Thesis Abstract

Title of Thesis	Essays on Household Air Pollution in Developing Countries: A Study of Households in an Indian Rural Village

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Household air pollution (HAP, hereafter) arising from the incomplete combustion of traditional fuels such as firewood, solid biomass fuels and coal, is a salient environmental and health risk particularly in rural areas of developing countries. Despite the alarming health risks from HAP, dirty fuel usage continues unabated particularly in the rural areas of developing countries. In this thesis, we attempt to extend the literature on the reduction of HAP in developing countries in general and rural India in particular. This thesis comprising of three empirical papers, focuses on the economics of HAP with an emphasis on the choice and usage of cooking fuels in rural India. In what follows, we summarize the three chapters of the dissertation thesis along with the publication information for each of them.

Chapter 2: Information dissemination through internet and choice of cooking fuels: A case study of rural Indian households

[Publication information: A preliminary draft of this chapter based on analysis with pilot test data is published as: CHATTOPADHYAY, M., ARIMURA, T. H., KATAYAMA, H., SAKUDO, M., & YOKOO, H. F. (2017). Cooking Fuel Choices—Analysis of Socio-economic and Demographic Factors in Rural India—. *ENVIRONMENTAL SCIENCE*, *30*(2), 131-140. However, the current version of the chapter is a single authored one]

One possible reason behind the unabated use of dirty cooking fuels despite the persistent health hazards from HAP in developing countries may be the knowledge gap. Researchers have identified different sources of information transmission like television, radio and newspaper in developing countries. With the rapid digitalization of services even in rural areas of developing countries, information may disseminate through the access to internet as well. However, the impact of access to information disseminated through internet on cooking fuel choice has not been explored in detail yet. In the second chapter, we try to bridge this gap and try to investigate how the access to information disseminated through internet may affect the likelihood to choose dirty cooking fuels analysing data from 565 rural Indian households.

In estimating individuals' likelihood to choose dirty cooking fuels, one plausible problem may be the endogeneity of 'access to internet'. To address this, we adopt an instrumental variable approach. As an instrument, we have used the 'whether the household is located in an interior region'. Furthermore, to address the feature that the error terms of the fuel choice equation as well as access to internet is jointly distributed, we jointly estimate the two equations using a bivariate probit model. The results of the maximum likelihood estimates suggests that access to internet has a negative and significant association with the likelihood to choose dirty cooking fuels. Testing for the strength of the instrument, we find that our instrument may be a weak one; thus, our results of the maximum likelihood estimation method may suffer from the caveat of weak instrument bias. Therefore, a better and more reliable approach is to use propensity score matching (PSM) approach to test the causal relationship between access to internet and cooking fuel choice and thereby address endogeneity arising from unobservable confounding factors.

Results from the PSM analysis suggests that households with access to internet are approximately 24% less likely to choose dirty cooking fuels in compared to matched control groups (households without access to internet). Furthermore, sensitivity analysis based on

bounding approach by Rosenbaum (2002) suggests that, this negative causal relationship between access to internet and likelihood to choose dirty cooking fuels is valid till the effect of hidden bias from the unobservable confounders cause a 60% increase in the odds of assignment to the treatment group compared to the control group.

Chapter 3: Subjective Probabilistic Expectations, Household Air Pollution, and Health: Evidence from cooking fuel use patterns in West Bengal, India

An increasing number of empirical studies have investigated the determinants of cooking fuel choice in developing countries, where health risks from household air pollution are one of the most important issues. Despite much evidence in the literature, there remains some unexplored aspect of the choice of household cooking fuel, specifically the role of expectations about health risks from HAP. In the third chapter of this dissertation, we contribute to this stream of literature by exploring the association between of individuals' subjective probabilistic expectations (SPEs) on cooking fuel usage pattern. We also explore how this pattern is associated with individuals' health status. We analyse a unique dataset on individuals' SPE elicited in probabilistic form from 557 survey respondents in rural India. To elicit the individuals' SPEs about the health risks related to HAP, we have adopted an interactive elicitation method using visual aids. A potential problem in estimating the health

status of the individuals is the endogeneity of the 'cooking fuel usage pattern' variable. To address this, we adopt an instrumental variable approach. As an instrument, we have used the 'opportunity to access cooking fuel for free' in our analysis. Further, to address the non-linearity associated with binary health status as well as the fact that cooking fuel usage pattern variable lying in the unit interval between 0 and 1, we have adopted the Two Stage Residual Inclusion (2SRI) model. Our results suggest that individuals' SPEs of becoming sick from dirty fuel usage are negatively and significantly associated with the fraction of days of dirty fuel usage in households. Concurrently, dirty fuel usage and self-reported health status of the individual being sick are also significantly correlated. We then conduct a policy simulation of information provision regarding the health risks of dirty fuel usage. Our simulation demonstrates that although the provision of information results in statistically significant changes in households' cooking fuel usage patterns and in individuals' health status, these changes may be small in size.

Chapter 4: Economics of clean air: Valuation of reduced health risks from Household Air Pollution - A study of rural Indian households

[Publication information: The version of the chapter submitted for interim reporting of PhD is published as a discussion paper in the WINPEC Discussion Paper series: Chattopadhyay, M. (2021). *Economics of clean air: Valuation of reduced health risks from Household Air Pollution-A study of rural Indian households* (No. 2119). This chapter is a single authored one]

Although the health risks from HAP is salient in developing countries, it can be adequately prevented. To overcome the numerous logistic challenges that may arise during the implementation of interventions to reduce HAP, it is necessary understand the attitude and/or

preference of the potential beneficiaries towards such mitigations. The attitude of the individuals towards the reduction of HAP may be studied by understanding the individuals' valuation of the reduced health risks (alternatively, perceived private health benefit) from the same. In the fourth chapter of the dissertation, we attempt to assess the individuals' valuation of reduced health risk from HAP exclusively, derived from a hypothetical improvement in household air quality using a stated preference method. In particular, we contribute to the literature on the economics of HAP by estimating the individuals' willingness to pay for reduction (WTP) in health risks related to HAP using a double bounded dichotomous choice (DBDC) approach. Concurrently, as an extension of estimating the individuals' WTP for reduction in HAP in this study, we attempt to explore the presence and source of starting point bias in our DBDC model. Using a unique contingent survey of 557 respondents in rural India, we estimated the mean annual WTP for the reduction in HAP to be INR 886.59 (~ USD 14.30) from the DBDC model, which accounts for approximately 1.06% of the annual household expenditure. Although we have conducted the study in a different time and with a different sample, the ratio of our estimated WTP to average household expenditure lies in a comparable range with previous literature. In conformation with literature on valuation of other goods and resources, our result shows that the estimated WTP is also lower than the individuals' expenditure on cooking fuels as well as switching cost to switch to cleaner fuels. Furthermore, our analysis suggests the presence of anchoring effect that validates the presence of starting point bias in our DBDC model. We also find that the estimated mean WTP is sensitive to several health and non-health factors. This exercise further enables us to recommend policy prescriptions like generating public awareness about HAP as well as, targeting potential beneficiaries based on observable characteristics to ensure smooth implementation and effectiveness of intervention programs to reduce HAP.