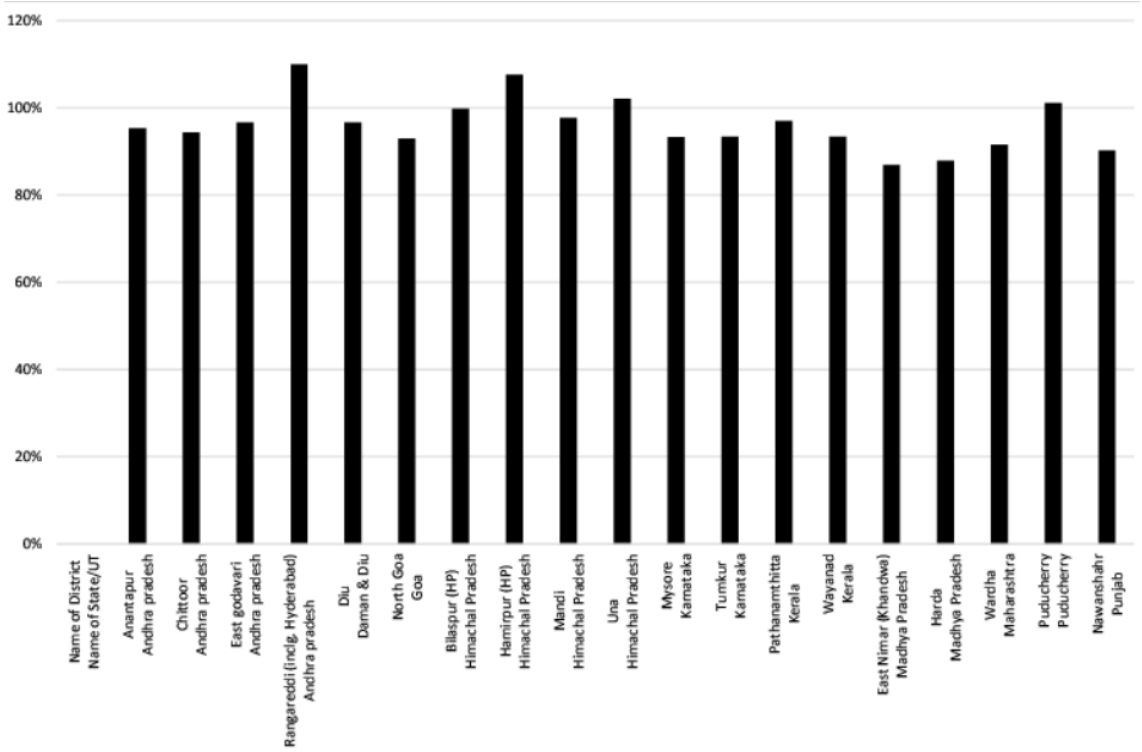
Proof: Since $\hat{c_f} = p + t - p_b$, $\hat{c_f}$ will fall when p^*_b increases. If the supply in the regulated market for commercial gas is perfectly elastic, total commercial gas purchased formally (i.e., at price $p+t$) by firms will be higher under the direct benefit transfer policy.

Two points are worth noting here. First, firms' decisions about gas storage and substitution to other fuel types in response to the policy change may reduce the observed effect size for formal commercial gas sales. Second, elasticity for commercial users may affect actual commercial gas purchase after the policy change. If the demand to buy gas at higher p_b or at the tax-inclusive formal price $p+t$ is low, the increase in commercial gas purchased may be lower than the decrease in household gas purchased.

Appendix D: Additional Results and Discussion

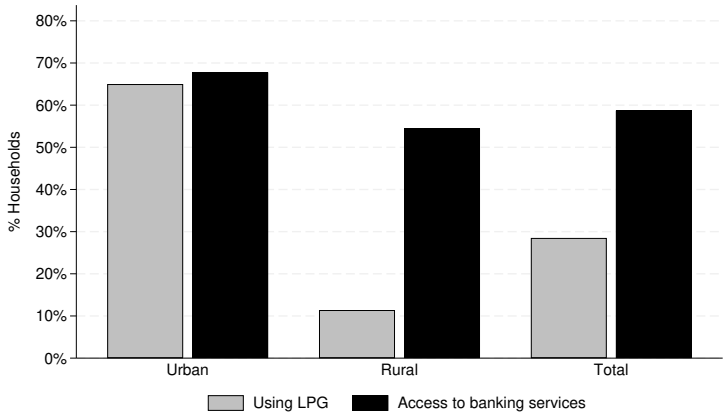
D1. Additional results

Figure D.1. : Aadhaar coverage in DBTL districts



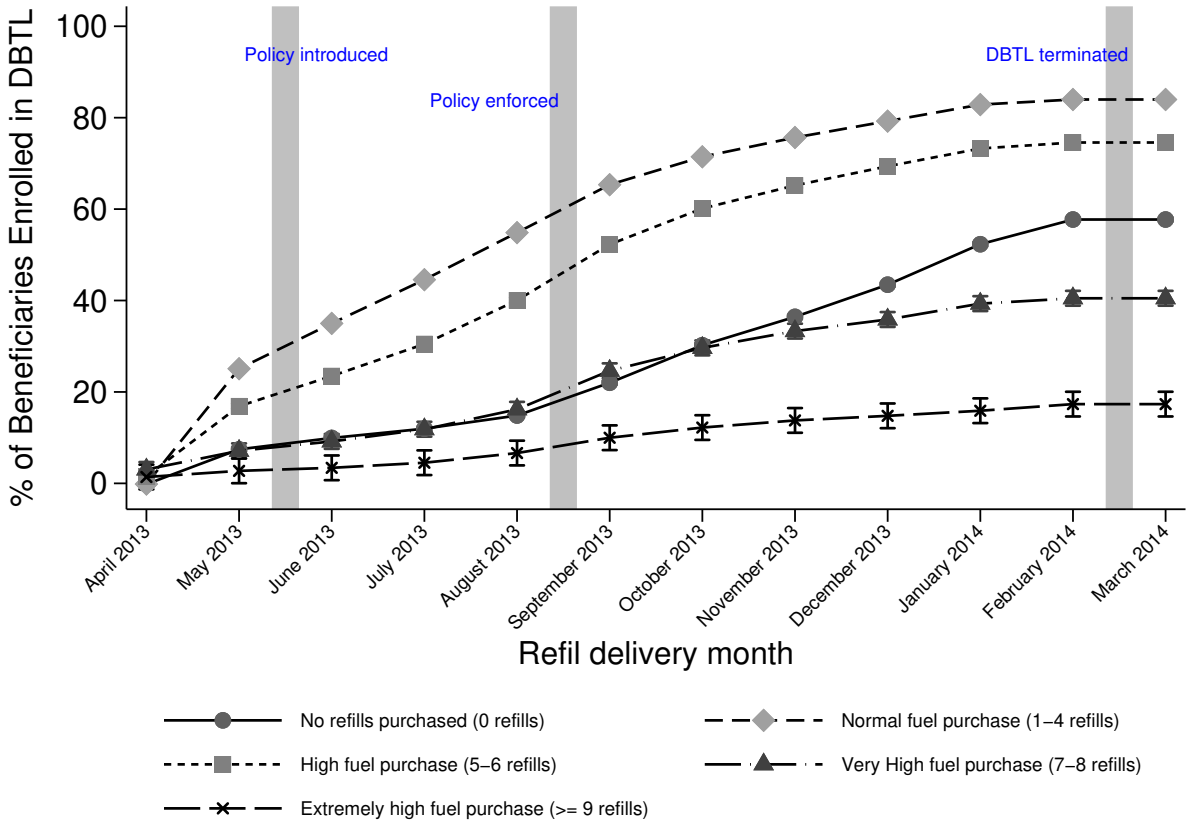
Notes: This graph shows Aadhaar coverage in DBTL Phase 1 districts as of January 2014 (Unique Identification Authority of India , UIDAI). In these districts, 98.5% of the population (compared to the 2011 census) had received Aadhaar. Aadhaar in four districts exceeds their respective population, likely because of in-migration since 2011. The actual Aadhaar enrollment rate may be lower due to population growth and in-migration since 2011. Likewise, it is also possible that some of the districts observed significant out-migration since 2011 and so the actual enrollment may be higher relative to the actual population living in these districts.

Figure D.2. : Access to banking services and LPG adoption



Notes: Data from 2011 Census (Registrar General of India, 2011). Reported share of households "having any type of bank account" according to the 2011 Census (excluding banking via self-help groups, agricultural credit societies, etc.). The average rate of bank account ownership dominates the rate of gas usage, both in urban as well as rural areas.

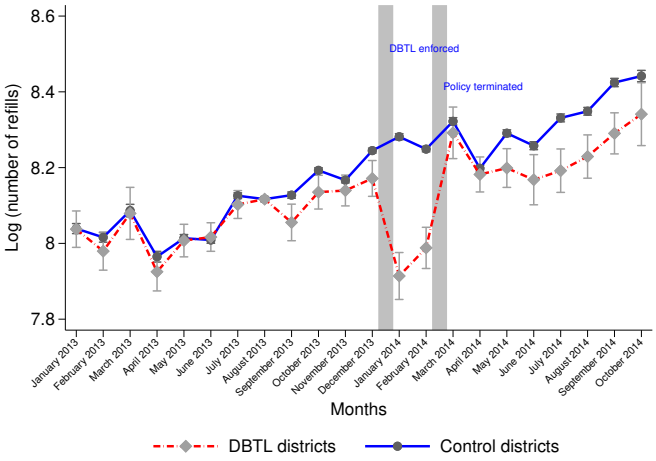
Figure D.3. : DBTL enrollment and pre-DBTL gas purchase



Notes: The above plot shows how DBTL enrollment levels vary across household gas refills purchased in the pre-DBTL period (April - August 2013) using household account-level data from DBTL Phase 1 districts. Household accounts purchasing 4 or fewer 14.2kg refills during the five months preceding the DBTL roll-out (as per the annual cap) are categorized as a "normal household". Household gas accounts with more frequent purchases consistently show low enrollment in DBTL. Note that household gas users who did not purchase a single refill in the pre-DBTL period show a higher enrollment rate after the policy is enforced. This is likely because the households applying for new gas connections may be more likely to enroll in DBTL.

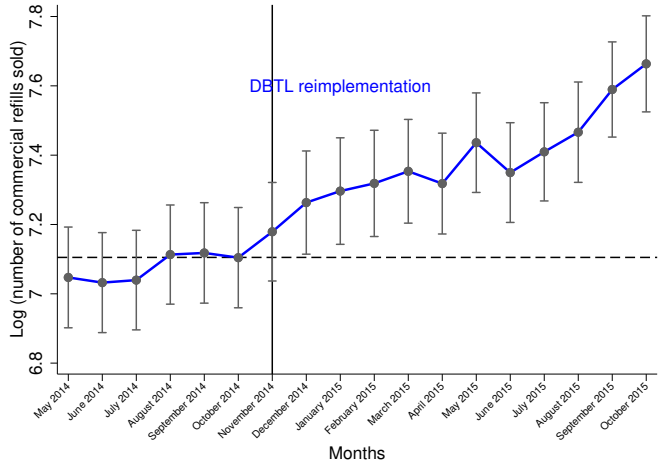
D2. Impact of DBTL: Additional results and robustness checks

Figure D.4. : Impact of DBTL on household gas sales in Phase 2 districts



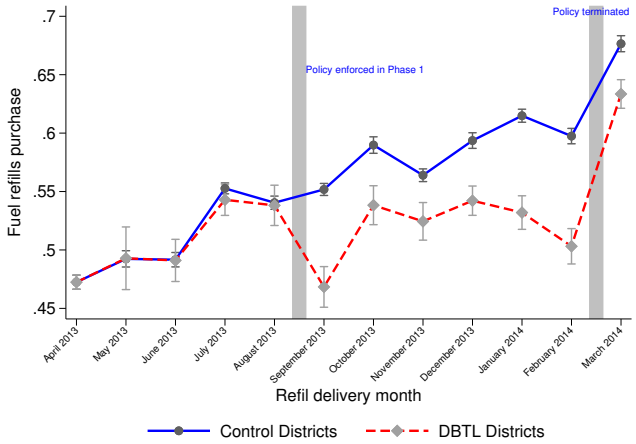
Notes: The above plot compares household gas purchases across DBTL Phase 2 and control districts using distributor-month level data. DBTL was voluntary for a period of four months, became mandatory in January 2014 in Phase 2 districts, and was terminated on March 10, 2014. 95% confidence intervals for the regression-adjusted mean gas sales in the DBTL policy group and control group districts are shown. Standard errors are clustered at the district level.

Figure D.5. : Gas sales to commercial accounts



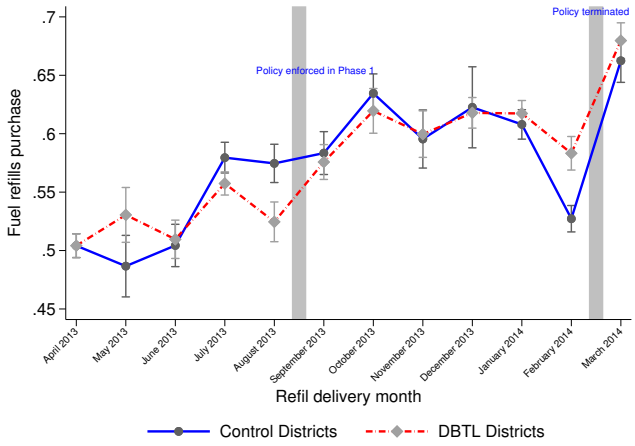
Notes: This plot shows 19kg commercial gas sales before and after DBTL reimplementation using district-month level data. The first 54 districts were brought under DBTL in November 2014 and the remaining 622 districts were brought under DBTL in January 2015. A transition period of three months was provided to both sets of districts. 95% confidence intervals are shown.

Figure D.6. : Impact of DBTL on gas purchase by household accounts (Phase 1)



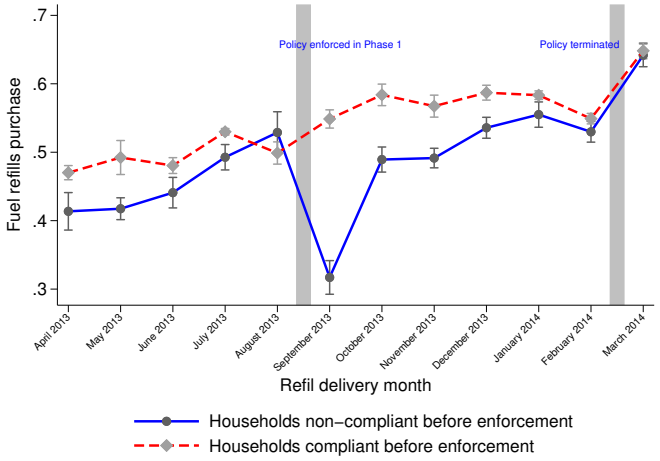
Notes: The above plot shows the impact of DBTL policy on household fuel sales using a household-month panel dataset. The dependent variable is the number of 14.2kg household gas refills purchased by a household account in a given month. Household account and month fixed effects are included. The sample includes gas refill transactions from 3,481,298 household accounts covering April 2013 to March 2014. This is a 10% sample from administrative records of HPCL. There are 16 Phase 1 districts in the treatment group and 473 districts in the control group (including Phase 3 to Phase 6 and the remaining non-policy districts). The policy was terminated on March 10, 2014. 95% confidence intervals for the regression-adjusted mean gas sales in the DBTL policy group and control group districts are shown. Standard errors are clustered at the district level.

Figure D.7. : Impact of DBTL on gas purchases by genuine household accounts



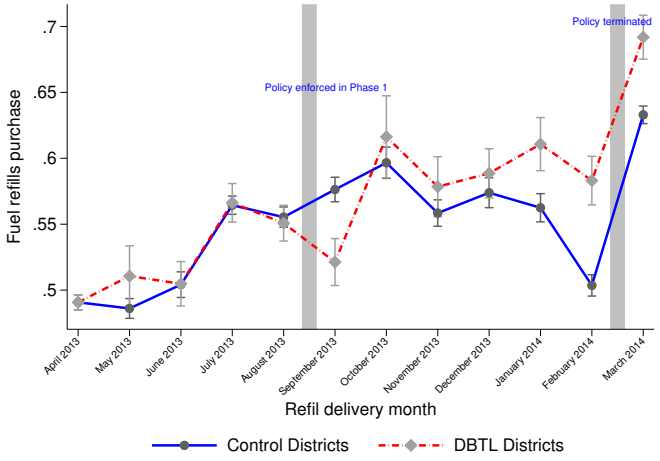
Notes: This plot shows gas refill purchases by DBTL-enrolled households in DBTL districts (Phase 1) and control group districts (Phase 6). Assuming only genuine households can enroll in DBTL, this provides a comparison of gas purchase by genuine households in treated districts with mandatory enrollment against genuine households in control districts with voluntary enrollment. Since the policy was introduced in Phase 6 districts in January 2014, this control group remains relatively free from concerns related to any effect of voluntary DBTL on household gas purchases (specifically, between September and December 2013). Household and month fixed effects are included. Standard errors, clustered at the district level, are in parentheses.

Figure D.8. : Gas purchase by early- vs. late-enrollee households in DBTL Phase 1 districts



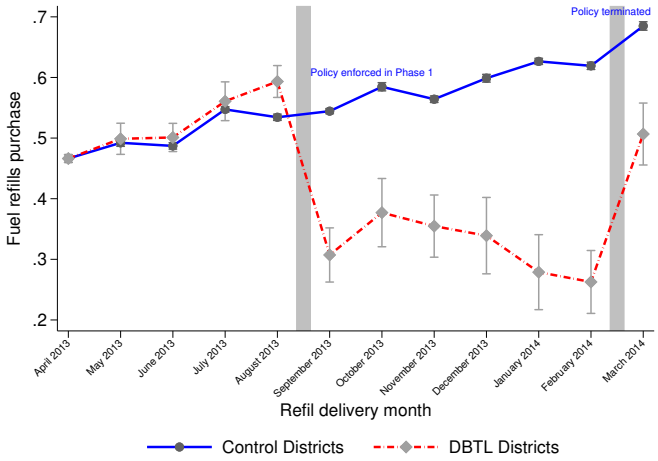
Notes: This coefficient plot compares gas purchases by late versus early DBTL enrollee households in DBTL Phase 1 districts. Late-enrollee households decreased their gas purchases in the first month of enforcement and then gradually converged with early-enrollee households. Late-enrollee households comprise about 20% of all households. 95% confidence intervals with standard errors clustered at the district level are shown.

Figure D.9. : Gas purchases by late-enrollee household accounts in DBTL districts vs. all household accounts in voluntary DBTL districts



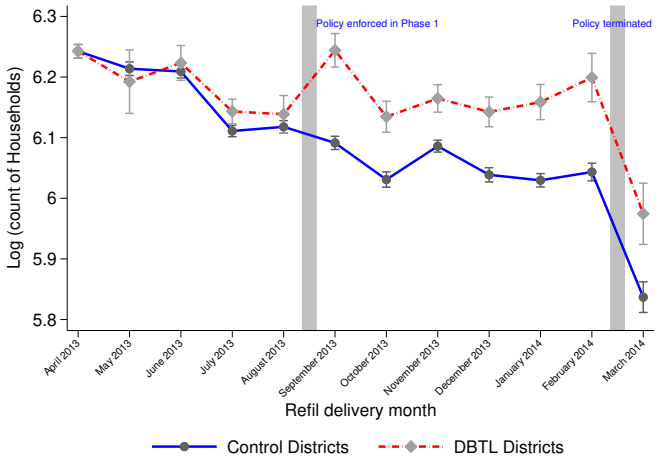
Notes: This graph shows gas purchases of late-enrollee households in Phase 1 districts compared to all enrollee households in voluntary enrollment districts. Household-month level data is used. Household account and month fixed effects are used. 95% confidence intervals with standard errors clustered at the district level are shown.

Figure D.10. : Gas purchased by household accounts who did not enroll in DBTL



Notes: The above plot shows the impact of DBTL policy on gas sales to household accounts in Phase 1 districts that did not enroll in DBTL by its termination in March 2014. Household-month level data is used. DBTL districts include all districts where DBTL was enforced in September 2013, and the control group includes districts with voluntary DBTL enrollment and those where DBTL was not yet scheduled for implementation. Household account and month fixed effects are included. 95% confidence intervals for the regression-adjusted mean gas sales in the DBTL policy group and control group districts are shown. Standard errors are clustered at the district level.

Figure D.11. : Impact of DBTL on number of household accounts not purchasing any gas



Notes: This plot shows the impact of DBTL on the number of households who did not purchase any gas refills in a given month. The outcome variable is the log of the number of zero-refill households, where the number of zero-refill households is calculated at distributor-month level. The treated group includes distributors in DBTL Phase 1 districts, and the control group includes distributors in DBTL Phases 3 to 6. Distributor and month fixed effects are included. 95% confidence intervals with standard errors clustered at the district level are shown.

Table D.1—: Testing for pretrends with a placebo DBTL policy

	(1)	(2)	(3)	(4)	(5)	(6)
	Gas refills purchased					
Year 2011-12 X DBTL	-0.00365	-0.000179	0.00248	0.00643	-0.00952	-0.00673
	(0.00756)	(0.00704)	(0.00817)	(0.00757)	(0.00829)	(0.00791)
Year 2011-12	-0.0280	-0.0322	-0.0341	-0.0373	-0.0221	-0.0251
	(0.00329)	(0.00345)	(0.00452)	(0.00443)	(0.00473)	(0.00487)
Monthly Cons/Exp (Rs.)		2.42e-06		1.94e-06		2.04e-06
		(4.48e-07)		(3.78e-07)		(4.73e-07)
Household size		0.0379		0.0402		0.0345
		(0.00131)		(0.00197)		(0.00156)
Constant	0.560	0.365	0.537	0.342	0.553	0.376
	(0.00159)	(0.00654)	(0.00202)	(0.00946)	(0.00207)	(0.00801)
Observations	94,889	94,889	55,274	55,274	57,176	57,176
R-squared	0.145	0.280	0.135	0.282	0.175	0.280
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Control Districts	All	All	Ph3-6	Ph3-6	Non-policy	Non-policy
Mean	0.566	0.566	0.552	0.552	0.579	0.579
Controls		Yes		Yes		Yes

Notes: This regression estimates the impact of a placebo DBTL policy on household gas consumption using data from the National Sample Survey rounds 2009-10 and 2011-12 (pooled cross-sectional household survey data). The outcome variable is self-reported gas consumption by households in the preceding month. Households provide information on the amount of gas they have purchased in the preceding month, which is then converted into the number of 14.2kg household gas refills. Since there is concern about non-reporting bias by households that did not purchase gas in the previous month, gas purchases are scaled by the median gas purchase in the administrative data. Both surveys were conducted before DBTL implementation in 2013-14. The placebo test assumes that DBTL was instead implemented between these two survey rounds. Here, the estimated difference-in-differences estimate would indicate whether there was any change in household gas consumption in the DBTL districts with respect to control districts three years before the DBTL policy was actually implemented. District and year fixed effects are included. Controls in even-numbered columns include monthly expenditure and household size. Phase 1 and Phase 2 districts are included in the DBTL group. Results are available for both phases separately (not reported). Columns 1 and 2 combine all upcoming phases and non-policy districts together as the control group. Columns 3 and 4 only include voluntary DBTL districts in the control group, while Columns 5 and 6 only include districts where DBTL was not yet scheduled in the control group. Standard errors are in parentheses. Standard errors are clustered at the district level.

Table D.2—: Impact of DBTL on gas sales (Phase 2 districts)

	(1)	(2)	(3)	(4)
	log(Household LPG sales)		log(Commercial LPG sales)	
DBTL X Post	-0.313		0.132	
	(0.0261)		(0.0432)	
DBTL X Post Termination		0.224		-0.113
		(0.0242)		(0.0486)
Observations	164,303	133,182	132,556	104,057
R-squared	0.943	0.950	0.921	0.922
Distributor FE	Yes	Yes	Yes	Yes
State-Month FE	Yes	Yes	Yes	Yes

Notes: This table reports regression estimates of the impact of the DBTL policy roll-out and termination on gas purchased by household accounts (Columns 1 and 2) and commercial accounts (Columns 3 and 4) in Phase 2 districts. The data consists of a distributor-month level panel covering the time period before and during the DBTL policy (January 2013 - February 2014) in Columns 1 and 3, and the time period during DBTL and post-termination of the policy (January 2014 - October 2014) in Columns 2 and 4. DBTL was mandatory in Phase 2 districts from January 1, 2014, till March 9, 2014. The outcome variable is the log of the number of 14.2kg gas refills sold to household accounts and 19kg gas refills sold to commercial accounts by distributors in a given month. The treated group includes all DBTL Phase 2 districts in the sample. The control group includes districts in DBTL Phases 3-6 and districts not yet scheduled for DBTL roll-out. Distributor and state-by-month fixed effects are included. Standard errors, clustered at the district level, are in parentheses.

Table D.3—: Impact of DBTL on gas sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(Subsidized household LPG)		log(Unsubsidized household LPG)		log (Commercial LPG)		log(total unsubsidized LPG)	
Panel A: DBTL Policy Roll-out								
DBTL X Post	-0.371	-0.381	2.396	2.372	0.126	0.136	1.289	1.289
	(0.0424)	(0.0425)	(0.172)	(0.154)	(0.0370)	(0.0421)	(0.114)	(0.113)
Observations	160,527	160,527	67,917	67,917	129,668	129,668	136,621	136,621
R-squared	0.939	0.940	0.766	0.790	0.920	0.923	0.886	0.893
Panel B: DBTL Policy Termination								
DBTL X Post Termination	0.330	0.358	-2.363	-2.731	-0.0753	-0.132	-1.211	-1.372
	(0.0381)	(0.0389)	(0.272)	(0.292)	(0.0377)	(0.0437)	(0.0963)	(0.0855)
Observations	178,803	178,803	81,108	81,108	141,174	141,174	150,279	150,279
R-squared	0.942	0.943	0.741	0.764	0.917	0.920	0.905	0.910
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE, State-Month trend	Yes	No	Yes	No	Yes	No	Yes	No
State-Month FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes: This table reports regression estimates of the impact of the DBTL policy roll-out (panel A) and termination (panel B) on subsidized and unsubsidized gas purchased by household accounts (Columns 1-4), unsubsidized gas purchased by commercial accounts (Columns 5-6), and total unsubsidized gas (i.e., the sum of commercial and unsubsidized household gas) sold (Columns 7-8). The data consists of a distributor-month level panel covering the time period before and during the DBTL policy (panel A), and the time period during DBTL and post-termination of the policy (panel B). The outcome variable is the log of the number of gas refills of type x sold by distributors in a given month, where x is subsidized household gas, unsubsidized household gas, commercial gas, and total unsubsidized gas (i.e., the sum of commercial and unsubsidized household gas). Note that columns 5-6 replicate columns 1-2 in Tables 6 and 7. The treated group includes all DBTL Phase 1 districts in the sample, and the control group includes districts in DBTL Phases 3-6 and districts not yet scheduled for DBTL roll-out. All odd-numbered columns include month fixed effects and state-month linear trends. All even-numbered columns include state-by-month fixed effects. Standard errors, clustered at the district level, are in parentheses.

Table D.4—: Impact of DBTL on household gas purchase in Phase 1 districts (Household accounts panel)

	(1)	(2)	(3)
	Gas refills purchased by household accounts		
DBTL X Post	-0.0647	-0.0578	-0.0743
	(0.00350)	(0.00357)	(0.00431)
Observations	38,294,278	29,814,648	13,435,235
R-squared	0.188	0.184	0.188
Mean of outcome var	.548	.551	.540
Households	3,481,298	2,541,287	1,221,385
Household FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Control group	Ph 3-6	Ph 3-6	Non-policy

Notes: This table reports regression estimates of the impact of DBTL on gas purchases by household accounts. A household-month level panel is used covering the time period before and during the DBTL policy reform. The outcome variable is the number of 14.2kg gas refills purchased by a beneficiary in a given month. Household and month fixed effects are included. The treated group includes all DBTL Phase 1 districts in the sample. Columns 1-2 combine districts in Phases 3-6 districts not on the DBTL implementation schedule together as the control group, while Columns 3-4 and Columns 5-6 present estimates separately for each control group. Standard errors are in parentheses. Standard errors are clustered at the district level.

Table D.5—: Impact of DBTL on household gas purchase in Phase 2 districts (Household accounts panel)

	(1)	(2)	(3)
	Gas refills purchased by household accounts		
DBTL X Post	-0.131	-0.120	-0.158
	(0.00618)	(0.00650)	(0.00658)
Observations	38,473,864	28,133,743	13,614,821
Households	3,497,624	2,557,613	1,237,711
Mean of outcome var	.546	.542	.535
Household FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Control group	Ph 3-6 & Non-policy	Ph 3-6	Non-policy

Notes: This table reports regression estimates of the impact of DBTL on gas purchase by household accounts in DBTL Phase 2 districts. A household-month level panel covering the period before and during DBTL policy reform is used covering April 2013 to February 2014. The outcome variable is the number of 14.2kg gas refills purchased in a month. Household and month fixed effects are included. The treated group includes all Phase 2 districts in the sample. Columns 1-2 combine districts in Phases 3-6 districts not on the DBTL implementation schedule together as the control group, while Columns 3-4 and Columns 5-6 present estimates separately for each control group. Standard errors are in parentheses. Standard errors are clustered at the district level.

Table D.6—: Impact of DBTL policy termination on current black-market price

	(1)	(2)	(3)	(4)	(5)	(6)
	log(price)					
	A. Deliverymen survey					
DBTL X Post Termination	-0.0580	-0.174	-0.184	-0.0222	-0.100	-0.00761
	(0.0258)	(0.0322)	(0.0324)	(0.0261)	(0.0447)	(0.0589)
Observations	1,202	1,202	1,202	838	838	838
R-squared	0.787	0.801	0.837	0.830	0.842	0.857
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Survey Date FE		Yes	Yes		Yes	Yes
State by Survey Round FE			Yes			Yes
	B. Small Business survey					
DBTL X Post Termination	-0.128	-0.205	-0.244	-0.0973	-0.264	-0.319
	(0.0546)	(0.0646)	(0.0631)	(0.0553)	(0.114)	(0.121)
Observations	1,926	1,926	1,926	1,334	1,334	1,334
R-squared	0.790	0.803	0.819	0.814	0.824	0.839
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Survey Date FE		Yes	Yes		Yes	Yes
State by Survey Round FE			Yes			Yes
Treatment Districts	Phases 1&2			Phases 1&2		
Control Districts	Phases 3-6 & Non-policy			Phases 3-6		

Note: This table reports the impact of the DBTL policy termination on the ongoing black market prices. Panel A uses data collected from deliverymen in the audit survey. Panel B uses data from small business survey. The outcome variable, i.e., black market price for household gas refill in INR, is log transformed. All regressions include district fixed effects in Panel A and small business (firm) fixed effects in Panel B. In both panels, columns 2 and 5 include survey date fixed effects and columns 3 and 6 include state by survey round fixed effects. Columns 1-3 in each panel show results with the control group including all districts where DBTL policy was available for voluntary take-up (Phase 3-6) as well as districts where DBTL policy was not yet introduced (Non-policy districts). Columns 4-6 include only voluntary DBTL districts as control. Results with non-policy districts in the control group are reported in the paper. Standard errors, clustered at the district level are in parentheses.

Table D.7—: Impact of DBTL Policy Termination on Black-market Price (Refill History Data from Small Businesses)

	(1)	(2)	(3)	(4)	(5)
			log(price)		
DBTL X Post Termination	-0.0786	-0.176	-0.169	-0.138	-0.197
	(0.0385)	(0.0254)	(0.0241)	(0.0253)	(0.0283)
Observations	2,508	2,754	2,773	1,731	1,325
R-squared	0.926	0.902	0.902	0.911	0.865
No. of Districts	74	79	81	53	37
No. of Firms	657	709	714	449	327
Firm and Purchase date FE	YES	YES	YES	YES	YES
Treatment Districts	Ph 1	Ph 2	Ph 1 & 2	Ph 1 & 2	Ph 1 & 2
Control Districts	Ph 3-6 & Non-policy			Ph 3-6	Non-policy

Notes: This table reports the impact of the DBTL policy termination on black market prices paid by small businesses using gas refill purchase history data collected in the survey. The outcome variable, i.e., the black-market price for household gas refill in INR, is log transformed. In the survey, each small business was asked for the date and price of their last five gas refills, resulting in a firm-by-date panel data set. The sample used here is restricted to black-market refills purchased during February and March 2014. Small Business (Firm) and refill date level fixed effects are included in all regressions. As indicated in the bottom two rows, different sets of districts are included in treatment and control groups to check for robustness. Standard errors, clustered at the district level, are in parentheses.

Table D.8—: Impact of DBTL on household service quality

	(1)	(2)	(3)
	Delay in household gas refills delivery (days)		
DBTLXPost	-0.788	-0.800	-0.754
	(0.283)	(0.303)	(0.300)
Observations	19,251,397	14,004,707	6,789,013
R-squared	0.518	0.527	0.478
Household FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Control Districts	Ph3-6 & Non-policy	Ph3-6	Non-policy
Mean delay (days)	3.488	3.725	3.009

Notes: This table presents difference-in-differences estimates of the impact of DBTL policy on service quality observed by households. The outcome variable is the delay (in days) in gas refill delivery to households by distributors and deliverymen, which represents the difference between the order date and the delivery date for gas refills. Household-month level panel data covering the time period before and during the policy reform (April 2013 to February 2014) is used. The average time for gas refill delivery is 3.4 days. Columns 1 and 2 combine districts in Phase 3-6 and districts not on the DBTL implementation schedule by March 2014 together as the control group; Columns 3 and 4 present estimates for a control group including districts in Phase 3-6 only; and Columns 5 and 6 for a control group including only those districts not on the DBTL implementation schedule. The treatment group consists of DBTL Phase 1 districts, while all districts where DBTL was never mandatory are in the control group. Household account and month fixed effects are included. Standard errors, clustered at the district level, are in parentheses.

Table D.9—: Impact of DBTL across the incidence of subsidy take-up before DBTL

	(1)	(2)	(3)	(4)
	Subsidized household gas refills purchased			
DBTL X Post	-0.160	-0.124	-0.163	-0.108
	(0.0139)	(0.0159)	(0.0137)	(0.0188
DBTL X Post X High Refills HH a/c	-0.110	-0.104		
	(0.0255)	(0.0249)		
DBTL X Post X (Refills=1)			0.0103	0.00336
			(0.00851)	(0.00856)
DBTL X Post X (Refills=2)			0.0132	0.00890
			(0.00847)	(0.00852
DBTL X Post X (Refills=3)			-0.0118	-0.0118
			(0.0113)	(0.0108)
DBTL X Post X (Refills=4)			-0.0584	-0.0548
			(0.0167)	(0.0156)
DBTL X Post X (Refills=5)			-0.123	-0.115
			(0.0201)	(0.0187)
DBTL X Post X (Refills=6)			-0.204	-0.193
			(0.0312)	(0.0316)
Observations	38,294,278	38,294,278	38,294,278	38,294,278
R-squared	0.195	0.197	0.212	0.214
Household accounts FE	Yes	Yes	Yes	Yes
Month FE	Yes		Yes	
State by Month FE		Yes		Yes
Household accounts		3.481 million		
Mean of outcome variable		0.536		

Notes: This table estimates the impact of DBTL across the distribution of pre-DBTL gas subsidy take-up by household accounts. The outcome variable is the number of subsidized gas refills purchased by household accounts. The sample includes transactions before and during DBTL policy reform. In columns 1 and 2, High Refills Household Accounts are defined as household accounts (hh a/c) with 5 or more gas refills purchased during the five months preceding the DBTL roll-out (April-August 2013). In columns 3 and 4, the interactions of DBTL X Post with the dummy variables for the number of refills purchased in the pre-DBTL period are included. Household accounts with at least six pre-DBTL refills are binned together. The full set of interactions is included, though only coefficients of interest are presented in the table. Columns 1 and 3 include household account and month fixed effects, while columns 2 and 4 include household and state by month fixed effects. Standard errors, clustered at the district level, are in parentheses.

Table D.10—: Impact of DBTL on number of household accounts purchasing no gas refills

	(1)	(2)	(3)
	log(Count of household accounts purchasing no gas refills)		
DBTL X Post	0.128	0.111	0.154
	(0.00697)	(0.00748)	(0.00777)
Observations	32,439	20,493	13,596
R-squared	0.983	0.986	0.980
Distributor FE	Yes	Yes	Yes
Month FE	Yes	Yes	Yes
Control Districts	Ph 3-6 & Non-Policy	Ph 3-6	Non-Policy

Notes: This table reports regression estimates of the impact of DBTL policy enforcement on the number of household accounts that did not purchase any gas refill in a given month. The outcome variable is log of number of household accounts which did not purchase any gas refill in the distributor-month level data. The distributor-month level panel is created by collapsing the household-month data. The treatment group consists of DBTL Phase 1 districts, while all districts where DBTL was never mandatory are in the control group. Data covers the time period before and during DBTL (April 2013 - February 2014). Distributor and month fixed effects are included. Standard errors are in parentheses and are clustered at the district level.

D3. Implementation Issues and Exclusion

It is important to discuss the implications of late- and non-enrollees for the estimates of diversion reduction. Household accounts enrolling in DBTL after the mandatory DBTL start date are categorized as late-enrollee households. Likewise, households enrolling in DBTL before DBTL became mandatory (i.e., during the voluntary DBTL period) are considered early-enrollee households. Household accounts that did not enroll in DBTL till its termination in March 2014 are categorized as non-enrollees.

The analysis in this section uses household-account by month level panel data on household gas purchases, constructed from the information on gas refill transactions by about 10% of household accounts under HPCL for the 2013-14 fiscal year. Table D.4 shows that the DBTL led to a 10%-14% decrease in household gas purchases. The coefficient on the interaction term in column 1 suggests a decrease of 0.0638 in monthly household gas refills, which is about 12% of the average number of gas refills per household per month. Columns 2 and 3 show estimates using alternative definitions of the control group.

Voluntary Non-Enrollment in DBTL: There is some evidence supporting voluntary non-enrollment in DBTL. The option to purchase household gas without subsidy did not exist prior to DBTL. Households may have decided not to enroll in DBTL for a number of reasons. Rich households may not need the subsidy and prefer to leave it for relatively less well-off households. They may value the privacy of sensitive data such as bank details and Aadhaar more than the gas subsidy. Alternatively, households may want to avoid any stigma associated with accepting subsidies.

Late Enrollment in DBTL: About 20% households in the DBTL districts enrolled after DBTL became mandatory. Delayed DBTL enrollment by households would bias the household gas leakage reduction estimated in Section IV.A upward to the extent that these delays affected household gas refill purchases during DBTL.

Figure D.7 compares the pattern of household gas refill purchases by DBTL-enrolled households in the earliest DBTL Phase (i.e., Phase 1) districts to household gas purchases by voluntarily enrolled households in later DBTL Phase (i.e., Phase 6) districts. Phase 6 provides a suitable control group here because DBTL was not introduced until January 2014. Except for the timing of enrollment, these two groups are similar and are unlikely to include ghost or duplicate beneficiaries. The coefficient plot shows that the household fuel purchase pattern is broadly similar across both groups.

Second, households may have been strategic in timing their next gas refill purchase, choosing when to enroll in DBTL accordingly. One possible explanation for this is household storage of gas. Households have significant storage capacity by design. A 14.2kg gas refill lasts almost two months for the median household, and households are able to keep up to two gas cylinders at a time.[24] Refills data shows that more than 90% of households do not need to purchase a gas refill every month. Thus, the relatively large dip observed in the first months of DBTL enforcement (seen in Figure D.6) may be partially attributed to an intertemporal substitution in purchase decisions. This would attenuate the estimates of the impact on household gas sales. However, given the total DBTL period of six months, this should not significantly affect the magnitude of the average effect. Rather, a relatively constant difference between policy-treated and control districts during the three interior months (October-December 2013) of DBTL enforcement indicates a stable pattern of gas purchases. This is despite more than 20% of households gradually enrolling in DBTL from September 2013 to February 2014.

Finally, I compare gas purchases by late-enrollee households to those by early-enrollee households in DBTL districts (Figure D.8) and to those of voluntarily enrolled households in districts where

[24]Keeping more than two gas cylinders per household is illegal, and the supply of empty gas cylinders is controlled by OMCs. However, much like gas itself, empty gas cylinders can also be purchased on the black market.

DBTL was not yet made mandatory (Figure D.9). Households that enrolled late did reduce their gas refill purchases immediately after the enforcement of DBTL, but they also compensated for it in subsequent months. These results provide some assurance against the concern that delayed DBTL enrollment caused significant reductions in household gas purchases.

Genuine Exclusion from DBTL: About 20% of beneficiaries in the treated districts had not enrolled for direct transfers by the time the DBTL policy was terminated. Some of this may be reflective of duplicate and ghost accounts that were unable to provide the required documentation for DBTL enrollment and were thus excluded by design. Second, well-off households may voluntarily not enroll in DBTL for the reasons discussed above. Third, genuine households without a bank account or Aadhaar would be unable to continue purchasing gas refills if the unsubsidized price was too high. This third sub-group poses the main concern to the estimated impact of DBTL on household gas leakage. While the administrative data does not provide a foolproof way of distinguishing between these three categories, it still offers some useful insights, as discussed below.

First, panel (a) of Figure 4 offers descriptive evidence that household gas accounts that purchased more than four household gas refills in the pre-DBTL period were less likely to enroll in DBTL. Further, the percentage enrollment declines at higher pre-DBTL refill counts. Household accounts that did not enroll in DBTL are also more likely to stop purchasing household gas in response to DBTL. Figure D.10 shows that there was a significant drop in gas refills purchased by household accounts that did not enroll in DBTL, as compared to all household accounts in Phases 3 through 6. By comparison, there is no similar drop in household fuel purchases by those household accounts that enrolled in DBTL but with some delay.

Second, I explore whether the proportion of household users purchasing zero refills responds to the introduction of the DBTL policy. Table D.10 reports that the DBTL policy caused a 10% to 13% increase in the total number of household accounts that did not buy a single household gas refill in a given month, irrespective of DBTL enrollment. To further investigate whether this effect is driven by low gas refill purchases in the first enforcement month (or the last month before policy-termination), Figure D.11 shows in DBTL districts there were more households which purchased zero gas refills throughout the entire DBTL enforcement period.

Third, Figure D.3 shows that the overall participation remained much lower among households that purchased more gas during the pre-DBTL period. Note that the steepest enrollment increase is among households that did not purchase a single gas refill in the pre-enforcement period, suggesting that these likely represent new gas customers.

These empirical patterns highlight a couple of important points. First, household accounts that failed to enroll in DBTL have different pre-treatment purchase behaviors. Second, while late-enrollee household accounts do not show a significant reduction in their purchase of gas refills during the DBTL period, non-enrollee household accounts significantly reduced their gas purchases during this period. Third, The number of household accounts purchasing zero refills during the enforcement period also aligns with the narrative that a significant proportion of ghost and duplicate account holders were forced to exit the black market when the DBTL policy became mandatory. Finally, taken together with the discussion on potential exclusion due to bank accounts and Aadhaar in Section D.D3, the proportion of legitimate households who failed to purchase household gas because of DBTL is unlikely to be significant.

D4. Magnitude of changes in gas sales

Here I discuss the magnitude of absolute changes in gas sales due to DBTL policy. The reduction in household (subsidized) gas sales should be quantitatively related to the increase in commercial (unsubsidized) gas sales. First, I compare household vs. commercial gas to provide a lower bound by combining all household gas refills together, irrespective of subsidy. The second approach, subsidized vs. unsubsidized gas, provides an upper bound by classifying gas refills on the basis of

subsidy. It is important to note that such comparisons are not straightforward for a number of reasons, and so, it should be interpreted with caution. Commercial users may switch to alternative fuels and reduce gas usage if they are unable to access cheap gas from the black market. Further, the commercial 19kg gas sales data used in this paper only covers commercial 19kg gas accounts primarily served by those gas distributors that also sell household gas. It therefore excludes commercial gas purchases in larger quantities and those intended for use as vehicle fuel. In addition, the possibility of storage and anticipation distorts the comparison in either approach, at least in the months immediately before and after the policy change. It is of particular concern if households strategically purchase and store gas before policy implementation, or they pause buying gas once they know that the policy is likely to be terminated soon. To address this, I drop the months immediately before and after the policy change while comparing changes in levels.

Under the first approach, I compare changes to total household gas sales to changes to commercial 19kg gas sales; the latter is about 15% of the former (columns 1,2,5 and 6 in Table D.11). Thus, a 100 kg reduction in household gas purchases translates to roughly a 15 kg increase in commercial gas purchases. Under the assumption that changes to commercial 19kg gas sales represent the full extent of diversion of household gas to the black market, this means that about 15% of the reduction in household gas sales can be attributed to a reduction in diversion. However, this estimate should be considered a lower bound, as irrespective of DBTL, 14.2kg household gas refills remained available at an unsubsidized price to all household accounts, genuine and otherwise. It is possible that a significant proportion of unsubsidized household gas (which remained cheaper than commercial gas due to additional taxes on the latter – see Figure 2a) was diverted to commercial users once DBTL was implemented. The main analysis in this paper (as shown in Tables 4- 7 and Figures 5-6) takes a conservative approach by considering all 14.2kg household gas refills (i.e., both subsidized and unsubsidized refills) as 'household gas', though, in reality, agents operating ghost accounts can continue to purchase 14.2kg gas refills at unsubsidized prices and divert them to the black market.[25]

The second approach uses information on whether the gas refill is subsidized or not. Household gas sales are broken down into subsidized and unsubsidized gas refills. DBTL policy directly affects the former *only*, and unsubsidized household gas remains available for purchase to household accounts regardless of DBTL enrollment. This means a reduction in diversion of subsidized household gas may also increase sales of unsubsidized household gas, which may in turn be diverted to the black market. Corresponding difference-in-differences estimates of the policy impact are provided in Table D.3. I compare changes in subsidized household sales to changes in combined commercial 19kg gas sales and unsubsidized household gas sales; the latter is about 68-73% of the former (columns 3,4,7 and 8 in Table D.11). This suggests that a 100 kg reduction in subsidized gas sales translates to about 72 kg increase in unsubsidized gas sales. An important caveat here is that any purchase of unsubsidized household gas refills by legitimate households that did not enroll in DBTL voluntarily or were excluded involuntarily can not be accounted for using this approach. For this reason, this estimate may be biased upward and should be considered as an upper bound.

An alternate and preferred way to compare the decrease in the amount of subsidized household gas to the increase in unsubsidized household gas and commercial gas sales. A DBTL-induced 100 kg decrease in the subsidized household gas purchase is associated with an increase of 68 kg in unsubsidized household gas and 5 kg in commercial gas purchases. Assuming no changes in household demand for gas under DBTL, this indicates that DBTL shifted the diversion from subsidized to unsubsidized household gas to a great extent. The average black market prices collected during the DBTL period were higher than the official unsubsidized household gas price but lower than the commercial gas price. This suggests that, while commercial gas sales increased

[25] While this approach of combining subsidized and unsubsidized household gas sales may lead to biased estimates of the policy's impact on leakage reduction, this bias would only make it more difficult to detect any effect of the DBTL policy.

in response to DBTL, a large margin of tax evasion remains open that DBTL was not designed to address.

Table D.11—: Magnitude of changes in gas sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LPG sales (in '000 Kg)							
	Household	Commercial	Subsidized	Total unsubsidized	Household	Commercial	Subsidized	Total unsubsidized
Panel A. District-level regressions								
DBTL X Post	-234.2	35.38	-726.9	528.1				
	(104.9)	(25.22)	(152.8)	(195.2)				
DBTL X Post termination					297.7	-44.14	793.1	-539.5
					(54.84)	(25.44)	(219.3)	(195.3)
Observations	5,190	5,190	5,190	5,190	7,143	7,143	7,143	7,143
R-squared	0.979	0.978	0.981	0.921	0.995	0.989	0.995	0.927
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Policy change	DBTL roll-out				DBTL termination			
	$\frac{\Delta Commercial\ sales}{\Delta Household\ sales}$=15.11%		$\frac{\Delta Non-subsidized\ sales}{\Delta Subsidized\ sales}$=72.65%		$\frac{\Delta Commercial\ sales}{\Delta Household\ sales}$=14.82%		$\frac{\Delta Non-subsidized\ sales}{\Delta Subsidized\ sales}$=68.03%	
Panel B. Distributor-level regressions								
DBTL X Post	-7.444	1.090	-22.81	16.45				
	(1.499)	(0.545)	(3.136)	(3.953)				
DBTL X Post termination					8.950	-1.385	24.24	-16.68
					(0.670)	(0.619)	(3.873)	(4.022)
Observations	109,908	109,908	109,908	109,908	165,397	165,397	165,397	165,397
R-squared	0.974	0.955	0.972	0.900	0.975	0.953	0.973	0.892
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Policy change	DBTL roll-out				DBTL termination			
	$\frac{\Delta Commercial\ sales}{\Delta Household\ sales}$=14.64%		$\frac{\Delta Non-subsidized\ sales}{\Delta Subsidized\ sales}$=72.14%		$\frac{\Delta Commercial\ sales}{\Delta Household\ sales}$=15.48%		$\frac{\Delta Non-subsidized\ sales}{\Delta Subsidized\ sales}$=68.79%	

Notes: This table reports regression estimates of the impact of DBTL policy roll-out and termination on gas sales. Gas sales are classified in two ways. Commercial users are sold 19kg gas refills (unsubsidized) and household accounts are sold 14.2kg gas refills (subsidized or unsubsidized). The first classification is based on commercial and household gas refills. The second classification combines both types of unsubsidized gas sales (i.e., commercial as well as unsubsidized household gas) together in one group, and keeps subsidized household gas refills in the other group. The DBTL roll-out period (columns 1-4) uses data from April 2013 to January 2014. The DBTL termination period (columns 5-8) uses data from October 2013 to October 2014. The months immediately before and immediately after the policy change (Aug-Sep 2013 and Feb-Mar 2014) are dropped to minimize concern about anticipation and storage. Phase 1 districts are included in the DBTL group. Districts in Phases 3-6 and non-policy districts are combined to create the control group. Panel A uses district-month level data, and panel B uses distributor-month level data. All regressions include state-month fixed effects. Standard errors are in parentheses and are clustered at the district level.