

567 Seminar

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

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- Health Impacts of the Green Revolution: Evidence from 600,000 Births across the Developing World. with Aaditya Dar, Ram Fishman, Gordon McCord, Nathan Mueller, and Jan von der Goltz. *Journal of Health Economics*, 2020.
- Mines: The Local Wealth and Health Effects of Mineral Mining in Developing Countries. with Jan von der Goltz. *Journal of Development Economics*, 2019.
- Assessment of Excess Mortality and Household Income in Rural Bangladesh During the COVID-19 Pandemic in 2020. with Yuling Yao, Yiqian Wang, Nishat Akter Juy, Shabib Raihan, Mohammad Ashraful Haque, and Alexander van Geen. *JAMA Network Open*, 2021.
- ...

Note:This research was started and conducted when Barnwal was a student at Columbia University.(First draft: November 2014; Publish: December 2024)

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Overview

Economics Question

How to improve in-kind subsidy programs and reduce corruption arbitrage?

The design of welfare programs in many low- and middle- income countries (LMICs) includes a combination of targeting and price subsidies, whereby prices of essential commodities such as food and fuel are subsidized for targeted beneficiaries.

In 2013, the government of India introduced Direct Benefit Transfer for LPG (DBTL), a reform whereby the over- the-counter price subsidy for gas was replaced with a direct transfer of the subsidy into beneficiary bank accounts.

Key Contributions

- **First Contribution:**
  - Empirical evidence on how dual price systems in targeted subsidies lead to leakage and diversion of public funds.
  - Shows that replacing subsidies with direct income transfers can reduce corruption and leakage.
  - Validates conjectures from prior work (Alderman 2002; Kojima 2013; Kotwal et al. 2011; Beegle et al. 2018; Khera).
- **Second Contribution:**
  - Demonstrates the value of modern technologies (e.g., biometric identification, bank accounts) in expanding state capacity in LMICs.
  - Highlights how modern payments infrastructure enables new policy implementations (e.g., Aadhaar in India, electronic food vouchers in Indonesia).
- **Third Contribution:**
  - Advances in detecting corruption using black market price changes as a proxy.
  - Methodological approach applicable to other contexts for detecting diversion of subsidized commodities.

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Background

Why India's cooking gas subsidy program?

- **Gas is a homogenous good.**
  The assumption that goods provided to beneficiaries by the state at a subsidized price are of the same quality as goods purchased by nonbeneficiaries in the open market is unlikely to be true in most in-kind transfer programs.
- **The base price of gas** (i.e., the unsubsidized household gas price) **is regulated by the Indian government in tandem with plausibly exogenous global prices and adjusted each month, while the subsidized price remains constant over the period of interest.**
  Thus, local demand and supply factors do not affect official subsidized or unsubsidized gas prices for users.

Public Distribution System for Cooking Gas

Three oil marketing companies (OMCs), controlled by the Indian Ministry of Petroleum and Natural Gas, supply gas to households and commercial consumers such as restaurants and businesses across the country.

- Two types categorised by distributors selling the gas refills to.
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Historically, political connections and bribes have played an important role in the allotment of gas distributorships, gas stations, and food PDS ration shops in India.

Pricing and Subsidy

Gas is subsidized for household cooking use only, while it is taxed for commercial users and when households want to use it for other purposes (e.g., as vehicle fuel).

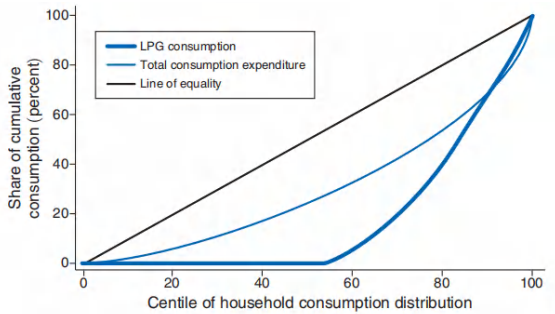


FIGURE 1. LPG SUBSIDY TARGETING

Notes: This graph shows the inequality in household gas purchase using NSS 68th round (2011–2012) household survey data. The 45-degree line shows the equal distribution, while the light blue curve shows the distribution of total expenses, as a proxy for income. The bold-blue curves shows the distribution of household gas purchase.

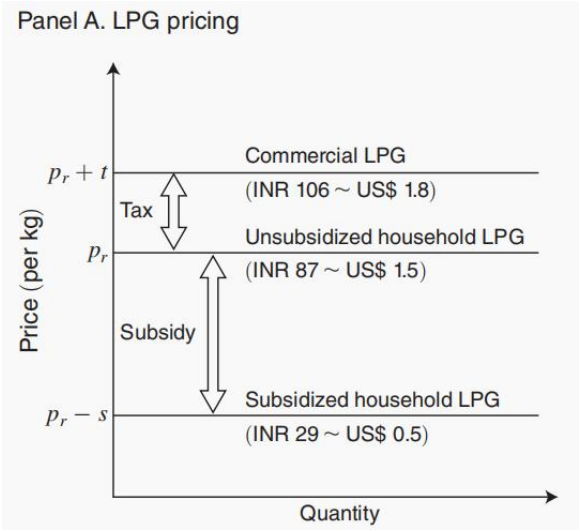
All households can get subsidies, but mostly middle- to higher-income families used.

Pricing and Subsidy

Three different prices for cooking gas.

- the subsidized household gas price (p − s)
- the unsubsidized household gas price (p)
- the commercial gas price (p + t)

p is similar to a base (roughly regulated price) the international market price.
(p − s) stable using a floating subsidy amount s, making the subsidized gas price households face effectively constant over time.
p + t. The additional tax on commercial gas t consists mostly of excise and value-added taxes.



Pricing and subsidy

To purchase gas refills, households need to open an account at the local distributorship for a net cost of about 6 US$.

- In 2013, household accounts were entitled to up to nine 14.2 kg refills.
- The government allowed households to purchase one additional subsidized refill each in February and March 2014.
- From 2014–2015 onwards, households can purchase up to twelve subsidized 14.2kg refills in a year.

The annual cap of nine 14.2kg gas refills at the time of DBTL implementation was exceeded by less than 5% of household accounts, as per the administrative data.

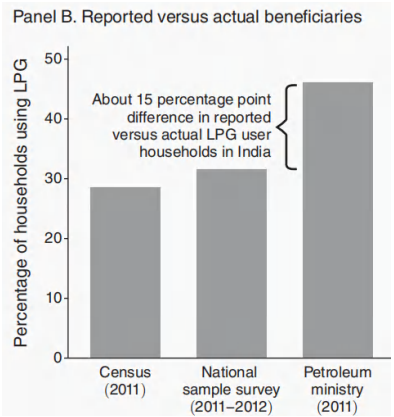
Enforcement of Dual Pricing and Diversion Incentives

Market Segmentation:

- Visual differentiation (color/size/shape of cylinders) reduces enforcement costs (similar to red-dye diesel analogy).
- Legal bans on unauthorized sales/transport/refills.

In practice, the audit and penalty policies have not been very effective in curbing diversion.

The number of household LPG accounts was significantly higher in the administrative record than in the household census and national sample surveys in 2011–2012, suggesting large-scale diversion using ghost and duplicate accounts in practice.



Enforcement of Dual Pricing and Diversion Incentives

For Black Market, key actors:

- Gas distributors and their deliverymen: Divert gas via ghost accounts or over-report refills.
- Independent agents and cartels: Collaborate with distributors for large-scale diversion

Legitimate households may also resell household gas from their own quota to make a profit. While the diversion by legitimate households cannot be ruled out, it would be more costly for a household to resell gas than for a distributor or deliverymen. The cap on household subsidized fuel purchases leaves a limited margin for resale beyond the household's own consumption.

Direct Benefit Transfer of LPG Subsidy (DBTL)

Under DBTL, subsidy benefits are transferred directly into the bank accounts of verified household beneficiaries, conditional on gas refill purchase.

- DBTL is not a lump sum transfer system.
- Households continue to face effectively the same lower price net of the subsidy transferred to their bank account.

To enroll in DBTL, registration requirements for household

- Bank account details.
- Aadhaar number (unique biometric-linked ID).
  - Basic info: Name, address, DOB, gender.
  - Photograph + identity/address proofs.
  - Biometrics: Iris scans, fingerprints.

As soon as a household enrolls in DBTL, a cash advance worth the subsidy for one gas refill is transferred to the bank account.The average duration between gas purchase and subsidy transfer was about three days.(in this paper)

Extension to Aadhaar

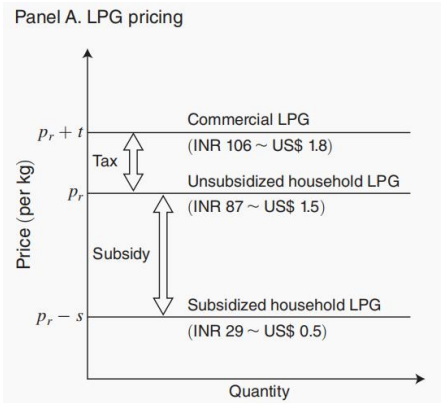
2009 年，印度政府启动一个后来成为全球第一大生物识别数据库的新身份项目，当时该举在国外并没有引起什么关注。该项目名为 Aadhaar，收集超过 10 亿人口的姓名、性别、地址、手机号以及可能更为重要的指纹、相片和虹膜扫描。在这一过程中，Aadhaar 渗透到了印度人们日常生活的几乎每一个方面，从到学校上学到去医院看病，再到去银行获得金融服务。它可谓打开了规模前所未见的数据收集的路径。



Aadhaar 是一个 12 位数的唯一身份号码，可以由印度居民根据他们的生物识别和人口统计数据获得。该数据由印度唯一身份识别机构（UIDAI）收集。

DBTL

Under DBTL, household accounts paid p to the gas distributor for gas refills, and the subsidy amount s was transferred directly to the purchasing household's bank account.



Irrespective of enrollment in DBTL, all household accounts could purchase unsubsidized household gas at price p.

Enroll in DBTL

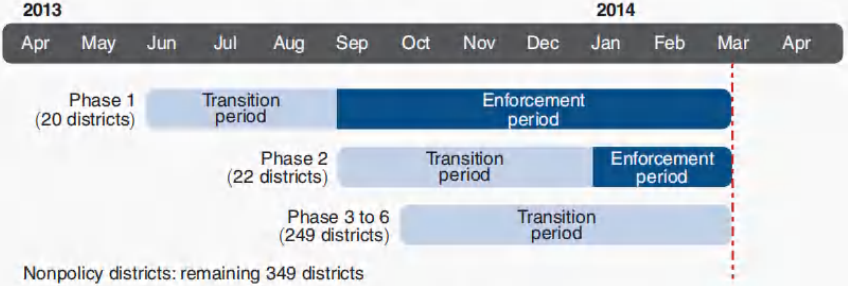


FIGURE 3. TIMELINE OF DBTL POLICY ROLLOUT AND TERMINATION

DBTL Rollout: DBTL is first introduced for voluntary enrollment and after the transition period is over, it is subject to mandatory enforcement. In the voluntary DBTL period, households enrolled in DBTL receive direct transfers while all other household LPG users (including ghost accounts) continue to receive household gas refills as usual. Once DBTL becomes mandatory, all household gas users purchase gas only at the unsubsidized price, and only those households enrolled in DBTL receive direct subsidy transfers after their refill purchase. By March 2014, the DBTL policy was available on a voluntary basis in 291 districts, but it was only fully enforced in 18 districts from Phase 1 and 22 districts from Phase 2. Two districts from Phase 1, Mysore and Mandi, observed a one-month and two-month delay, respectively, in the enforcement of DBTL due to by-elections. 14 additional districts from Kerala state were included in Phases 1 and 2 for voluntary DBTL, but DBTL was not enforced there until its termination in March 2014.

DBTL Rollout

- Introduced for voluntary enrollment in about half of the districts in India, staggered over six phases beginning in June 2013.
- In March 2014, it had been mandatory in 18 districts (Phase 1 districts) for six months and another 22 districts (Phase 2 districts) for two months.
- The primary criterion for a district to be included in DBTL was Aadhaar coverage.
- In June 2013, the average Aadhaar coverage in Phase 1 districts was more than 91 percent, and it approached 100 percent in these districts by January 2014

DBTL Policy Termination and Reimplementation

Termination:

- January 30, 2014, CCPA announced DBTL would be terminated.
- March 10, 2014, the decision of termination went into effect.

Roughly 17 million households were reverted from bank transfer of the subsidy to traditional subsidy disbursement.

Reimplementaion:

- November 2014, the newly elected government restarted the DBTL policy.
- The policy was relaunched as PAHAL.
- The "Give It Up" campaign encouraged wealthier households to voluntarily give up their gas subsidies.
- Over 10 million households opted out of subsidies within a year, indicating significant voluntary self-exclusion from the DBTL program.

Additional Considerations Regarding DBTL Policy

Why the policy reform may fail to reduce the diversion of household gas?

- New channels of household gas diversion may open up in response to higher expected profits in the black market.
- In the absence of rigorous validation of the household address, Aadhaar, and bank account, middlemen might collude with households to set up gas accounts for different members of the same household.
- Due to the high expected profits, genuine households might even consider independently reselling unused gas from their annual quota.

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Data resources

Two main types: Administrative data and Survey data.

- Administrative data on cooking gas refill sales by three government-controlled OMCs to estimate the impact of DBTL policy rollout and termination on 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.
  - **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).
- Survey data on black market prices is used to estimate the impact of DBTL's termination on black market gas prices.
  - **Small business survey:** the demand side in the black market
  - **Deliverymen survey:** the supply side in the black market

Additional datasets: Center for Monitoring of Indian Economy (CMIE) Household Expenses Details database; National Sample Survey (NSS)

Administrative Data on Cooking Gas Sales

TABLE 1—DESCRIPTIVE STATISTICS: ADMINISTRATIVE DATA

	Mean	Median	SD
Panel A. Distributor level gas sales			
14.2 kg gas refills (household)	5,419	3,504	5,809
Subsidized	5,247	3,382	5,641
Unsubsidized	172.0	0	672.1
19 kg gas refills (commercial)	255.2	40	784.8
Distributors		19,527	
Districts		681	
States		37	
Time period		34 months (Jan. 2013–Oct. 2015)	
Panel B. Household level gas refills purchase (HPCL only)			
Subsidized 14.2 kg gas refills	6.523	7	2.853
Total 14.2 kg gas refills	6.575	7	2.935
Monthly 14.2 kg gas refills	0.553	1	0.586
Households		3.79 million	
Distributors		3,165	
Districts		509	
States		25	
Time period		12 months (April 2013–March 2014)	
Transactions		23.2 million	

Notes: Panel A shows distributor-level sales data for household and commercial gas from all three OMCs (BPCL, HPCL, and IOCL). Panel B shows details of household account-level gas refills (14 kg refills) transactions data obtained from HPCL. This sample represents about 10 percent of HPCL household gas accounts (i.e., about 2.5 percent of all household beneficiaries) during the financial year 2013–2014.

Pre-DBTL

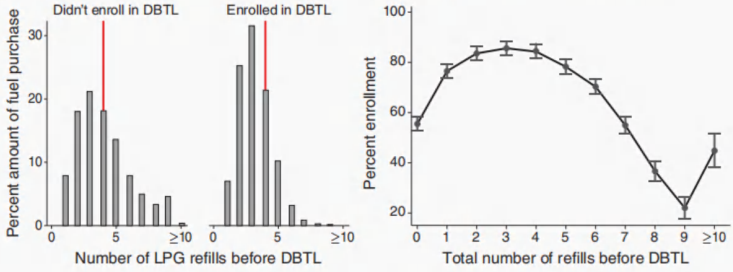


FIGURE 4. PRE-DBTL FUEL PURCHASE AND HOUSEHOLD ENROLLMENT IN DBTL

Notes: The above plot shows the distribution of pre-DBTL household gas refill (14.2kg) purchases by the DBTL enrollment status of household accounts in Phase 1 districts. The vertical axis in subplot A reports the percentage share of gas purchased by household accounts in the five-month period (April–August 2013) before DBTL policy became mandatory in Phase 1 districts. The vertical lines (in red) indicate the prorated annual LPG refill cap in 2013–2014, i.e., 3.75 gas refills rounded off to four LPG refills during five months period. The annual cap for LPG subsidy was nine 14.2 kg LPG refills in this time period, which explains the bunching at nine refills in subplot A. Subplot B shows the percentage of households enrolled in DBTL over the number of gas refills purchased during the pre-DBTL period in Phase 1 districts. The data used is collapsed to the distributor-by-refills level. Enrollment status of households is defined considering as of March 9, 2014, i.e., one day before the DBTL policy termination. Ninety-five percent confidence interval is shown. More than 10 LPG refills are combined together in both subplots.

Survey of the Black Market for Cooking Gas

TABLE 2—DESCRIPTIVE STATISTICS: AUDIT SURVEY IN THE BLACK MARKET

Variable	Observations	Mean	SD	Min	Max
Small business survey price (₹)	2,369	1,039.13	241.26	430	1,600
Deliverymen survey price (₹)	1,202	1,062.49	233.41	550	1,950
Small businesses			1,452		
Deliverymen			1,202		
Districts			89		
States			11		

Notes: The above table shows summary statistics of black market prices for 14.2kg gas refills collected from the deliverymen and small businesses in two rounds of survey (before and after the policy termination). Price values are in ₹ (2013–2014 exchange rate: US$1 = ₹60 approximately). Price values reported by the respondents, which are below the average OMC price for subsidized fuel or above the average OMC price for nonsubsidized commercial fuel, are dropped. The small-business survey had a 20 percent attrition rate in the post-termination round.

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Difference-in-Difference

The staggered rollout of DBTL as well as its unexpected termination in early 2014 to estimate the impact of DBTL

$$Y_{idsm} = \alpha + \beta Post_m \times DBTL_d + \mu_i + \delta_m + \gamma_{sm} + \epsilon_{idsm} \quad (1)$$

- Y_{idsm}: $\log(gas\,sales)$ for distributor i in district d, state s, and month m.
- μ_i: Distributor fixed effects, controlling for time-invariant factors at the distributor level.
- δ_m: Month fixed effects, controlling for time-varying factors at the month level.
- γ_{sm}: State-month linear trend, controlling for state-specific time trends.
- ϵ_{idsm}: Random error term, representing the unexplained part of the model.

Event Study

Further estimate an event study model with month dummies interacted with policy treatment assignment:

$$Y_{idsm} = \sum_{\tau=\text{Jan2013}}^{\text{Oct2014}} \beta_\tau \text{DBTL}_d \times 1\{m = \tau\} + \mu_i + \delta_m + \gamma_{sm} + \epsilon_{idsm} \quad (2)$$

β_τ provides the month-specific policy effect on gas sales.

Finally, the author estimates the impact of DBTL policy termination on black market fuel prices using price survey data and a specification similar to equation (1)

Parallel Trends and Placebo Tests

TABLE 3—PRE-TRENDS IN GAS SALES

	log(*Household LPG sales*)		log(*Commercial LPG sales*)	
	(1)	(2)	(3)	(4)
DBTL × *Jan.–Feb. 2013*	0.0490		0.0595	
	(0.0315)		(0.0466)	
DBTL × *Mar.–Apr. 2013*	0.0343		−0.0136	
	(0.0318)		(0.0494)	
DBTL × *May–June 2013*	0.000899		0.00848	
	(0.0163)		(0.0419)	
DBTL × *Jan. 2013*		0.0433		0.0672
		(0.0311)		(0.0590)
DBTL × *Feb. 2013*		0.0462		0.0383
		(0.0479)		(0.0716)
DBTL × *Mar. 2013*		0.0450		−0.00904
		(0.0437)		(0.0625)
DBTL × *Apr. 2013*		0.0152		−0.0310
		(0.0345)		(0.0604)
DBTL × *May 2013*		0.0243		0.0217
		(0.0297)		(0.0635)
DBTL × *June 2013*		−0.0313		−0.0165
		(0.0179)		(0.0622)
DBTL × *July 2013*		−0.00869		−0.0132
		(0.0192)		(0.0685)
Constant	8.324	8.258	4.884	4.999
	(0.00441)	(0.0372)	(0.00718)	(0.0775)
Observations	87,079	87,079	70,686	70,686
R^2	0.955	0.956	0.935	0.936
Distributor FE	Yes	Yes	Yes	Yes
State-month or State-bimonth FE	Yes	Yes	Yes	Yes
Pr(> *F*)	0.453	0.165	0.228	0.0736

Notes: This table shows the difference in gas refill purchases between DBTL and non-DBTL districts over time. Both 14.2kg household gas refills (columns 1 and 2) and 19kg commercial gas refills (columns 3 and 4) are shown. The treated group consists of DBTL Phase 1 districts where the policy was enforced in September 2013. July–August 2013 bin is set as the base cat-

Impact of DBTL Policy on Gas Purchased by Household Accounts

TABLE 4—IMPACT OF DBTL ON HOUSEHOLD GAS SALES

	log(*Household LPG sales*)					
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL × *post*	−0.167	−0.188	−0.174	−0.189	−0.113	−0.154
	(0.0297)	(0.0341)	(0.0304)	(0.0349)	(0.0246)	(0.0519)
Observations	160,879	160,879	90,900	90,900	76,166	76,166
R^2	0.942	0.943	0.946	0.947	0.938	0.939
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE, state-month trend	Yes		Yes		Yes	
State-month FE		Yes		Yes		Yes
Control districts	Phase 3–6 and nonpolicy		Phase 3–6		Nonpolicy	

Notes: This table shows difference-in-differences estimates of the impact of DBTL policy on gas sold to household accounts. The data consists of distributor-month level panel covering the time period before and during the policy reform (January 2013 to February 2014). The outcome variable is the log of total household gas refills sold in a given month. The DBTL policy group consists of DBTL Phase 1 districts. 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. Phase 2 districts are not included. All estimates include distributor fixed effects and either month fixed effects and state-month trends or state-month fixed effects. Standard errors, clustered at the district level, are in parentheses.

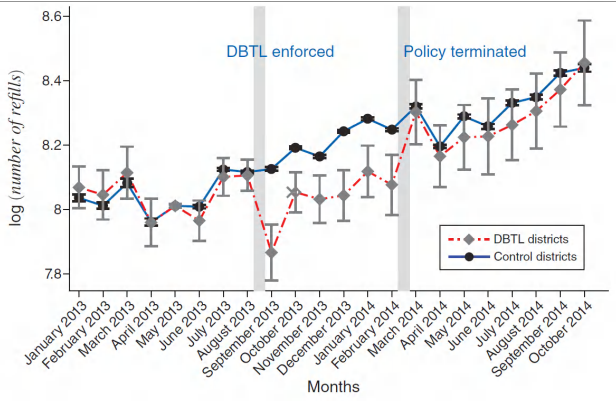


FIGURE 5. IMPACT OF DBTL ON HOUSEHOLD GAS SALES BY DISTRIBUTORS

Notes: The above plot shows the impact of DBTL on household gas sales using a distributor-month panel dataset. The outcome variable is the log of the total number of 14.2kg household gas refills sold. This plot reports month-wise regression-adjusted means of household fuel sales in DBTL policy and control districts. Distributor and state-by-month fixed effects are included. DBTL policy districts include all districts where DBTL was enforced in Phase 1 in September 2013, whereas the control group includes districts with voluntary DBTL as well as those where DBTL was not yet scheduled for implementation. Phase 2 districts and two districts in Phase 1 where DBTL was enforced after September 2013 are excluded. As shown by the vertical bars, DBTL was enforced on September 1, 2013, and terminated on March 10, 2014. Ninety-five percent confidence intervals shown are for the regression-adjusted mean sales by distributors in the DBTL policy and control groups. Standard errors are clustered at the district level.

Policy Terminated

TABLE 5—IMPACT OF DBTL TERMINATION ON HOUSEHOLD GAS SALES

	log(*Household LPG sales*)					
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL × *post termination*	0.136	0.141	0.141	0.143	0.126	0.187
	(0.0241)	(0.0261)	(0.0242)	(0.0262)	(0.0236)	(0.0382)
Observations	179,404	179,404	100,422	100,422	85,571	85,571
R^2	0.943	0.944	0.949	0.950	0.937	0.938
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE, state-month trend	Yes		Yes		Yes	
State-month FE		Yes		Yes		Yes
Control districts	Phase 3–6 and nonpolicy		Phase 3–6		Nonpolicy	

Notes: This regression shows difference-in-differences estimates for the DBTL policy termination on household gas sales. Data consists of distributor-month level panel data during the policy reform and after its termination (September 2013 to October 2014). The outcome variable is the log of total household gas refills sold to households in a given month. The DBTL policy group consists of DBTL Phase 1 districts. 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. Phase 2 districts are not included. All estimates include distributor fixed effects and either month fixed effects and state-month trends or state-month fixed effects. Standard errors, clustered at the district level, are in parentheses.

Subsidized and Unsubsidized

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

	(1) log(Subsidized household LPG)	(2)	(3) log(Unsubsidized household LPG)	(4)	(5) log (Commercial LPG)	(6)	(7) log(total unsubsidized LPG)	(8)
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.

Market Effects of DBTL Policy

TABLE 6—IMPACT OF DBTL ON COMMERCIAL GAS SALES

	log(*Commercial LPG sales*)					
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL × *post*	0.126	0.136	0.115	0.133	0.130	0.0298
	(0.0370)	(0.0421)	(0.0373)	(0.0422)	(0.0455)	(0.0811)
Observations	129,668	129,668	76,903	76,903	57,933	57,933
R^2	0.920	0.923	0.929	0.933	0.904	0.907
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE, state-month trend	Yes		Yes		Yes	
State-month FE		Yes		Yes		Yes
Control districts	Phase 3–6 and nonpolicy		Phase 3–6		Nonpolicy	

Notes: This regression shows difference-in-differences estimates for the impact of the DBTL policy on commercial gas sales. Data consists of distributor-month level panel data before and during the policy reform (January 2013 to February 2014). The outcome variable is the log of the total 19kg commercial gas refills sold to commercial accounts in a given month. The DBTL policy group consists of DBTL Phase 1 districts (16 districts). 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. Phase 2 districts are not included. All estimates include distributor fixed effects and either month fixed effects and state-month trends or state-month fixed effects. Standard errors, clustered at the district level, are in parentheses.

Impact on Gas Purchased

TABLE 7—IMPACT OF DBTL POLICY TERMINATION ON COMMERCIAL GAS SALES

	log(*Commercial LPG sales*)					
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL × *post termination*	−0.0753	−0.132	−0.0660	−0.136	−0.0505	−0.113
	(0.0377)	(0.0437)	(0.0387)	(0.0439)	(0.0392)	(0.0600)
Observations	141,174	141,174	83,533	83,533	63,174	63,174
R^2	0.917	0.920	0.927	0.930	0.901	0.903
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE, state-month trend	Yes		Yes		Yes	
State-month FE		Yes		Yes		Yes
Control districts	Phase 3–6 and nonpolicy		Phase 3–6		Nonpolicy	

Notes: This regression shows difference-in-differences estimates for the impact of the DBTL policy termination on commercial LPG sales. Data consists of distributor-month level panel data during the policy reform and after its termination (September 2013 to October 2014). The outcome variable is the log of the total 19 kg commercial LPG refills sold to commercial accounts in a given month. The DBTL policy group consists of DBTL Phase 1 districts (16 districts). 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. Phase 2 districts are not included. All estimates include distributor fixed effects and either month fixed effects and state-month trends or state-month fixed effects. Standard errors, clustered at the district level, are in parentheses.

Impact on Black Market Prices

TABLE 8—IMPACT OF DBTL POLICY TERMINATION ON BLACK MARKET GAS PRICES

	log(*price*)					
	Panel A. Deliverymen survey			*Panel B. Small Business survey*		
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL × *post termination*	−0.127	−0.159	−0.183	−0.186	−0.189	−0.198
	(0.0401)	(0.0389)	(0.0293)	(0.0617)	(0.0612)	(0.0485)
Observations	504	504	504	796	796	796
R^2	0.756	0.778	0.862	0.744	0.771	0.783
District FE	Yes	Yes	Yes			
Small business FE				Yes	Yes	Yes
Survey date FE		Yes	Yes		Yes	Yes
State by survey round FE			Yes			Yes

Notes: This table presents difference-in-differences estimates of the impact of DBTL termination on black market gas refill prices. Two rounds of surveys (during DBTL and after the policy termination) collected information on gas prices from gas deliverymen in an audit survey and from small businesses in interviews. The outcome variable, i.e., the price for a household gas refill sold in the black market (₹), is log-transformed. Results are shown separately using price information collected from deliverymen in panel A and from small businesses in panel B. The treatment group consists of the DBTL districts (Phase 1 and 2) and the control group of districts where DBTL was not yet scheduled for implementation, totaling 38 districts in 8 states. District fixed effects are included in panel A and small business (firm) fixed effects are included in panel B. Survey date fixed effects are used in columns 2 and 4. State-by-survey round fixed effects are included in columns 3 and 6. Standard errors, clustered at the district level, are in parentheses.

Robustness checks in control groups

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.

Impact on Price by Termination

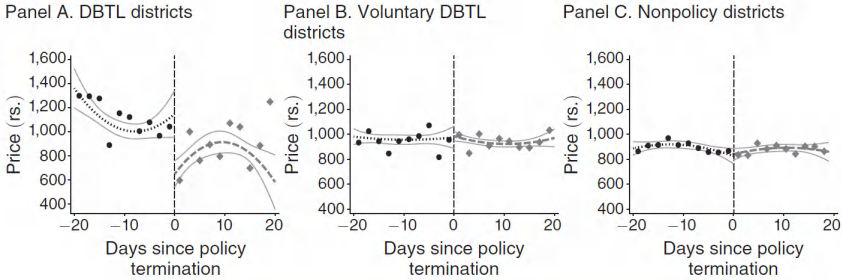


FIGURE 7. POLICY TERMINATION: IMPACT ON PRICES IN THE GAS BLACK MARKET

Notes: This plot shows the discontinuity in black market LPG refill prices at the time of DBTL termination in DBTL districts (panel A). The price and refill dates reported by commercial users in the survey are used to construct the time series of black market prices. A 20-day window is used on either side of the DBTL termination date. A fitted quadratic curve is shown with a 95 percent confidence interval. Panel A shows results using data from DBTL Phase 1 and 2 districts, while panels B and C show results using data from control districts (DBTL Phase 3–6 and nonpolicy districts). Nonpolicy districts include all districts where DBTL was not yet scheduled for implementation. While the government decided to terminate the policy on January 30, 2014, the official notification of DBTL termination was released on March 7, 2014 (Friday), and the policy was effectively terminated on March 10, 2014 (Monday). Thus, the exact DBTL policy termination date was not publicly known until the business day before the actual termination.

Taken together, the results on black market prices and on commercial and household gas sales indicate that restoring the household gas dual-pricing regime increased the diversion of subsidized gas to the black market, causing a positive supply chock.

This offers a reasonable explanation for the decline in the equilibrium black market price and the decline in gas purchases by commercial accounts as businesses turned more to the black market for gas

Model framework

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.

$$\text{Genuine household demand} : D_{hh} = D_{hh}(p - s, x) \tag{3}$$

Agents active in diverting gas to the black market purchase gas meant for household usage at the same unit price as households.

$$\text{Black-market agent's demand} : D_a = D_a(p, p_b, s, c_a, \mathbb{I}_{\text{dual price}}) = D_a(p_b - (p - s \times \mathbb{I}_{\text{dual price}}) - c_a) \tag{4}$$

Under DBTL, the dual price system due to over-the-counter subsidy is eliminated, which I indicate as $\mathbb{I}_{\text{dual price}} = 0$.

Demand side in the black market

Potential penalties if caught by enforcement agencies, and these costs, denoted 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 $\dot{c}_f = p + t - p_b$.

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:

$$\int_0^{\dot{c}_f} q(p_b + c_f) dF(c_f) = \int_0^{p+t-p_b} q(p_b + c_f) dF(c_f) \tag{5}$$

- Total formal fuel demand of commercial users:

$$\int_{\dot{c}_f}^{\infty} q(p + t) dF(c_f) = q(p + t)[1 - F(\dot{c}_f)] \tag{6}$$

Definition: *A black-market equilibrium is a price p_b^* such that the supply in the black market $S_b : D_a(p_b^* - (p - s \times \mathbb{I}_{OC}) - c_a)$ equals the demand in the black market $D_b : \int_0^{p+t-p_b^*} q(p_b^* + c_f)dF(c_f)$ (Eq. [7]).*

$$D_a(p_b^* - (p - s \times \mathbb{I}_{\text{dual price}}) - c_a) = \int_0^{p+t-p_b^*} q(p_b^* + c_f)dF(c_f) \tag{7}$$

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

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 $q_{h,dbil}^*$ under the direct benefit transfer policy will be lower than $q_{h,dual}^*$ under dual pricing.

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

Potential Mechanisms

It is important to understand how changes in household and commercial gas purchases are related quantitatively.

For each kilogram decline in subsidized household gas purchases due to DBTL, unsubsidized household gas purchase rose 0.68 kg while commercial purchases (of 19 kg units) rose 0.05 kg. This suggests that leakage reduction occurred in two ways:

- Through a large decline in subsidies provided to household accounts
- Through a smaller decrease in tax evasion by commercial users

Service Quality: Delay in Delivery of Household Gas Refills

On average, a household waits 3.2 days for a gas refill.

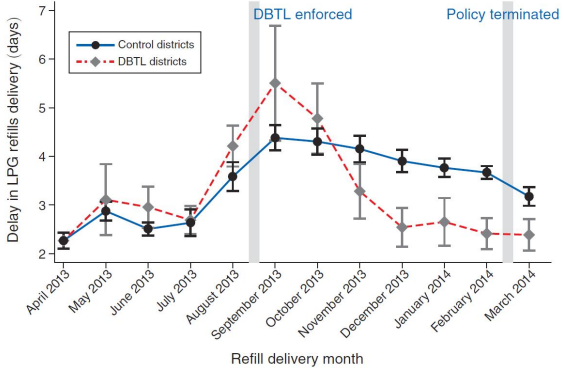


FIGURE 8. DBTL'S IMPACT ON PDS SERVICE DELIVERY

Notes: This plot shows the impact of DBTL policy on service quality observed by households. The outcome variable is the number of days taken by the distributor and deliverymen in delivering the gas refill, once a household has ordered it. This plot reports monthly regression-adjusted means of delay to household accounts in DBTL policy and control districts. Household and month fixed effects are included. Ninety-five percent confidence intervals shown are for the regression-adjusted mean delays by distributors in the DBTL policy and control groups. Standard errors are clustered at the district level.

Service quality

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.

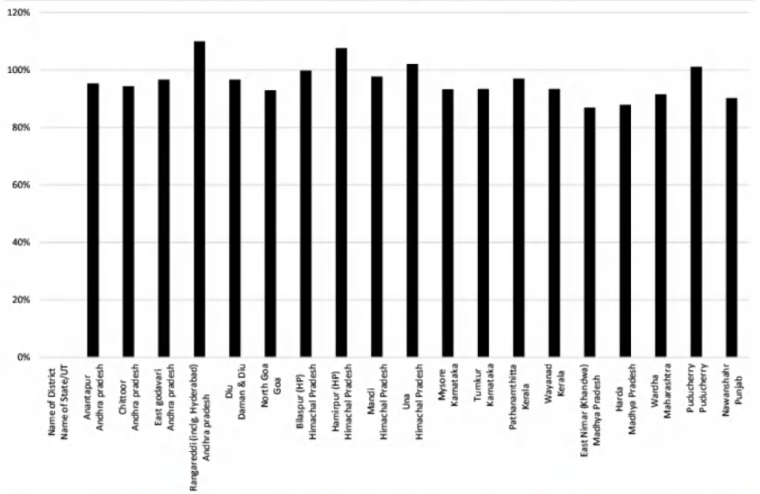
Exclusion of Households in DBTL

Potential alternative explanations for the estimated impact of DBTL on household gas sales other than reduced leakage.

- voluntary nonenrollment (i.e., genuine households choosing not to enroll in DBTL);
- late enrollment (i.e., genuine households enrolling in DBTL with a delay);
- exclusion (i.e., genuine households unable to enroll in DBTL due to lack of a bank account or Aadhaar number)

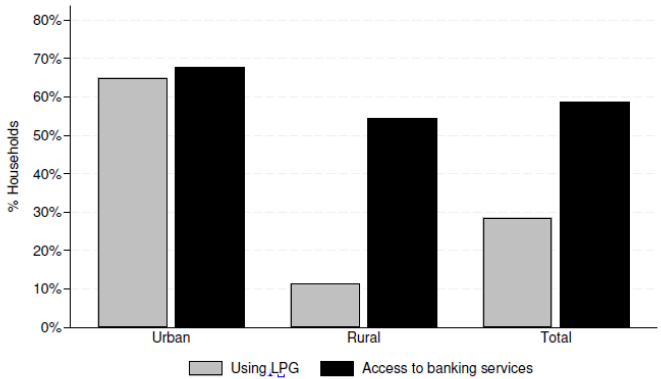
By January 2014, 98.5 percent of the population in Phase 1 districts had an Aadhaar (online Appendix Figure D.1).
The 2011 census shows that the proportion of households with access to banking is higher than the proportion of households using gas (online Appendix Figure D.2).
Average banking access was about twice the average gas usage in the 2011 Census, with a smaller, but still positive, difference in urban areas.

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.

CMIE survey data for household expenditure

TABLE 9—IMPACT OF DBTL ON HOUSEHOLD FUEL EXPENDITURE

	Cooking fuel's expenditure share		
	(1)	(2)	(3)
DBTL × *pre termination*	0.000877 (0.00112)	0.00154 (0.00121)	−0.000364 (0.00156)
Observations	1,296,514	1,296,514	1,296,514
R^2	0.539	0.542	0.545
Household FE	Yes	Yes	Yes
Month FE	Yes	Yes	
State-month trend		Yes	
State-month FE			Yes
Mean of outcome variable		0.048	

Notes: This table presents difference-in-differences estimates of the impact of DBTL policy on households' cooking-fuel expenditure share. The outcome variable household cooking fuel expenditure is constructed using CMIE household survey data (January to October 2014) covering the period during DBTL (*pre termination* = 1) and after its termination (*pre termination* = 0). On average, households spend 4.8 percent of their monthly expenditure on cooking fuel. Standard errors, clustered at the district level, are in parentheses.

Distributional Effects of DBTL Policy

It would be a concern if the DBTL policy had adverse distributional implications despite the leakage reduction. To study this

- first show how the cooking fuel expenditure share changes with DBTL across expenditure groups.
- then analyze the incidence of policy reform by the pre-DBTL level of gas subsidy received by household accounts.

Two types of effects:

- Impact across Household Expenditure Quintiles. (Table 9 & Figure 9)
- Impact across Initial Incidence of Benefits (Figure 10 & Appendix Table D9)

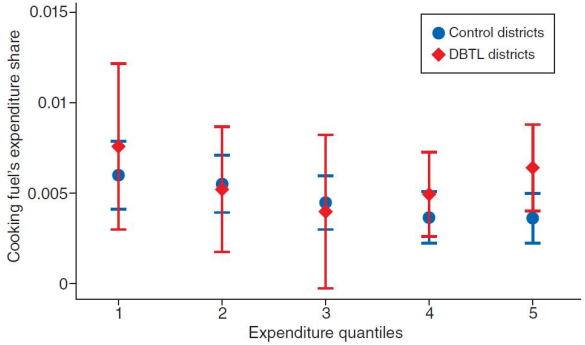


FIGURE 9. DBTL'S IMPACT ON COOKING FUEL EXPENDITURE

Notes: This plot shows the impact of DBTL policy on household cooking fuel's expenditure share across monthly total expenditure quintiles. It employed a triple-interaction (i.e., *DBTL* × *Pre Termination* × *Expenditure* quintiles) regression model. The outcome variable is cooking fuel's expenditure share. Household-month level data from CMIE surveys are used. The data covers January–October 2014, which includes two months (January and February 2014) of the DBTL enforcement period. Thus, the coefficient plot shows the change in fuel expense proportion between the DBTL enforcement period and after its termination (March–October 2014) for households in DBTL and non-DBTL districts. Ninety-five percent confidence interval with standard errors clustered at the district level is shown.

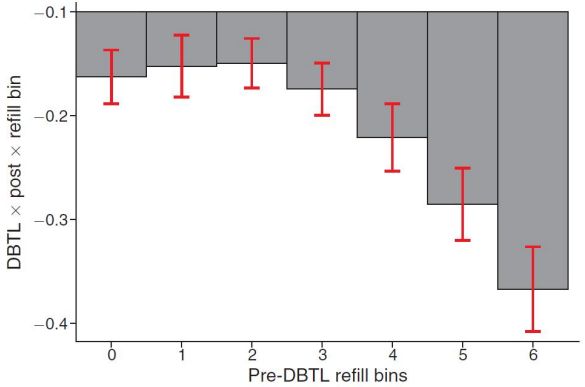


FIGURE 10. DISTRIBUTIONAL EFFECT ACROSS THE INITIAL SUBSIDY INCIDENCE

Notes: This graph shows the impact of DBTL policy on subsidized gas purchases across different bins of pre-DBTL subsidy incidence. Household accounts are categorized into seven groups starting with zero subsidized refills purchases to six or more refills purchased during the five months leading up to the DBTL rollout (April–August 2013). The median household account purchased three refills in this period. Household and month fixed effects are included. Ninety-five percent confidence intervals with standard errors clustered at the district level are shown.

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)	69%	84%	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

Diversion of Fuel by Households

Does directly transferring subsidies to households cause an increase in gas subsidy diversion by genuine households? (like tax evasion)

Enforcing DBTL caused a 4 percent increase in purchases of gas refills by households in treated districts when compared with households in voluntary DBTL districts.

TABLE 10—IMPACT OF DBTL ON GAS PURCHASES BY HOUSEHOLDS ENROLLED IN DBTL

	Number of LPG refills purchased	
	(1)	(2)
DBTL × *post*	0.0234	−0.00195
	(0.00492)	(0.00562)
Observations	9,542,478	3,899,918
Household FE	Yes	Yes
Month FE	Yes	Yes
Control districts	Phase 3–6	Phase 6
Mean of outcome variable	0.546	0.551

4%
(0.0234/0.546)

Notes: This table reports difference-in-differences estimates for the impact of the DBTL policy on gas purchases by household accounts enrolled in DBTL. Household-by-month level panel data covering the time period before and during the DBTL policy reform (April 2013 to February 2014) is used. The outcome variable is the number of gas refills purchased by a household account in a given month. All household accounts enrolled in DBTL by March 2014 are included. Household accounts that did not enroll in DBTL by March 2014 are not included in this sample. Column 1 includes households voluntarily enrolled in DBTL from Phase 3–6 districts as the control group. Column 2 includes households voluntarily enrolled in DBTL from Phase 6 districts as the control group. Standard errors are in parentheses. Standard errors are clustered at the district level.

Two explanation

There are two potential explanations for why, despite the high prices households could fetch on the black market, they do not increase their engagement in the diversion.

- First, households may face higher legal and logistical costs when selling gas refills on the black market, especially since they do not have access to aggregation technology or the market access that suppliers do.
- Second, social norms may make it costly for a household to participate in the black market

DBTL Reimplementation across the Country

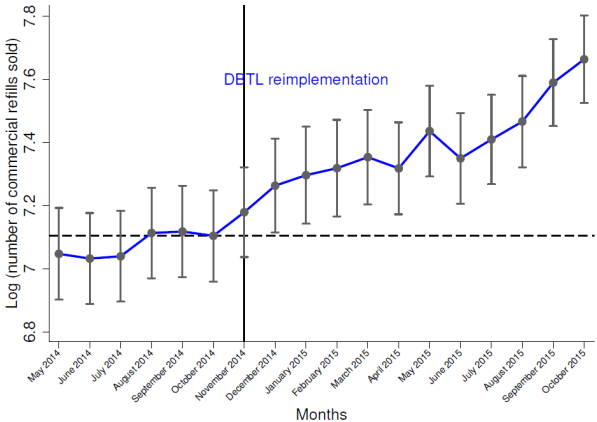
TABLE 11—IMPACT OF DBTL REIMPLEMENTATION ON HOUSEHOLD AND COMMERCIAL GAS PURCHASES

	Panel A. log(*household LPG refills*)			*Panel B.* log(*commercial LPG refills*)		
	(1)	(2)	(3)	(4)	(5)	(6)
DBTL2 × post	−0.180	−0.171	−0.128	0.111	0.117	0.127
	(0.0158)	(0.0161)	(0.0207)	(0.0314)	(0.0334)	(0.0385)
Observations	99,369	99,369	99,362	77,193	77,193	77,193
R^2	0.956	0.956	0.957	0.930	0.930	0.931
Distributor FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes		Yes	Yes	
State-month trend		Yes			Yes	
State-month FE			Yes			Yes

Notes: This table reports the difference-in-differences estimates of the impact of DBTL reimplementation in November 2014. The DBTL2 group includes the 54 Phase 1 and Phase 2 districts, whereas the control group includes all remaining districts. This regression uses data from May to December 2014. Data for November is omitted because the DBTL policy was implemented in the middle of November 2014. Columns 1–3 report the estimated difference-in-differences coefficient for household LPG, while columns 4–6 report the same for commercial LPG. Standard errors, clustered at the district level, are in parentheses.

The newly elected Indian government reimplemented DBTL in 54 districts on November 15, 2014, and in the remaining 622 districts from January 1, 2015

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.

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Review

How developing countries can improve in-kind transfer programs is an important question with significant welfare implications.

This paper studies a policy reform in a large, in- kind transfer program in India that sought to bridge the over- the-counter price gap by transferring the subsidy amount directly to beneficiaries. During the implementation of the policy,

- household gas purchases decreased by 17% to 19%
- commercial gas purchases increased by 13% to 14%
- black market prices decreased by 18% to 20%

proving that the reform significantly suppressed the black market resale of subsidized gas.

Inspirations

Overall, these findings support the narrative that the arbitrage incentives created by a dual-pricing design of in- kind transfers led to a high level of diversion of public funds in the gas subsidy program.

On a broader level, reforms to welfare delivery need much stronger political support, especially when adversely affected groups are likely to lobby against (or subvert) such reform.

Accurate distribution through biometric and electronic payment technology may be a good way to solve corruption and resource leakage while maintaining policy coverage.

Looking for questions and criticism!