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What Makes Rural Households Use Traditional Fuel? Empirical Evidence from India

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Abstract

This paper investigates the effects of different types of cooking fuels on the technical efficiency of household meal production in rural India. Rural households in India use for cooking either traditional fuels like firewood, dung, crop residue, and coal or modern fuels like liquefied petroleum gas (LPG) and kerosene, or a combination of both traditional and modern fuels. Using the stochastic frontier method, this paper estimates the influence of different types of cooking fuel and other household level characteristics on the technical efficiency of household meal production. We use a representative sample of 3880 rural households from the India Human Development Survey, 2008. Our results indicate that efficiency of meal preparation is significantly higher when households use either a traditional or a combination of both traditional and modern fuels than if they use modern fuels alone. Thus, results of this paper shed light on reasons other than cost behind the overwhelming popularity of traditional fuels in spite of their adverse health and environmental effects. This result is likely to be driven by the capacity constraint imposed by LPG and kerosene burners in cooking a large quantity of food at a time. Our study identifies use of traditional fuel as a viable option for reducing energy poverty in rural India, and recommends extensive policy for supplying improved wood burning cook stoves and afforestation to reduce the harmful pollution effects of open fire. The policy makers should also emphasize on provision of biogas plant and biomass gasifier along with afforestation. Further, our study recognizes the need for developing and supplying more efficient cooking stoves for modern fuels to promote higher use of clean energy sources. Our results also suggest policy intervention in improving womens education, household income, provision of ration card, and providing government support in acquiring improved cooking stoves for increasing efficiency of meal production at the household level.

***Keywords*:** Meal production; Modern fuel, Technical efficiency; Traditional fuel; Stochastic frontier analysis

***JEL Codes*:** Q40, D24

1. Introduction

This paper estimates a production frontier and analyzes the technical efficiency of meal production at the household level. Meals are among commodities which households do not directly consume but prefer to transform into consumable goods through a household production function. Thus, households play a dual role of being consumers as well as producers (Davis, 2013, 2010; Rose, 2007; Huffman, 2011; Becker, 1965). Household meal production transforms inputs like energy, raw materials, and human effort into cooked food for daily meals. The importance of such production lies in the fact that people derive utility and build health from cooked food.

In India, meal production accounts for 84% of a rural household's energy consumption (MNES, 1995a). Several types of cooking fuels are used in the country, including biomass like firewood, crop residue, and dung cake; or non-biomass sources like kerosene and liquefied petroleum gas (LPG). Some households use charcoal and coal as well. However, in the rural areas, people predominantly use biomass. A nationwide survey has shown that almost 71.4 % rural households use biomass, 24.4% use LPG, 0.9% use kerosene, and a very small percentage of households use other sources of energy for cooking (MOSPI, 2013). The objective of this paper is to estimate a meal production function at the household level using the total amount of food prepared by each household as the output variable and examine effects of different types of fuel and other social, economic, and demographic factors on technical efficiency of meal preparation.

Technical efficiency refers to the capability of a production system to produce maximum amount of output with the given resources and technology. Thus, a production unit is said to be technically inefficient if it fails to produce the maximum possible output with the given set of inputs. The degree of technical inefficiency is measured by the deviation of actual output from the maximum possible one. Reasons for such deviation are attributed to factors that can be controlled by the producers - like managerial error, coordination failure and so on. The basic concept of estimating technical efficiency is rooted in the seminal papers by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977) and the literature since then. A general discussion on measurement of productive efficiency and the related literature can be found in Lovell (1996), Kumbhakar and Lovell (2000), and Coelli et al. (2005). In this study, we use stochastic production frontier approach (SPF) to measure efficiency of meal production. The SPF approach econometrically estimates the degree of technical inefficiency in a production system after accounting for the random shocks that are responsible for influencing the total output either in a positive or in a negative fashion.

We find that technical efficiency of household meal production is significantly higher if a household uses traditional fuel like firewood, dung, crop residue, and coal or uses a combination of traditional and modern fuel that includes liquefied petroleum gas (LPG) and kerosene versus households using only modern fuels for cooking. Thus, our results shed light on a reason other than cost behind choosing traditional fuel like firewood by majority of households in rural India. The rural households in India use the type of fuel for cooking that generates maximum amount of cooked food with the given resources, even if use of that type of fuel causes health hazards and increases pollution in the environment. Thus, a rural household tends to maximize short term private benefits instead of maximizing social and long term benefits. Further, we find that higher female education, income, availability of ration card, and government support can improve technical efficiency of household food production. We also find significant regional disparities in such efficiency.

To the best of our knowledge, this is the first study to examine the effects of different types of cooking on the efficiency of household meal production in rural India. There are many studies at both international and national level that focus on the issue of household energy use (Mainali et al., 2015; Hassan et al.,2013, Demerger, 2011; Balachandra, 2011; Gundimeda et al., 2008; Rao and Reddy, 2007; Madhubanshi et al., 2006; Heltberg, 2005; Pachauri, 2004), but none that examines the specific issue of energy type and efficiency of household meal production. This study is also important from the policy perspective as 57% people in rural area suffer from energy poverty (Khandkar et.al., 2012) – an issue that is intertwined with income poverty and other causes of backwardness. The, alleviation of energy poverty will take enormous resources and time. Meanwhile, it is critical that existing resources be used in a sustainable manner. Findings of this paper will help policy makers better understand behavior of rural households regarding fuel choice for cooking and guide them in designing policies to ensure sustainable and efficient supply of energy in rural areas.

The structure of the paper is as follows. Section 2 describes the data, and descriptive statistics. We present the empirical model and method in section 3. Results are discussed in section 4 that is followed by conclusion in section 5.

2. Data Description

This study uses the 2008 Indian Human Development Survey (IHDS). It is a nationally representative data set that has detailed information on household characteristics including the type of fuel used for cooking. This survey covers a total of 41,554 households out of which 26,734 households are from rural areas. The sample is drawn using stratified random sampling spread across 1,503 villages and 971 urban blocks in 33 states of India (NCAER, 2014). This data set is prepared jointly by a team of representatives from the University of Maryland and the National Council of Applied Economic Research (NCAER), New Delhi. We use information from 3880 rural households for this study[3]. Tables 1 and 2 present summary statistics for the variables used in our study.

(Insert Table 1 and Table 2 here)

[3] The data set did not have relevant information for all rural households.

From the descriptive statistics in Table 1, we find that the average family size in rural India is 5.82 which is bigger than the national average of 4.91 (Census, 2011). Each family contains approximately 2 children on average. A rural household cooks 3 meals for family members everyday on average and also provides some food to hired workers. We find that the average time spent for cooking and collecting firewood in a rural household is a little over 3 hours per day and they expend approximately INR 114 per year on crockeries. A household spends approximately INR 3 per day as fuel expenditure. Average expenditures for different types of fuel used are also presented in Table 1.

The summary statistics for the variables of the inefficiency model are given in Table 2. We observe that majority of rural households (58%) in our sample use traditional fuels for cooking and firewood is the most common cooking fuel. Almost 26% households use a combination of both traditional and modern fuels and 15% use only modern fuels for cooking. This is in line with the typical pattern of cooking energy use in developing countries where biomass is the most common fuel and people using modern fuels also prefer to use traditional fuel alongside (Cheng et al., 2014). Among other variables used in the inefficiency model, we find that the highest female education level as measured by the number of years of schooling is a little over 3 years in our sample. Approximately 49% households belong to the low income category[4] and 86% of households have ration cards. Percentages of households belonging to East India, Northeast India, South India, West India, and North India are 23%, 6%, 23%, 15%, and 33% respectively.

3. Empirical Model and Estimation Methodology

We specify a cross-sectional stochastic production frontier model to estimate efficiency of household food production. The production frontier is specified as -

[4] Low income refers to earning below median income, as defined in the next section.

$$y_i = f(x_i; \beta) + v_i - u_i \quad (1)$$

where, y_i is the observed output of household i, $f(\cdot)$ is the production function specifying the maximum possible output level for given inputs and technology, x_i represents inputs used in household i, and β is the technology parameter. v_i - a component of the composite error term represents random shocks to the production system. The other component u_i captures inefficiency effects that are responsible for reducing the actual output below the maximum possible level.

The output variable (y) in our model is the product of the number of meals served in a household per day and the total number of individuals who were served those meals. The total number of heads receiving meals in a household includes adults and children members, and outsiders like hired workers who are served daily meals in that household. Following the ICMR (2009) recommendation of calorie requirement in rural India, we incorporate a calorie requirement in children up to age 14 years as 63% of that of an adult for our analysis[5]. The inputs for household meal preparation are labor hour (labor), expenditure on raw materials (material), expenditure on fuel (energy), and expenditure on crockeries (capital).The labor hour is measured as the sum of daily stove burning hours in a household and the time spent on collecting firewood for cooking by household members[6]. In the rural areas, people collect firewood for cooking, involving a significant amount of labor time that could have been utilized for other productive activities. Expenditure on raw materials includes the value of all food materials purchased daily by the households and the market value of home grown food materials. This type of

[5] Though there could be difference in recommended calorie requirement and actual calorie intake, it is not possible to account for that difference in this study due to data limitation. In general, this difference may depend on a range of economic, social, psychological, and other factors that are not easy to capture in any empirical study. We focus on rural households only where these factors are likely to be more homogeneous.

[6] Since we do not have data on actual labor hours spent for daily cooking and relevant data to calculate shadow price of firewood, we use the total time spent on cooking related activities as labor hour. Thus we are unable to identify the heterogeneous effects of time and number or age of individuals involved on household meal production. However, we use similar measure of labor for all households for which the ranking of type of cooking fuels in term of efficiency will not be affected.

expenditures typically involve expenditure on rice, wheat, cereal products, pulse products, milk products, vegetables, non-vegetarian items, salt, sweeteners, spices etc. The expenditure on energy used for cooking includes the total daily expenditure on different types of energy like kerosene, LPG, coal, charcoal and firewood (if purchased). Finally, we consider crockeries as the quasi-fixed capital input in our production model and measure it by the expenditure incurred in last 365 days to buy crockeries[7].

Using a Cobb-Douglas production[8] function for daily food produced in a household, we estimate technical inefficiency from the following –

$$\ln(y_i) = \beta_0 + \beta_1 \ln(Labor_i) + \beta_2 \ln(Material_i) + \beta_3 \ln(Capital_i) + \beta_4 \ln(Energy_i) + v_i - u_i \qquad (2)$$

i = 1, 2, 3, …, N, where, N represents the number of households in our sample. The random error v_i is normally distributed, $v_i \sim N(0, \sigma_v^2)$. u_i is the one-sided inefficiency term. We assume that the inefficiency effect follows a nonnegative truncated normal distribution. Thus, $u_i \sim N^+(\mu_i, \sigma_u^2)$. Further, v_i and u_i are assumed to be independent. This assumption is not unreasonable for our analysis since v_i represents the random shocks that are not under the control of a producer and u_i represents inefficiency effects that can be controlled.

Average technical inefficiency may also depend upon several exogenous factors. Thus we simultaneously estimate an inefficiency model to identify factors that influence technical inefficiency in (2). We categorize households based on the type of fuel used for cooking - traditional, modern or a combination of the two and analyze effect of the type of fuel on efficiency of food production. Since, people in rural India mostly rely on cooked food rather than processed items for their daily consumption, this analysis captures effect of type of fuel used on the efficiency of cooked food production. Among

[7] The IHDS data that we use for this study does not provide any information on other form of capital goods (like stove) that are relevant for food preparation. Since we use similar information for all households, this limitation will not affect the efficiency measures computed from our model.

[8] We find that the translogarythmic production function is not a better fit for our sample, based on AIC, and BIC.

household characteristics, we examine the effect of income status on efficiency of food production. Since there is wide income disparity among households, we identify the yearly median income as INR 24,650 and categorize households belonging to low income group if the yearly household income is less than or equal to the INR 24,650. We also examine effect of highest level of female education in a household, possession of a ration card, receiving government support to buy chulha[9], and region dummies on the efficiency of food preparation. We model mean of the pre-truncated inefficiency distribution (see Kumbhakar et. al., 1991; Huang and Liu, 1994 for details) as –

$$u_i = \partial_0 + \partial_1(Traditional\ fuel_i) + \partial_2(Combination\ fuel_i) + \partial_3(Female\ education_i) + \partial_4(Low\ income_i) + \partial_5(Ration\ card_i) + \partial_6(Government\ support_i) + \sum_{M=1}^{4} \partial_M(Region\_M_i) + \tau_i \quad (3)$$

To consistently estimate technical inefficiency scores of every household and marginal effects of exogenous factors on them, we estimate equations (2) and (3) simultaneously using Maximum Likelihood method[10]. This method is an improvement over the two-step method used in the literature (for example, Kalirajan and Shand, 1985), as this method allows consistent estimation of the technical inefficiency terms (and parameters) even if they are correlated with the inputs, and incorporates the non-positive nature of the inefficiency values. Following Jondrow et al. (1982) the conditional mean of technical inefficiency given random shocks are calculated as $E(u_i|e_i)$ where $e_i = v_i - u_i$. The density function of $(u_i|e_i)$ is $N^+(\mu_{*i}, \sigma_*^2)$ such that

$$E(u_i|e_i) = \frac{\sigma_* \emptyset\left(\frac{\mu_{*i}}{\sigma_*^2}\right)}{\emptyset\left(\frac{\mu_{*i}}{\sigma_*^2}\right)} + \mu_{*i} \quad (4)$$

[9] The stove or burner used for cooking
[10] We use STATA for empirical analysis

where $\emptyset(.)$ is the probability density function and

$$\mu_{*i} = \frac{-\sigma_u^2 e_i}{\sigma_v^2 + \sigma_u^2} \tag{5}$$

$$\sigma_*^2 = \frac{\sigma_v^2 \sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{6}$$

By construction, none of the households in our sample is fully efficient as we calculate the expected value of the conditional inefficiency here, and inefficiency scores represent the extent of reduction in actual output as compared to the maximum possible level, for the given inputs.

4. Results and Discussion

Table 3 presents estimation results from the production frontier. Significant positive elasticities for all inputs confirm the required monotonic relationship between the output and inputs. We also test for the presence of technical inefficiency in the production model. The null hypothesis of absence of technical inefficiency is rejected at 1% significance level, validating our effort of measuring and analyzing inefficiency of household meal production for our sample.

(Insert Table 3 here)

Estimated marginal effects of several economic, demographic, and household level factors are presented in table 4.

(Insert Table 4 here)

Our results show that the technical inefficiency in household meal production is reduced by 0.11 percentage points (3.83%) and by 0.07 percentage points (2.33%) when households use traditional fuel and a combination of traditional and modern fuel respectively, as opposed to using only modern fuel. We further find that the technical inefficiency of household meal production is reduced by an increase in female's education in a family, income level, possession of ration card, and access to government support to buy chulha (stove). Moreover, the southern region is the most technically efficient in energy use for cooking purposes, followed by the western and eastern region in comparison to the northern region. The north-eastern region is the most inefficient in this regard but the inefficiency does not statistically differ from the North India. We also find that the average technical inefficiency of household meal production is around 3 percent in the rural India as shown in Table 5.

(Insert Table 5 here)

Use of traditional fuel very often is objected on the ground of causing indoor air pollution that involves significant health hazards, especially, for women and children (Sarigiannis et al., 2015; Kurmi et al., 2013; Fullerton, 2009; Smith et al., 2011). Traditional fuels also emit greenhouse gas (Jerneck et al., 2013; Tucker, 1999) that affects the environment negatively. In spite of that, preference for traditional fuel is a predominant characteristic of rural India. Our results shed light on the rationale for such behavior of rural households. It shows that traditional fuel is the most technically efficient cooking fuel choice for rural households, meaning that such fuel can produce maximum amount of food for them when compared to other energy sources. Therefore, generally poor and resource constrained households maximize individual short term utility by choosing traditional fuel, even if that is not optimal in the long run or from the collective point of view.

Further, our results also provide explanation for invalidity of the energy ladder hypothesis in rural India. According to the energy ladder hypothesis, the demand for traditional fuel should be income elastic because it is inferior in nature. However, there is evidence that income elasticity of firewood use does not validate energy ladder hypothesis (Akpalu et al., 2011; Masera et al., 2000, 1997). The effect of income on fuelwood consumption in most studies appears to be small and demand for firewood may not decline with rise in income in rural areas as predicted by the energy ladder hypothesis (Gundimeda et al., 2008; Arnold et al., 2006). In other words, in the rural areas traditional fuel is a normal good and as income rises demand for traditional fuel rises as well. Social norms and customs also make people prefer firewood as a predominant source of energy (BMZ, 2014; IEA, 2006; Hosier et al., 1993).

Government of India has taken several initiatives to increases the use of renewable energies (Bansal et al., 2013) and subsidizes the use of modern fuels, but traditional fuel remains preferred. Our study adds a new reason for the preference of firewood apart from the cost and social norm consideration – households in rural India choose to use firewood for cooking as it is technically most efficient.

Modern fuels are likely to be less efficient in rural areas for several reasons. First, food habits in rural areas are different from urban areas. For an average person in rural India, food accounts for 52.9% of the value of consumption which is almost 10% higher than the urban households (NSSO, 2013). Per capita monthly cereal consumption is 12.12 kilogram in rural areas where as it is 9.32 kilogram in urban households. Further, 90% of the cereal comprises rice and wheat that require cooking for a considerable time. Rural households also consume more fresh food compared to processed food (NSSO, 2013). Therefore, food production in rural households needs more cooking and more energy. Stoves that are typically used in rural India with LPG and kerosene may not be suitable for such purposes due to their capacity constraints. Second, rural households generally cook more food because of larger family sizes as opposed to urban households. Taking into consideration the composition and size of meal, cooking with modern fuel may not be cost and time effective. At the same time multiple cooking related activities can be performed while cooking with traditional fuels such as heating water or roasting while cooking the staple food.

Our results are similar to the findings of Masera et al., (2000) that technical characteristics of cook stoves and cultural factors play an important role in the process of cooking fuel selection. The study conducted in Mexico reveals that people prefer traditional fuels as the burner surface in LPG stoves are too small to permit the cook to prepare more than two tortillas at once versus the ten tortillas that can be prepared with the traditional method. Thus people in Mexico prefer traditional fuels because they are technically suitable for their cooking, showing that there are other reasons besides cost of fuel that affect the choice of cooking fuel in households. One study worth mentioning in this context is conducted by Horst (2008). He conducted the study in Maun area of Botswana and found that traditional energy use was not driven by poverty. Rather, it was the result of active decision making based on individual preference and broader lifestyle consideration, which were diverse rather than uniform.

While examining other household level factors, we find that inefficiency declines with the highest female education level in the household. An extra year of education reduces inefficiency by 0.022 percentage points (0.73%). Since an educated woman is likely to be more aware of her environment, she is likely to choose proper utensils, chulha, raw materials, and implement suitable coordination to ensure efficiency in cooking. Further, higher level of education also increases the possibility of earning higher income, and hence affording for superior quality of firewood and utensil.

We also find that a family with low income is 0.164 percentage points (5.47%) more inefficient in cooking as compared to a household with higher than median income. Such result is likely to be driven by the fact that a poor household may not have easy access to good quality cooking fuel and proper utensils. Moreover, rural people mostly buy low quality food from public distribution scheme (Khera, 2011) that may need longer cooking hours. Further, as noted earlier in the rural areas traditional fuel is a normal good and as income rises demand for traditional fuel and hence efficiency of cooking rises as well.

We find that having a ration card in the household reduces inefficiency by 0.235 percentage points (7.83%). A ration card owner gets kerosene at subsidized rate which they may use along with firewood to cook more efficiently. Since a household with ration card gets the essential food materials including rice, wheat, sugar, oil at a price that is lower than the market value, the household may find it easier to spend for good quality fuel as well.

Government assistance for improved chulha is also likely to reduce inefficiency of home food production by 0.146 percentage points (4.87%). According to our result, technical inefficiency scores are 0.521 percentage point (17.37%) lower in the southern region, 0.488 percentage points (16.13%)

lower in the eastern region and 0.05 percentage points (1.67%) lower in the western region as compared to the northern region of the country. The regional disparities in technical inefficiency can be explained by the region specific economic, demographic, and social factors. The southern and eastern part of India is ahead of others where government flagship programs are more successful (Cavatorta et al., 2015, Jayaranjan 2011, Carswell, 2014, MNESb, 1995; Khera, 2011) and quality of life is better in this region (Balakrishnan, 2015), justifying the reason for higher efficiency in food preparation as found in our study. We do not find statistically significant difference in such inefficiency scores for the north-eastern region.

5. Conclusion

This study examines technical efficiency of household food production and finds that use of traditional fuel, higher female education, higher income, possession of ration card, and access to government support for buying improved stoves are likely to increase efficiency of meal production. The study concludes that given the nature of food consumed in rural areas, cooking can be most efficiently done with fuels like firewood, dung, crop residue and coal/charcoal. . We also conclude that a household's socio economic characteristics and institutional support are important in improving such efficiency.

Our study suggests that policies targeted at good quality firewood supply and improved cooking stoves provision – both for wood burning and for using modern fuels are important for rural India. Clearly, firewood is the dominant component in the traditional fuel category as it is used by almost 77.3% traditional fuel users in our data set, and by almost 85% of rural households in India as shown in the Census Report of Government of India, 2011. Improved wood burning stoves that are designed to promote complete combustion of firewood, not only generate less air pollutant like smoke and fine particulates, they also require 60-70 % less firewood compared to open fire cooking methods[11]. Thus, the harmful effects of traditional cooking fuel can be reduced by promoting improved wood burning stoves and also by creating awareness for maintaining good indoor ventilation in rural India. From macro perspectives, it is worth mentioning that use of traditional fuels like firewood produce less greenhouse gas than clean fuels like LPG, oil or electricity (Hamilton, 2008). Forest acts as natural carbon sink and use of firewood should not be a problem if forest is regenerated at sustainable rate (Reitze et al., 2008; Couture et al., 2012). Morever, logging and forestry business may strengthen local economy by creating job opportunities. For such virtues the countries in the European Union are trying to encourage the use and production of quality wood to reduce emission (IEE, 2010). Therefore, provision of good quality firewood through afforestation, along with access to improved wood burning stoves for cooking can help reduce the energy poverty in rural India.

Further, ambitious policy like supplying modern fuels in rural India at subsidized rate will only be effective if the government correspondingly focuses on distributing and proliferating the use of customized cooking stoves fueled by such clean fuels to cater rural cooking needs. Emphasis should also be given on renewable energy for replacing firewood with biogas and biomass gasifier. The Ministry of New and Renewable Resources of Government of India has initiated several measures under the National Biogas and Manure Management Programs, but they are not extensive yet. Extensive measures should be taken to increase awareness level about such renewable energy sources.

We must keep in mind that our efficiency measure does not capture the cost aspect or the environmental and health hazards associated with different types of fuel[12]. Our measure only captures deviation of actual quantity of food produced from the maximum possible level for the used inputs. Since use of traditional fuel may not be socially optimum from environmental and health perspectives,

[11] See www.ecologic.org
[12]Incorporating such aspects are beyond the scopes of the paper.

one way to promote modern fuel that has less negative impact on the environment and health will be to improve the capacity of stoves used with modern fuels, so that rural households find them equally or more technically efficient than other options. However, transition from one to another type of fuel within a reasonable time frame is rarely achieved because developing countries are far away from meeting the necessary requirements and conditions related to infrastructure, economics, and local culture needed to implement different objectives of such policies (Maesa et al., 2012). In that case, increasing sustainability of the current traditional biomass system must be considered. This can be realized by an integrated approach, in which national and regional fuelwood policies are adapted, awareness is created to increase meal production efficiency, and improved cook stoves are distributed.

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Table 1: Summary Statistics of Variables Used in the Production Frontier

Production Frontier				
Variables	**Mean**	**Standard Deviation**	**Min**	**Max**
No. of children (0 - 14 years) in a household	1.95	1.69	0	13
Household size	5.82	2.69	1	29
No. of workers who were served meals	0.28	0.67	0	5
Number of meals (per day)	2.86	0.67	0	6
Food produced (per day)	14.76	7.71	0.04	94.20
Labor hours (per day)	3.28	1.49	1	11
Expenditure on crockery (annual)	114.05	404.77	0	11000
Expenditure on raw food material (per day)	55.53	38.52	4.47	654.5
Expenditure on firewood used for cooking (per day)	0.59	2.40	0	33.33
Expenditure on dung used for cooking (per day)	0.097	0.73	0	20
Expenditure on crop residue used for cooking(per day)	0.018	0.35	0	13.33
Expenditure on kerosene used for cooking (per day)	0.31	0.78	0	17.33
Expenditure on LPG used for cooking (per day)	1.47	3.35	0	20.83
Expenditure on coal used for cooking (per day)	0.075	0.78	0	13.33
Total cooking fuel expenditure (per day)	2.56	4.40	0.001	37.67

Table 2: Summary Statistics for Variables Used in the Inefficiency Model

Inefficiency Model				
Non-Categorical Variables	**Mean**	**Standard Deviation**	**Min**	**Max**
Highest female education	3.43	4.43	0	15
Annual income	44794.88	74040.08	0	1587227
Dummy Variables	**Percent**			
Low income	49.33			
Ration card	85.79			
Firewood used for cooking	77.3			
Dung used for cooking	43.21			
Crop residue used for cooking	13.62			
Kerosene used for cooking	20.48			
LPG used for cooking	24.49			
Coal used for cooking	2.46			
Traditional fuel used for cooking	58.60			
Modern fuel used for cooking	15.29			
Combination fuel used for cooking	26.10			
East India	23.22			
Northeast India	6.24			
South India	22.88			
West India	15.09			
North India	32.57			

Table 3: Stochastic Production Frontier Estimation Results

Dependent Variable: Ln(Food produced)	
Variables	**Ln(Food produced)**
Ln(Labor)	0.241*** (0.015)
Ln(Material)	0.352*** (0.013)
Ln(Capital)	0.002*** (0.001)
Ln(Energy)	0.003* (0.002)
Constant	1.359*** (0.065)
Number of observation	3880
Wald chi2 (4)	1109.26***
H0: No inefficiency component	Prob<=z=0.000

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses

Table 4: Marginal Effects of Exogenous Factors on Technical Inefficiency

Inefficiency Model	
Variables	Marginal Effects
Traditional fuel	- 0.115*** (0.051)
Combination fuel	- 0.07* (0.043)
Female education	- 0.022*** (0.004)
Low income	0.164*** (0.033)
Ration card	- 0.235*** (0.038)
Government support	- 0.146*** (0.035)
East India	- 0.488*** (0.060)
Northeast India	0.032 (0.108)
South India	- 0.521*** (0.075)
Western India	- 0.0504*** (0.067)
Constant	0.984*** (0.059)

Note: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses.

Table 5: Estimated Technical Inefficiency

Statistics	Value (%)
Mean Technical Inefficiency	3.00
Standard Deviation of Technical Inefficiency	0.254
Minimum Technical Inefficiency	2.066
Maximum Technical Inefficiency	3.974