American Economic Review: Papers & Proceedings 2015, 105(5): 242–246
http://dx.doi.org/10.1257/aer.p20151097

Moving up the Energy Ladder: The Effect of an Increase in Economic Well-Being on the Fuel Consumption Choices of the Poor in India†

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Millions of poor households continue to use potentially hazardous, dirty fuel sources. As of 2010, an estimated 41 percent of households worldwide relied on solid fuel for cooking (Bonjour et al. 2013), while an estimated 500 million households use kerosene lighting (Lam et al. 2012).

What will change the types of fuels poor households in developing countries consume?[1] One common hypothesis is that economic growth shifts households toward better fuel: the so-called "Energy Ladder." In theory, however, the relationship between an increase in economic well-being and the use of dirty fuels is not obvious.

Consider a simple unitary household model where households choose between purchasing dirty fuel and other consumption (including clean fuel).[2] Assume that consumption of dirty fuel has a negative effect on health and labor supply, but that clean fuel and other consumption does not.

While the wealth effect from a capital influx would induce households to buy more dirty fuel, they might simultaneously reduce their purchases depending on the degree of substitutability with clean fuels and other consumption. This substitution effect will not necessarily dominate the wealth effect, unless dirty fuels are an inferior good. However, a capital increase could also cause labor to become relatively more productive, discouraging the purchase of any health-damaging, dirty fuels. Thus, the overall effect on dirty fuel purchases depends on both the substitution effect and the extent to which the health effect matters.

To test the implications of the model, we exploit an experiment in rural India that sought to improve the livelihoods of the poor in Murshidabad, West Bengal, India. About 800 households were targeted and about half were randomly assigned to an asset transfer program that was administered by Bandhan, a local NGO. Banerjee et al. (2011) found that the intervention led to a large and persistent increase in both assets and consumption at both 18 and 30 months. Thus, the program provides an ideal setting in which to explore how a persistent rise in a household's economic well-being affects both total fuel expenditures and fuel composition.

Section I provides a description of the experiment and data. Section II provides the results. Section III provides a discussion of the findings in terms of their health and environmental implications.

I. Experiment and Data

A. *Experiment*

We exploit data from a randomized experiment described in Banerjee et al. (2011). Details can be found in their paper and in online Appendix 2. Starting in late 2006, Bandhan targeted poor households in the Murshidabad district based on income. Half of the recruited households were randomly assigned to receive the livelihoods intervention, which consisted of a grant in the form of an asset (two cows, four goats, one cow

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† Go to http://dx.doi.org/10.1257/aer.p20151097 to visit the article page for additional materials and author disclosure statement(s).

[1] In a developed country setting, Barreca, Clay, and Tarr (2012, p. 2) document how the use of bituminous coal sharply fell due to "coal strikes of the second half of the 1940s, the end of war-related supply restrictions on oil and natural gas, increased supply via new long-distance pipelines, and the availability of low-cost conversion units for furnaces."

[2] The model is provided in online Appendix 1.

and one goat, or a non-farm enterprise). In addition, they received a stipend of Rs 90 (US$2.25) for 13 to 40 weeks depending on their asset choice. Households were required to attend weekly meetings to collect the stipend and to save Rs 10 (US$0.25) at each meeting. After 18 months, they were given a three-day micro-credit orientation and became eligible for loans.

B. *Data*

We exploit data from the baseline survey, an endline survey at 18 months post-asset transfer (but before the micro-finance orientation), and a second endline survey at about 30 months. We use data from the household module, which includes data on 388 control and 429 treatment households. We use data on treatment status, total and detailed fuel expenditures, light source, and stove type.

As Banerjee et al. (2011) discuss, the randomization was successful and attrition was not differential by treatment; we also perform a randomization check for the fuel variables and find that they are also balanced by treatment status at baseline.

Households reported spending Rs 38.43 on fuel in the past 30 days (3 percent of baseline consumption). Households predominately used dirty fuels for cooking: 93 percent of households reported having a stove that used wood, 54 percent reported having one that used cow dung, and 27 percent reported having one that used kerosene.[3]

Relatively few sample households (12 percent) relied on electricity for light in the baseline, much lower than India's average. Instead, households relied on subsidized kerosene, with 87 percent reporting that they had bought it in the last 30 days.

II. Results

A. *Overall Fuel Expenditures*

In Table 1, we explore the intervention effect on the log of household fuel consumption (column 1) and on the ratio of the log of fuel to the log of non-fuel consumption (column 2). We regress the outcome, y_{it} for $t = 1, 2$, on treatment status, T_i:

$$y_{it} = \beta_0 + \beta_1 T_i + \beta_2 y_{i0} + e_t + h_i + e_{it}.$$

We control for the household's baseline outcome variable (y_{i0}), the fixed effect of Endline 1 (e_t), and hamlet fixed effects (h_i).[4] Standard errors are clustered at the household level.

Fuel consumption significantly increased. The treatment group consumed 12.8 percent more fuel than the control group. The ratio of fuel to non-fuel consumption did not change, indicating that the percent of the budget spent on fuel remained constant as assets increased. Note that since only about half of households enrolled, those who actually enrolled consumed 22 percent more fuel than those who did not.[5]

TABLE 1—TOTAL FUEL CONSUMPTION

	log(fuel cons) (1)	log(fuel cons)-log(non-fuel cons) (2)
Treat	0.128	0.004
	(0.041)***	(0.366)
Observations	1,585	1,584

Notes: This table explores the reduced form effect of the treatment on monthly fuel consumption. The consumption variables are top-coded at the 99th percentile. All regressions control for the baseline value of the outcome variable, include an indicator variable for Endline 1 and hamlet fixed effects, and are clustered at the household level.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

B. *Specific Fuel Use*

Next, we examine whether the asset transfer program had an effect on fuel composition. Table 2 shows the treatment effect on light and stove choices.

[3] Even though households report owning multiple stoves, they typically only use one type (Hanna, Duflo, and Greenstone 2012).

[4] The results are robust to omitting baseline controls and/or hamlet fixed effects, as well as including baseline controls for health and education. The results are also robust to levels, rather than logs.

[5] The estimate of the treatment effect on log fuel expenditures is larger in magnitude in Endline 1 than Endline 2 (0.165 versus 0.084; the p-value of this difference in estimates is 0.134).

Table 2—Effect on Primary Light Source and Stove Type

	Light	Primary stove					
	Electricity (1)	Dung (2)	Wood (3)	Charcoal (4)	Coke/coal (5)	Kerosene (6)	LPG/electricity (7)
Treat	0.047	0.106	−0.091	0.001	0.004	−0.003	0.001
	(0.024)**	(0.027)***	(0.030)***	(0.001)	(0.008)	(0.003)	(0.001)

Notes: This table explores the reduced form effect of the intervention on the types of fuel used for light and cooking. The light variable (column 1) includes both Endline 1 and Endline 2 with a sample size of 1,585, while the stove type variables (columns 2 through 7) include only Endline 1 (sample size of 812) because the question was not administered in Endline 2. Wood includes all wood and non-forest timber products. All regressions control for the baseline value of the outcome variable, include hamlet fixed effects and an indicator variable for Endline 1, and are clustered at the household level.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Electricity use increased as a result of the program: those in the treatment group were 4.7 percentage points more likely to report using electricity as their primary source of light relative to the control group (column 1); this translates to a 13 percent increase relative to the control group. However, we find no observable shift toward better stove technologies, e.g., kerosene, electricity, or LPG. We do, however, find an increase in the use of cow dung as the primary stove fuel and a corresponding decrease in wood and non-forest timber products. This likely reflects a relative decrease in cow dung price for households who acquired livestock and is consistent with the cross-sectional finding that wealthier households use more cow dung.

Table 2 explored the extensive margin, i.e., whether households switched their primary lighting or stove type on net. Note that even if households increased their purchases of clean fuel to the point that it is now their primary fuel source, they might still consume more of the dirty fuel. Thus, in Table 3, we test whether the program impacted fuel consumption in the last 30 days for either lighting or cooking, by fuel type.

While the survey questionnaire did not distinguish between lighting and cooking, very few households report cooking with kerosene (and this did not change as a result of the program), so kerosene expenditures are likely for lighting; similarly, wood and cow dung are primarily used for cooking.

Kerosene expenditures increased as a result of the program. The number of households that reported buying kerosene fell, likely due to the switch from kerosene to electricity for light. However, total kerosene expenditures rose. Consistent with regressions on the primary fuel used for cooking, we observe an increase in the value of cow dung consumed and a decrease in wood. The number of households that report using cow dung increased, consistent with the shift to using cow dung as the primary fuel. However, the number of households who reported consuming at least some wood remained the same (column 3), either because there may not have been enough cow dung to meet their full demand or some form of kindling was necessary to start the fire even if cow dung was used.

The increase in total fuel consumption could have been due to switching to more expensive fuel types (e.g., changing from kerosene to

Table 3—Effect on Detailed Fuel Consumption

	Kerosene (1)	Dung (2)	Wood (3)	Other (4)
Panel A. Reported consuming				
Treat	−0.012	0.098	−0.025	0.004
	(0.006)*	(0.026)***	(0.016)	(0.008)
Panel B. Value of consumption				
Treat	1.946	23.476	−12.214	0.827
	(0.970)**	(4.188)***	(4.898)**	(0.977)

Notes: This table explores the reduced form effect of the intervention on detailed fuel consumption. The other category includes LPG, matches, incense, etc. All regressions include hamlet fixed effects, total baseline fuel consumption, and an indicator variable for Endline 1, and are clustered at the household level. Sample size: 1,585.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

electricity), or from either cooking more or using more light with the dirty fuel, or some combination of both. While we do not have information on the number of hours that households lit the house, it is likely due to a combination of both margins for light given that more households used electricity for light, but that overall kerosene purchases also increased (and kerosene is primarily used for light). On the other hand, in addition to not observing a shift to a better cooking fuel type, we do not observe any changes in overall cooking time (results available upon request).

III. Discussion

In this paper, we study an asset transfer program to understand how an increase in economic well-being affects fuel choices.

Electricity for light increased with a change in economic status. This is perhaps unsurprising, given the many benefits that electricity brings to the lives of the poor (Lipscomb, Mobarak, and Barham 2013; Dinkleman 2011). According to our estimates, a 5 standard deviation increase in assets would shift everyone within this income bracket to use electricity as their primary source of light. While we may not expect this large an increase in the near future, given the nearly 1.5 billion people worldwide without electricity, even a marginal improvement in their economic circumstances would result in a substantial increase in electricity demand. Hence, one of the consequences of the growth of income transfer programs is added stress to already overloaded electricity systems. Thus, this implies that a sustainable system will require the development and marketing of more energy efficient products in developing countries, as well as broader efforts in electricity conservation.

At the same time, the program also increased kerosene expenditures, which has large health (Barron and Torero 2013; Epstein et al. 2013) and environmental implications (Lam et al. 2012). Thus, economic growth, within at least the range in this study, would not necessarily limit the threats posed by kerosene lighting.

Households did not switch to a better cooking source and, in fact, many switched to a worse, but more readily available source—the assets that are in the form of livestock produced a cheap source of dung for fuel use. Many reasons may have prevented the switch to a better fuel—from lack of information about health risks to the fixed costs of acquiring a stove for a different fuel. Nonetheless, without other intervention, we may not expect changes in income status to dramatically switch people away from wood and cow dung, at least within this income bracket.

On net, we show that even the poorest members of society, who are often greatly overlooked in the energy debates and estimates of fuel growth (Wolfram, Shelef, and Gertler 2012), increase fuel consumption with rising economic well-being. This implies that this group should not be ignored in energy policy design.

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