# The Response of Consumption to Fuel Switching: Evidence from Indonesia LPG Conversion Program

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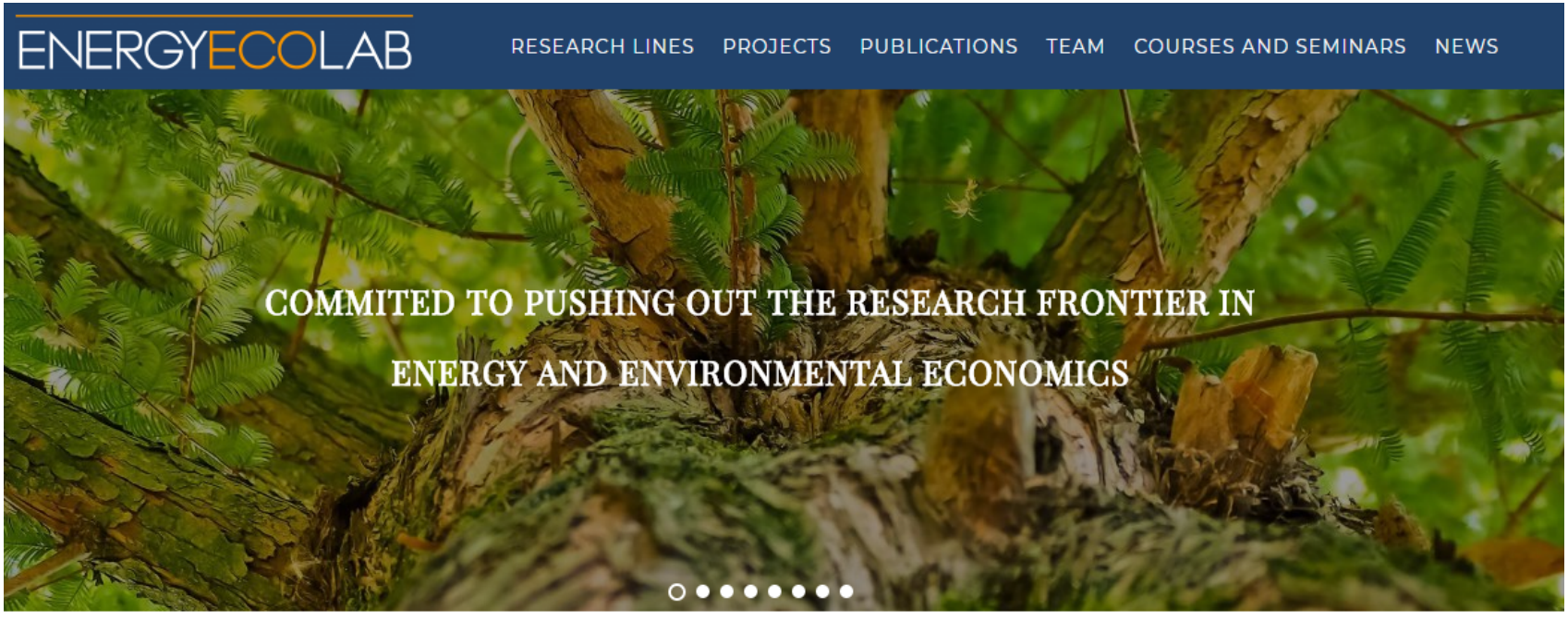
# Energy Eco Lab

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# Publication

- Indoor Air Pollution and Infant Mortality: A New Approach (Imelda)
- Variable Pricing and Social Cost of Renewable Energy (Imelda, Michael J. Roberts, Matthias Fripp)
- Competition Among Renewables (Natalia Fabra and Gerald Llobet)
- Real Time Pricing for Everyone (Natalia Fabra, Mar Reguant, David Rapson)

# Outline

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Main Results

Conclusion

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# Motivation

- Energy efficiency (Law No. 30/2007) and conservation (Gov. Regulation No. 70/2009).
- Energy efficiency = energy services provided per unit of energy input.
- Improving energy efficiency may save less energy than expected due to a **rebound** of energy use.
- Rebound effect = when demand for energy end uses increases as a result of greater efficiency.

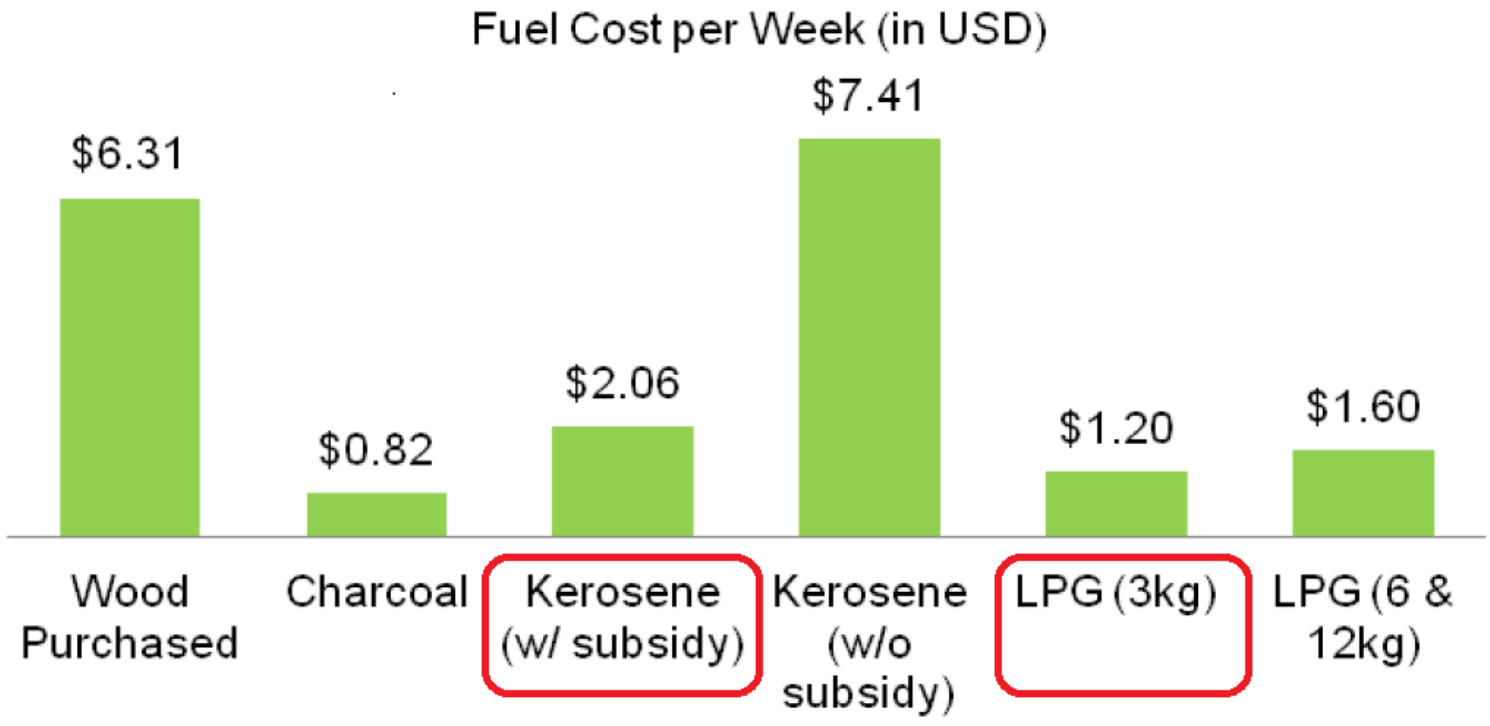
# Research questions

- Does using more efficient energy lead to a rebound of energy use?
- Do households improve their economic well-being as they switch to more energy efficient energy?

# Main contribution in the literature

- Measuring causal effects of energy efficiency improvement.
- Accounts for time-variant unobserved heterogeneity.

# Fuel cost comparison per end-use energy equivalent




Source: Global Alliance for Clean Cookstoves: Indonesia Market Assessment, 2011

# Existing studies

- Indoor air pollution and well being (Smith et al, 2011, Duflo et al., 2008; Jeunland et al., 2015; Hanna et al., 2016; Barron and Tereno, 2017; Imelda, 2018)
- Energy rebound (Davis et al. 2008, 2015; Gillingham, 2013)
- Impact evaluation and the program details (Budya et al., 2011; Andadari et al., 2014; Thoday et al., 2018)

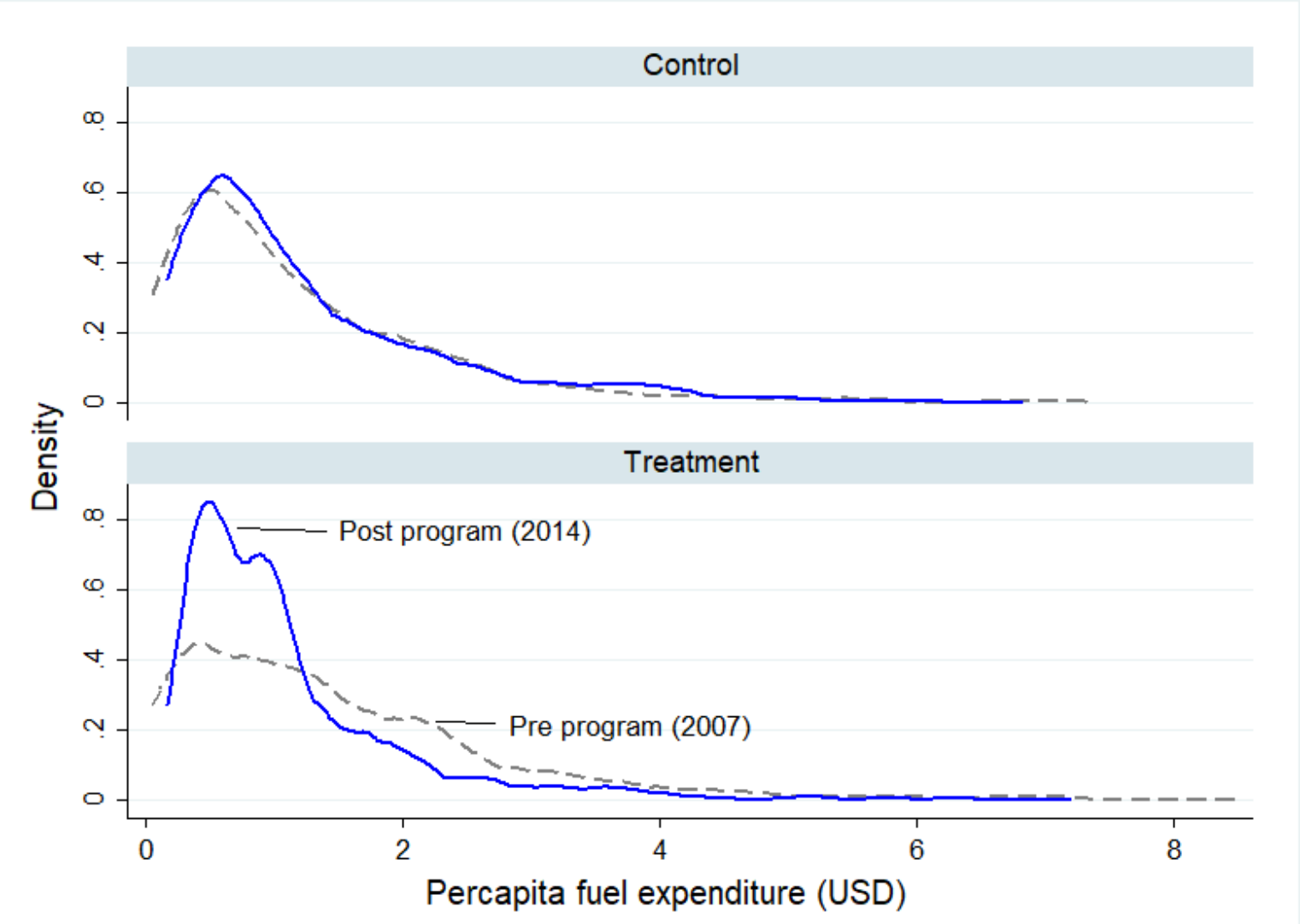
# Results Highlights

- Households reduce their kerosene consumption up to 100%.
- The utility bills decline by about 40%, 1.19 USD per month, on average, which is driven by the reduction in fuel expense.
- Little evidence of rebound effect.
- By converting 50 million households to use LPG, this program can lead to a cost reduction up to 700 million per year, on average.

# Data

- Indonesian Family Life Survey (IFLS) 2000, 2007 = pre, and 2014 = post (balanced panel with 36,891 obs.)
- Program implementation data from Pertamina

# Fuel expenditure before and after the program




This figure shows the density curve of percapita fuel expenditure for treatment and control group before and after the program. The treatment group is households who reside in the district that get the program before 2011 and the control group is households who reside in the district that get or not yet get the program after 2011.

# Empirical Strategy - Difference-in-differences with fixed effects

$$C_{hrt} = \beta_{1h} + \beta_{2t} + \beta_3 P_{r2014} + \beta_4' X_{ht} + \epsilon_{hrt}$$

- where $h$ indexes households, $r$ indexes district, and $t$ indexes year of survey, $C$ is household consumption or their log; $\beta_{1h}$, $\beta_{2t}$ are household, and time fixed effects. $X_{ht}$ is a set of covariates that capture household characteristics (age, family size, interview month and year).
- $P_{r2014}$ is a dummy of the program implementation, that is the interaction between treated district and year of 2014.
- $\beta_3$ = policy effect

# Main Results

Table 1: Effect of the program on expenditures

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Log exp. | nondurables | Log food exp. | | Log utilities bill | |
| ProgamX2014 | -0.234 | -0.287 | 0.040 | 0.009 | **-0.379*** ** | **-0.403*** ** |
| Standard Error | (0.165) | (0.200) | (0.067) | (0.090) | (0.094) | (0.117) |
| Obs. | 15,089 | 15,089 | 15,143 | 15,143 | 14,768 | 14,768 |
| $R^2$ stat | 0.180 | 0.638 | 0.138 | 0.601 | 0.383 | 0.740 |
| District FE | Y | | Y | | Y | |
| Household FE | | Y | | Y | | Y |
| Month FE | | Y | | Y | | Y |

Each column reports the estimated differences from a regression of log percapita monthly nondurables expenditure (column 1-2), log percapita monthly food expenditure (column 3-4) and log percapita monthly utilities bill, which includes fuel, electricity, water and telephone, (column 5-6) on the treatment dummy. Model 1, 3, and 5 capture the regression coefficient within district, while model 2, 4, and 6 capture within household, controlling for the interview month. The standard error is clustered by district.

# Main Results

## Table 2: Effect of the program on each component in utility bills

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Fuel exp. | | Electricity exp. | | Water exp. | | Telephone exp. | |
| ProgamX2014 | **-0.455*** ** | **-0.439** ** | -0.154* | -0.134 | 0.013 | 0.248* | 0.101 | 0.054 |
| Standard Error | (0.136) | (0.182) | (0.087) | (0.145) | (0.074) | (0.146) | (0.076) | (0.147) |
| Obs. | 8,443 | 8,443 | 9,104 | 9,104 | 2,835 | 2,835 | 6,660 | 6,660 |
| $R^2$ stat | 0.133 | 0.682 | 0.238 | 0.802 | 0.377 | 0.895 | 0.176 | 0.776 |
| District FE | Y | | Y | | Y | | Y | |
| Household FE | | Y | | Y | | Y | | Y |
| Month FE | | Y | | Y | | Y | | Y |
| Mean dep. var. (USD) | 2.71 | | 5.77 | | 1.73 | | 16.96 | |

**Each column reports the estimated differences from a regression of log percapita monthly expenditure on fuel (column 1-2), electricity (column 3-4), water (column 5-6) and telephone (column 7-8) on the treatment dummy. Model 1, 3, 5, and 7 capture the regression coefficient within district, while model 2, 4, 6, and 8 capture within household, controlling for the interview month. The standard error is clustered by district. The sample uses only IFLS 2007 and 2014.**

# Main Results

Table 3: Effect of the program with alternative control groups on utility bills

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Early vs Untreated | | Late vs Untreated | | Early vs Late Treated | |
| Panel A. Before the program (parallel trend prior to the program) | | | | | | |
| ProgramX2007 | -0.034 | 0.010 | 0.008 | 0.089 | -0.044 | -0.034 |
| Standard Error | (0.091) | (0.115) | (0.117) | (0.176) | (0.080) | (0.098) |
| Obs. | 8,589 | 8,589 | 1,884 | 1,884 | 9,594 | 9,594 |
| $R^2$ stat | 0.381 | 0.800 | 0.396 | 0.833 | 0.374 | 0.798 |
| Panel B. Full sample | | | | | | |
| **ProgamX2014** | -0.388*** | -0.409*** | -0.328*** | -0.264** | -0.057 | -0.061 |
| Standard Error | (0.094) | (0.115) | (0.106) | (0.126) | (0.053) | (0.063) |
| Obs. | 12,654 | 12,654 | 2,794 | 2,794 | 14,135 | 14,135 |
| $R^2$ stat | 0.384 | 0.739 | 0.395 | 0.758 | 0.377 | 0.736 |
| District FE | Y | | Y | | Y | |
| Household FE | | Y | | Y | | Y |
| Month FE | | Y | | Y | | Y |

# Policy Implications

The reduction in the fuel expenditures is about a third of the price subsidy provided by the government per household.

# Conclusion

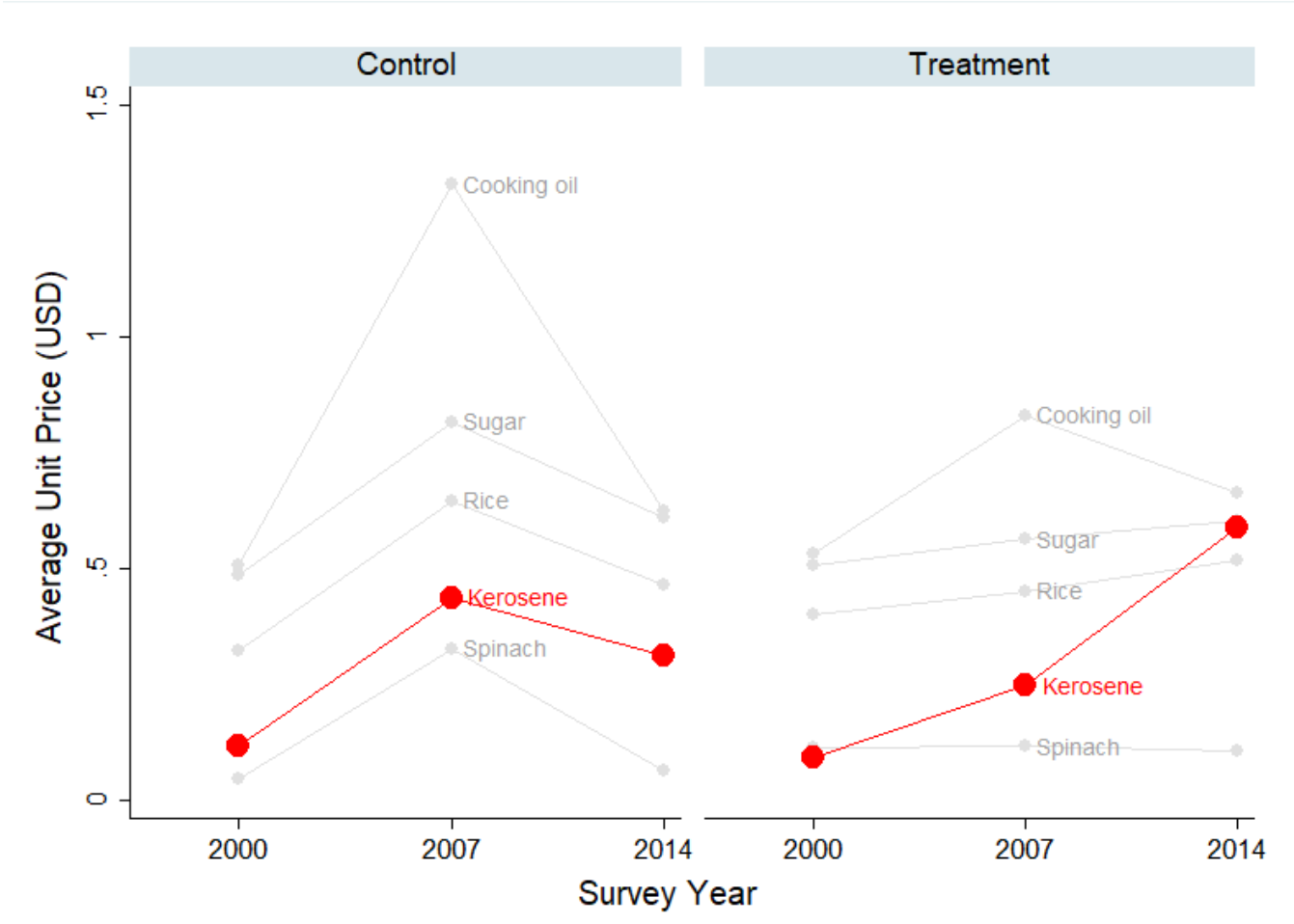
- Households reduce their kerosene consumption up to 100%.
- The utility bills decline by about 40%, 1.19 USD per month, on average, which is driven by the reduction in fuel expense.
- Little evidence of rebound effect.
- No response on other nondurable expenditures.
- Households who got the program earlier experienced a greater reduction in their utility bills.
- Overall, switching to a cleaner fuel can lead to cost saving.

# Questions and Comments?

- iimelda@eco.uc3m.es
- https://sites.google.com/a/hawaii.edu/imelda/
- These are preliminary findings.

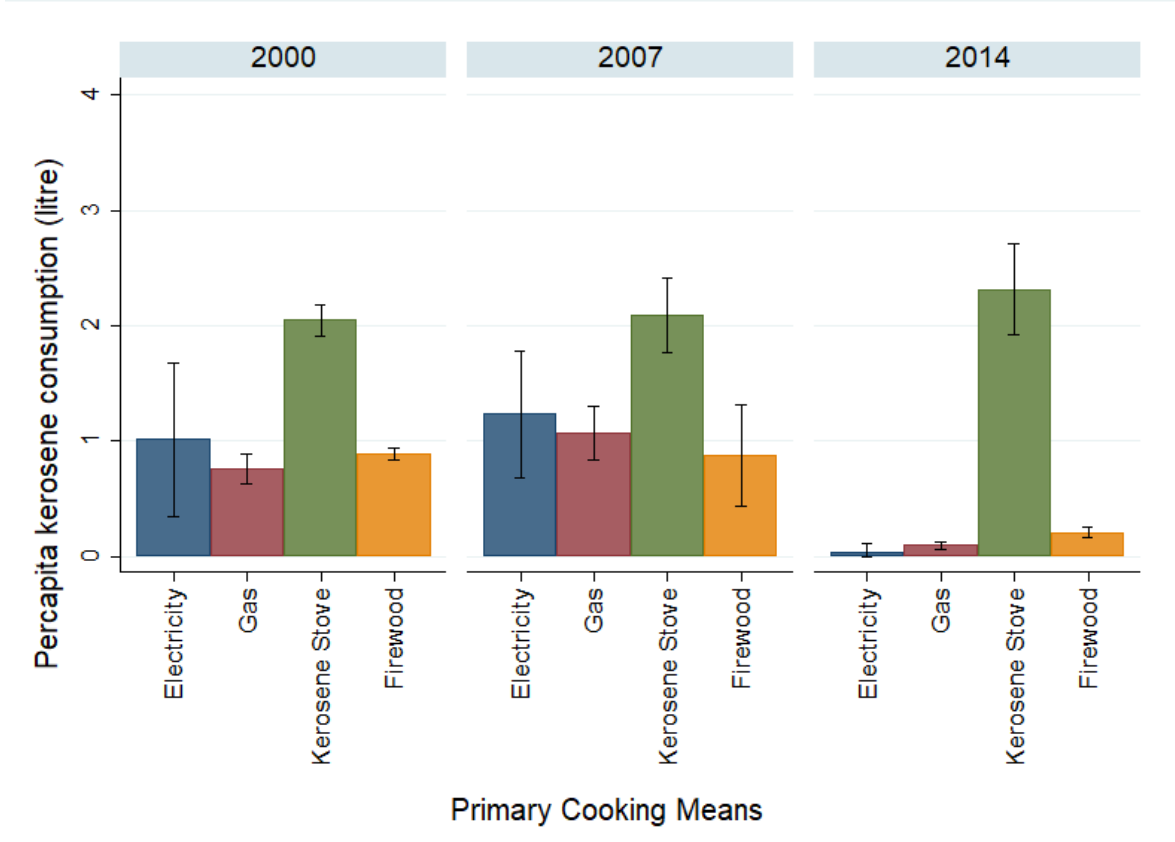
Appendix

Figure 3: Trend of Kerosene Price in Treatment and Control group




This figure plots the average of CPI adjusted kerosene price per litre and other main household's food commodities. 1 USD = Rp 13,000.

Figure 4: Percapita of kerosene consumption by primary cooking fuel




This figure plots the average percapita of kerosene consumption from the recent purchase by households' primary cooking fuel.

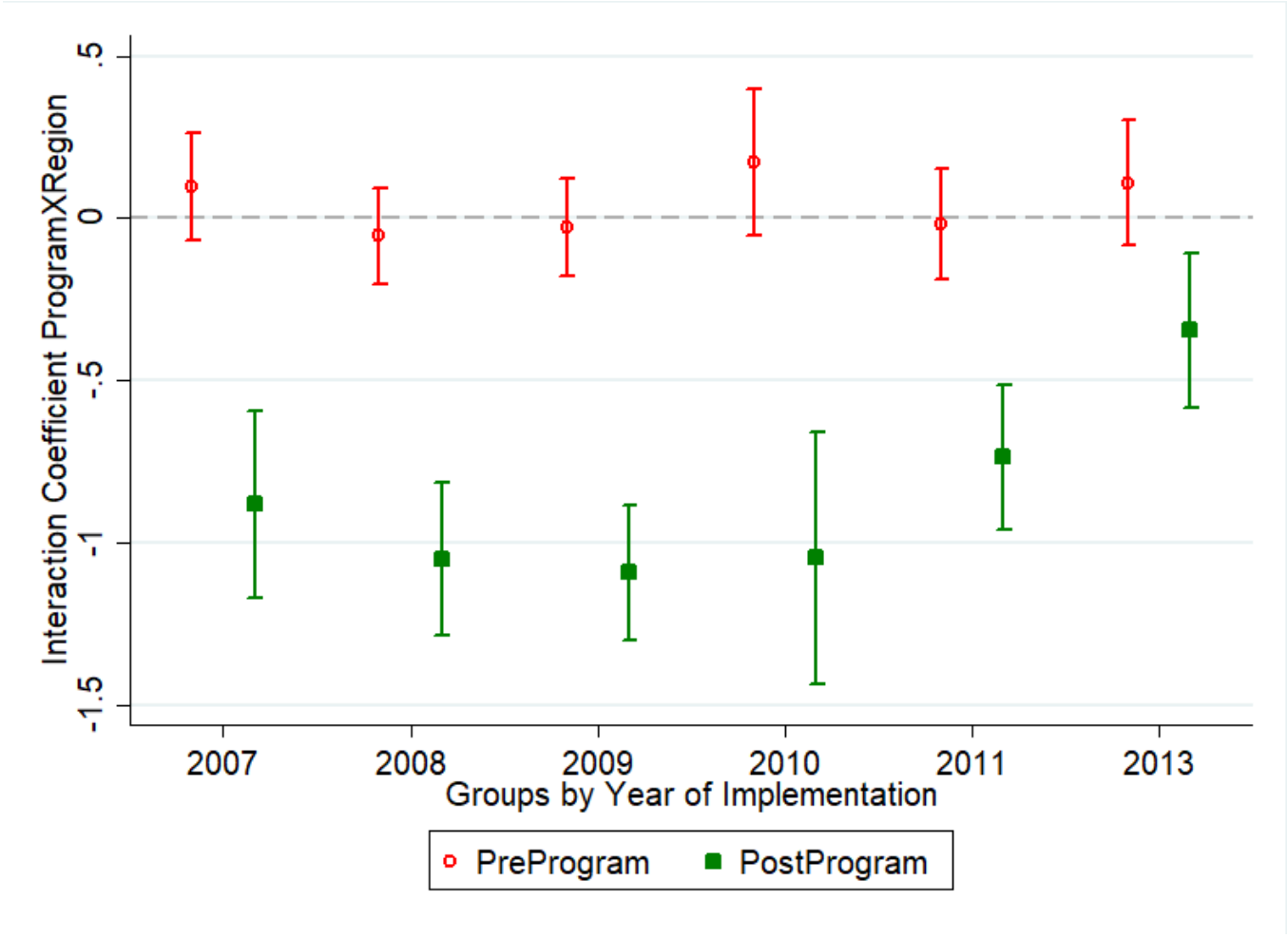
# Table 4: Test of parallel time trends

| | (1) Strictly non-durables | (2) Food | (3) Utility bills | (4) Trans-portation | (5) Rotating savings | (6) Household ex-penses | (7) Personal toi-letries |
|---|---|---|---|---|---|---|---|
| Panel A | | | | | | | |
| ProgramX2007 | 0.261* | 0.128 | 0.123 | 0.728 | 0.066 | 0.211 | 0.291 |
| Standard error | (0.142) | (0.109) | (0.294) | (0.827) | (1.036) | (0.215) | (0.312) |
| Obs. | 15,058 | 15,097 | 15,097 | 15,097 | 15,097 | 15,097 | 15,097 |
| R-squared | 0.642 | 0.599 | 0.579 | 0.505 | 0.612 | 0.407 | 0.448 |

| | (8) Servants' wages | (9) Sweeptakes | (10) Monthly expen-diture | (11) Durables | (12) Medical | (13) Last year income |
|---|---|---|---|---|---|---|
| Panel A | | | | | | |
| ProgramX2007 | 0.265 | -0.002 | 0.287** | 1.017*** | -0.542 | 0.418 |
| Standard error | (0.197) | (0.094) | (0.144) | (0.385) | (0.433) | (0.531) |
| Obs. | 15,097 | 15,097 | 14,995 | 15,097 | 15,097 | 15,129 |
| R-squared | 0.499 | 0.353 | 0.666 | 0.524 | 0.455 | 0.548 |

Notes: Sample is prior to the program. All regressions include district fixed effects and month-year dummies. The standard error is clustered by district.

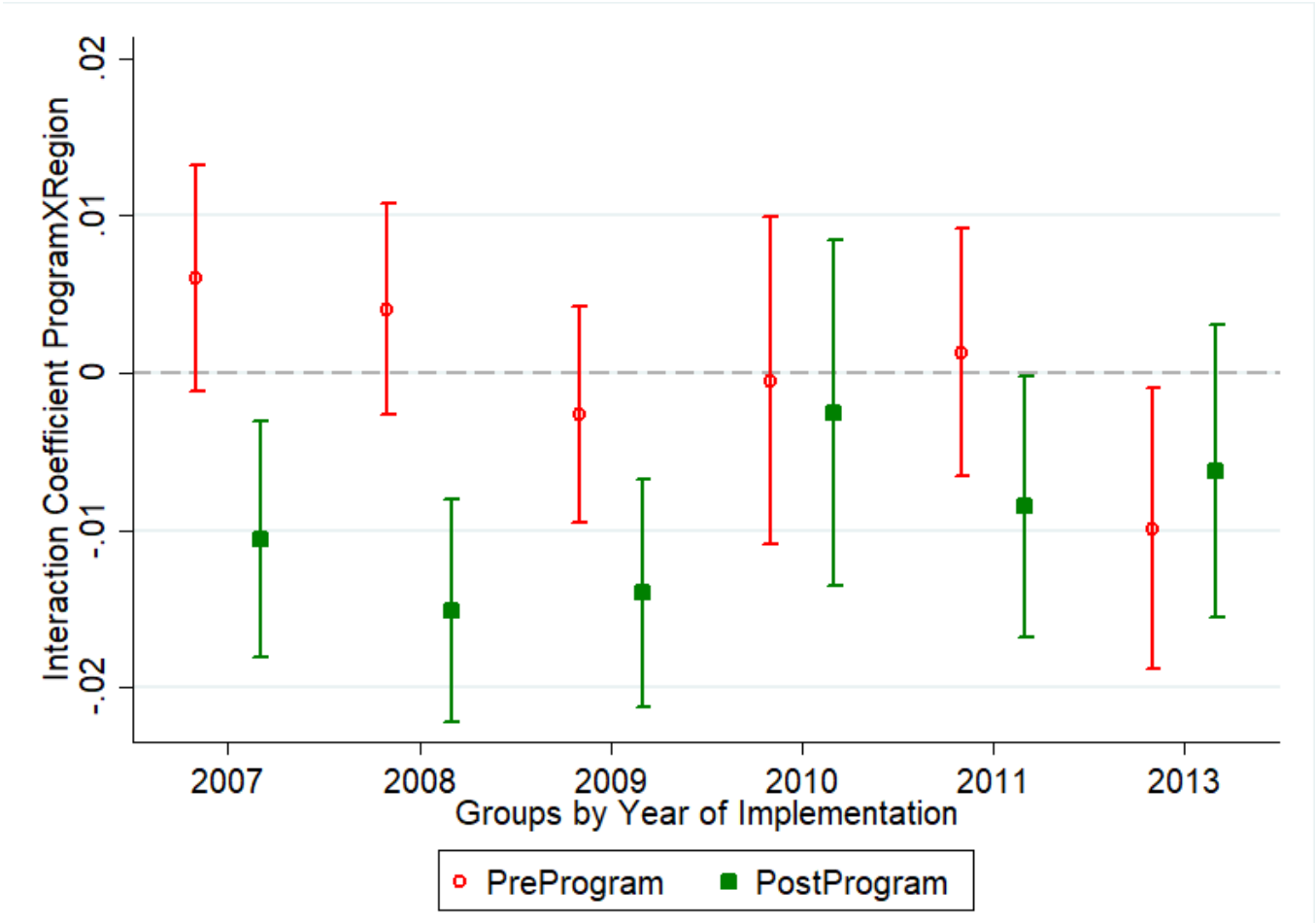
# Policy Effect on Kerosene Quantity




**DID estimation** $C_{it} = \alpha + \beta_{0i} + \beta_1 D_{rt} + \beta_2 P_t + \beta_3 D_r * P_{2014} + \beta_4^{'} X_{it} + \beta_{4s} + \epsilon_{it}$

N=11,499

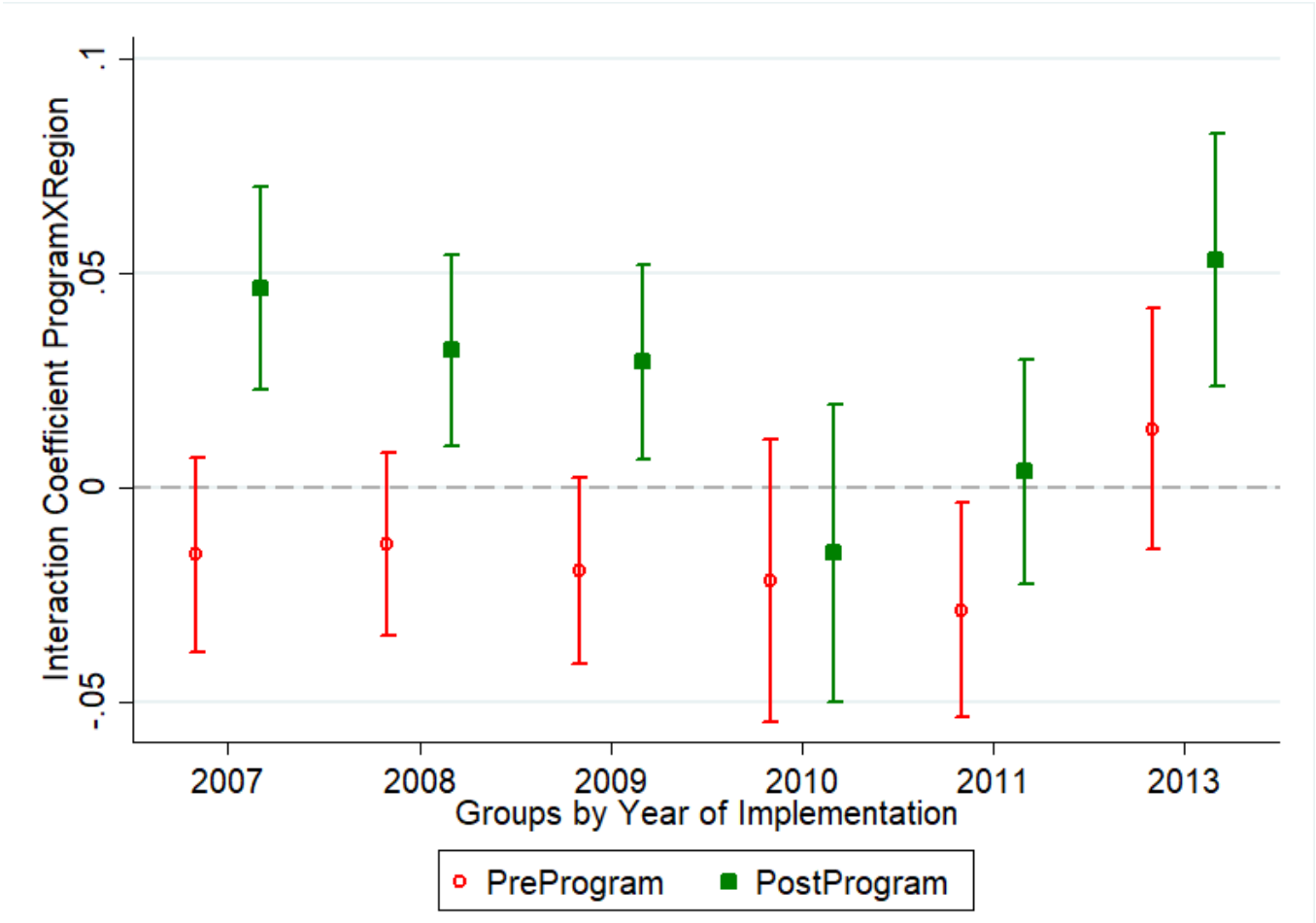
# Policy Effect on Fuel Cost Share




**DID estimation** $C_{it} = \alpha + \beta_{0i} + \beta_1 D_{rt} + \beta_2 P_t + \beta_3 D_r * P_{2014} + \beta_4^{'} X_{it} + \beta_{4s} + \epsilon_{it}$

N=11,499

# Policy Effect on Food Cost Share




**DID estimation** $C_{it} = \alpha + \beta_{0i} + \beta_1 D_{rt} + \beta_2 P_t + \beta_3 D_r * P_{2014} + \beta_4^{'} X_{it} + \beta_{4s} + \epsilon_{it}$

N=11,499

# Conclusion

- The program reduces household fuel expenditure share and increases household food expenditure share in the long run.