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Health and Environmental Consciousness Effects of Wealth in Low Income Countries: Evidence from Households' Energy, Water, and Sanitation Services Consumption in Burkina Faso

Ibrahim Niankara

College of Business, Al Ain University of Science and Technology, P.O. Box: 112612, Abu Dhabi, UAE; Tel: +97124444696 Ext: 539 ; Fax: +97124444304 ; E-mail: ibrahim.niankara@aau.ac.ae

Abstract

Relying on Random Utility Theory (RUT) as the guiding mechanism for the Data Generating Process (DGP), this paper uses households consumption choices on cooking fuel, drinking water, and sanitation from the 2014 United States Agency for International Development's (USAID) Demographic and Health Survey (DHS) data on Burkina Faso, to characterize and investigate the inter-linkages between health consciousness and environmental consciousness, and their relationship with wealth in a low income country context. We achieve this by specifying sequentially three econometric modeling frameworks: the first one being independent binary probit (IBP) models to describe each choice process, followed by a fully parametric trivariate probit (FPTP) model to account for choice dependency, and finally by a semi-parametric trivariate probit (SPTP) model to further relax the linearity assumption. Based on the Akaike Information criteria (AIC) and the estimated Trivariate model correlation coefficients, the SPTP framework is found to be the best specification for describing the observed consumption behaviors. The results show that increased wealth level raises households health and environmental consciousness, while leaving the relative preference ordering over the elements in the household consumption basket unchanged.

Keywords: Consumer Behavior, Cooking Fuel, Environmental Consciousness, Health Consciousness, Semi-parametric Estimation, Trivariate Probit, Water and Sanitation, Wealth
JEL: C51, D12, F64, I12, Q25, Q42

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1. Introduction

The risk transition hypothesis predicts that overtime as countries develop, major risks to health shift from traditional risks which are associated with poverty (e.g. inadequate nutrition or unsafe water and sanitation) to modern risks which are associated with physical inactivity (e.g. overweight and obesity) (Omran, 1971). Global patterns of health risks also show that more than one third of the world's deaths are attributable to a small number of risk factors (World Health Organization, 2009), most of which with environmental roots especially in the developing world (World Health Organization and others, 2017; Garchitorena et al., 2017). In such a context, the materialization of health consciousness as a consistent preference for healthy versions of products across categories or alternatives Prasad et al. (2008), can be assessed differently depending on whether we are in a developed country, or a developing country. In fact, in developed countries health consciousness can best be captured by consumption choices that mitigate modern health risks. In developing countries however, where basic consumption is not always met, health consciousness can be best captured by consistent choices mitigating traditional risks factors associated with poverty. Although the literature on consumer health consciousness is rich (Prasad et al., 2008; Park et al., 2017; Joe et al., 2017; Karn et al., 2017; Wang et al., 2017; Choi and Reid, 2017; Park et al., 2017), it still fails to properly align with the realities of the developing world.

Numerous authors have also evidenced a strong relationship between health and the environment(Organization et al., 2010; Olivero et al., 2017; Elliott, 2017; Garchitorena et al., 2017; Elliott, 2017), and suggested that many health issues especially in the developing world, are due to poor environmental conditions. For example in a meta-synthesis of key evidence relating diseases to the environment, Prüss-Üstün (2016) shows that much of the 22% of the global burden of disease due to the environment can be prevented by reducing the environmental risks to health.

Despite this proven link between health and the environment, only few studies report on the link between health consciousness and environmental consciousness and their influence on consumer choices. For example in the case of Greek consumers, Arvanitoyannis et al. (2004) reports a significant link between health and environmental consciousness and expressed purchasing of organic and ISO-14000-certified food products. In their study investigating the role of health and environmental attitudes in predicting Taiwanese consumers' attitude towards organic foods, Chen (2009) found that concerns for one's health and for the environment are the two most commonly stated motives for purchasing organic foods, with the former exceeding the latter in importance. Similar results are found for consumers in three German cities where Kriwy and Mecking (2012) reports stronger health consciousness effects on organic products purchases, relative to the environmental consciousness effect. Furthermore in the US, focusing on female college students beauty products purchases, Kim and Seock (2009) found that health and environmental consciousness significantly influence the importance placed on beauty products attributes. Finally, In a more rencent cross-cultural analysis in US, UK and Gemany using a discrete choice experiment, Ghvanidze et al.

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(2017) reported that the environmental values, ethical concerns, and health consciousness of consumers significantly influence their food and wine choices. None of this latter referenced literature is however related to the developing world therefore, this paper's main objective is to fill this void in the literature by linking health consciousness and environmental consciousness to consumers' choices of cooking fuel, drinking water and sanitation facility in the developing world.

We rely here on households' choices of cooking fuel, drinking water and sanitation to characterize health and environmental consciousness since these represent three essential goods/services consumed on a daily basis by households living in the developing world. As such, they provide us with the opportunity to describe health and environmental conscious behaviors, based on a consistent revealed preference for the improved alternatives, over the unimproved ones in each choice situation. Our underlying assumption is that within the context of low income countries, consistent preference for improved alternatives of culinary energy, drinking water and sanitation facility, over the unimproved alternatives is a good indication of households' health and environmental consciousness.

In fact, if it's true that a great deal of health issues in the developing world have environmental roots (Prüss-Üstün, 2016; World Health Organization and others, 2017), then it must be that raising environmental consciousness would also affect health consciousness, and thereby improve health outcome. That is to say that we would expect a positive relationship between environmental consciousness and health consciousness; although this effect would be moderated by wealth since environmental pathologies show higher incidences in poorer parts of the world, than the wealthier parts.

For example, choosing woods substitutes as a culinary energy source not only reduces deforestation (Sulaiman et al., 2017), and environmental degradation (Berisso, 1995; Olivero et al., 2017), but also reduces disease burden from ambient air pollution through CO2 emissions from biomass combustion during cooking (Heslop et al., 1981; Zhou et al., 2014; Landrigan et al., 2017; Perera, 2017). Also, choosing a cleaner water source for cooking and drinking avoids adverse health episodes such as diarrheal diseases (Wolf et al., 2014; Darvesh et al., 2017; Cohen and Colford, 2017) and other pathologies linked to impure (surface or river) water drinking (Werner, 2003; Bain et al., 2014a,b). Finally, choosing an improved sanitation facility or latrine-based one over open nature defecation also avoid many bacterial diseases (Ziegelbauer et al., 2012; Berendes et al., 2017) and various health problems linked to environmental pollution from wastewater and fecal matter mismanagement(Gadenne et al., 2009; Prüss-Ustün et al., 2014; Freeman et al., 2017).

As a low income Sub-Saharan African country, Burkina Faso offers a great opportunity to investigate behaviors with regards to households energy, water and sanitation services consumption. Therefore, In line with the above discussion, the following questions can be formulated :

- **Q01**: *Does wealth significantly affect households members health and environmental consciousness in Burkina Faso ?*

- **Q02**: *Are the health and environmental consciousness effects of wealth if any, significantly related in Burkina Faso ?*

more specifically:

- **Q01**: *Does wealth significantly affect households decisions to adopt improved alternatives of cooking fuel, drinking water and sanitation services in the country ?*
- **Q02**: *Are the within household decisions to adopt improved alternatives of cooking fuel, drinking water, and sanitation services significantly related in the country ?*

the maintained null hypothesis are:

- $H_0(1)$: *wealth has no significant effect on households' decisions on cooking fuel, drinking water and sanitation services in Burkina Faso.* In other words, wealth has no bearing on households health and environmental consciousness in the country;
- $H_0(2)$: *The within households' decisions on cooking fuel, drinking water and sanitation services are not related in Burkina Faso.* Equivalently to say that the within household health consciousness and environmental consciousness are unrelated in the country.

In our quest to test the above hypothesis, the rest of the paper is organized as follows: Section 2 provides a background on wealth, cooking fuel, drinking water and sanitation services in Burkina Faso. Section 3 describes the theoretical underpinning of the Data Generating Process. Section 4 presents the data and the variables used in the econometric estimations. Section 5 illustrates the trivariate probit model linking wealth to the three household decisions on (Cooking Fuel, Drinking Water and Sanitation Services). Section 6 discusses the estimation results, while section 7 concludes the analysis

2. Background on Wealth, Cooking Fuel, Water and Sanitation in Burkina Faso

This section describes the state of wealth, cooking fuel, water and sanitation in burkina faso, before we proceed to linking them in the next sections

2.1. The Wealth Index

Wealth is a household characteristic that often has a large effect on health and other household decisions (Howe et al., 2008). It is captured here by the wealth index as provided by the United States Agency for International Development (USAID) Demographic and Health Survey (DHS). The methodology used to calculate the Wealth Index is based on the principal components analysis and covered in Filmer and Pritchett (2001); Rutstein et al. (2004). Both papers compare the DHS

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Wealth Index with more traditional indexes of consumer expenditures (Rutstein and Staveteig, 2014), concluding that the Wealth Index better represents long-term (permanent) economic status, and also is much easier to implement.

This index is based on the assumption that an underlying continuum of economic status exists which is related to household wealth(Rutstein, 2008). While economic wealth can be objectively measured (net worth equal to the total value of assets less the total value of liabilities), in practice a household's wealth is very difficult to measure directly. DHS treats wealth (and economic status) as an underlying unobserved dimension that can be estimated using latent variable techniques such as factor analysis or latent trait analysis, and assumes that the possession of observable or easily asked about assets, services, and amenities is related to the relative economic position of the household in the country(Howe et al., 2009). The original list of assets and services used to calculate this index is based on questions already in the household questionnaire for purposes other than determining economic status, more details on this measure are provided in (Rutstein, 2008)

2.2. Cooking Fuel in Burkina Faso

Focusing on the three major cities of Ouagadougou, Bobo-Dioulasso and Ouahigouya in Burkina Faso, (Ouedraogo, 2006) reports a culinary energy balance for the country that shows the preponderance of traditional energies which represents 90% of the culinary energy balance compared to 8% for hydrocarbons and 2% for electricity. 97% of household culinary energy supply is derived from biomass (mainly firewood and charcoal), and in rural areas nearly all culinary energy consumed is biomass based. The report also shows a national average consumption of 0,69 kg of firewood per person per day. This ratio rose in some areas up to more than 1 kg, especially where moisture in the wood fuel reduced the efficiency hence causing a higher wood fuel consumption. The increased demand for wood-based culinary energy, led to over-exploitation of forest ecosystems and added to the annual deforestation rate.

An earlier report (GGY- Consult, 2005) also showed that urban households prefer charcoal to wood because it is perceived as a cleaner and more modern alternative. However, because of the application of low efficient technologies in the charcoal production, the use of charcoal in towns is implicating a high wood consumption in rural areas. In response to this situation, several initiatives aimed at reducing and/or optimizing the wood biomass consumption were engaged including:

- re-organizing and concentrating the charcoal production in five production areas,
- promoting improved households cooking stoves,
- subsidizing butane gas usage,
- introducing alternative fuels,
- sensitizing households on the phenomena of desertification

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Despite these efforts, no significant decrease in wood consumption was recorded. The latest national report by the Institute for Statistics and Demography INSD (2014) shows firewood as still the main source of energy for the kitchen to more than 80% of households in the country. This level of use is over 95% in rural areas. Taking into account the charcoal, the proportions of total wood utilization reaches 88.5%, with 65.8% in urban areas and 97.4% in rural. The use of wood substitutes such as butane gas slightly augmented in urban areas (31.4%), but remained very negligible in rural areas (1.2%). Therefore, the question of sustainable domestic energies in burkina faso still remains unresolved.

2.3. Water and Sanitation in Burkina Faso

The Millennium Development Goals' (MDGs) targets for the water and sanitation sectors were: (i) 87% and 80% of the urban and rural population, respectively, having access to safe water; and (ii)57% and 54% of the urban and rural population, respectively, having access to improved sanitation (World Health Organization et al., 2015). To achieve these objectives, Burkina Faso required a total financing of US $324 million between 2007 and 2015 in the urban areas and US $810 million in the rural areas. Burkina Faso's Urban Water Sector Projet Appraisal report (World Bank, 2009), highlights four main challenges to the development of water supply and sanitation (WSS) services in the country, including: (i) the scarcity of water resources; (ii) the weak capacities in the rural WSS sub-sector; (iii) the high growth of the urban population; and (iv) the unequal progress of water and sanitation services. The National Water Supply and Sanitation Program (Programme national d'approvisionnement en eau potable et d'assainissement), increased the water access rate to 73% in urban areas and 55% in rural areas in 2008 and improved sanitation at 17% and 11% in urban and rural areas, respectively (USAID, 2010).

Despite the many efforts and acquired results mostly in the urban sector, the latest national report by the Institute for Statistics and Demography INSD (2014) suggests that the rural sub-sector could benefit from additional reforms in WSS policies, decentralization, and expansion of sustainable services. In fact, it is reported that more than 7 out of 10 households in burkina faso had access to potable drinking water sources by 2013. This level was 74% for the whole country, 66% for rural areas and 93% for urban areas. Of these urban households 15.2% used private taps, 12.2% used standpipes, while 44% used public fountains. Among the rural households however, only 4.8% have access to tap water 0.8% to private taps, and 4% to public fountains. It should be noted however that up to 18.2% still use non-potable drinking water of which unprotected ordinary wells represent 16.4% and rivers 1.7%. In general, depending on the place of residence, the rate of access to water (less than 30 minutes) is more than 9 households in urban areas, which is characterized by public fountains and the presence of piped to compound water in homes. In rural areas where wells and boreholes are the main sources of water supply, the access rate is more than 7 out of 10 households (INSD - NMCP - IFC - USAID, 2015).

In regards to sanitation, the reportINSD (2014) shows that nature remains the main place of comfort for many people in Burkina Faso, particularly in rural areas. More than one in two households (50.5%) use open nature, 38% of households use traditional latrines, of which 10% are without slab and 28% with slab. The other types of sanitation facilities are rarely used. In rural areas more than 7 out of 10 households (67.3%) use open nature as sanitation facility, 27% use traditional latrines, of which 16,9% with slab, and 10% without slab. On the other hand, in urban areas, 66.1% of households use traditional latrines, 10.1% with slab 5% without slab. The new and improved latrine formulas are used by only 14.7% of households, while only 11.5% have flush toilets. The report also show that regardless of residential setting, the street is the main sewage disposal site for most households. In fact, nine 9 households out of 10 dispose of their waste water by dumping it in the street. The hole on compound, the second means of waste water evacuation, accounts for less than one in ten households. The proportions are 6.6% overall, 8.1% in urban areas and 6.2% of households in rural areas. As a result, 70% of hospital beds are occupied by patients suffering from lack of sanitation. Its observing these challenges, that the national campaign on sanitation "FasoToilettes 2017" was lunched on december 23 2016, calling on all citizens of Burkina Faso to get involved in making universal sanitation by 2030 a reality.

3. The Theoretical Underpinning of the Data Generating Process

In order to characterize health and environmental consciousness in a low income country context, we use a retrospective cross-sectional design with secondary data from the 2014 Malaria Indicator Survey, administered by the National Institute for Statistics and Demography in Burkina Faso, with support from USAID, through its DHS Programs (INSD - NMCP - IFC - USAID, 2015). In doing so, we adopt the view under which the data is generated through a process consistent with Random Utility Theory. Under this view, we can use Utility Maximization behavior to describe the true Data Generating Process (DGP) (Azari et al., 2012).

To do so, we define three potential choice situations, each divided into two choice alternatives, with one alternative representing all available improved choices in that given choice situation, and the other alternative representing the standard unimproved alternatives. More specifically, we consider households decisions on Culinary Energy (cooking fuel), Drinking Water, and Sanitation. This yields three choice situations, with the first choice situation presenting two alternatives (1- if household chooses a wood-substitute fuel as a main cooking fuel, and 0- if the household chooses wood or wood-based culinary energy as main cooking fuel); the second choice situation presenting also two alternatives (1- if household chooses drinking water from an improved source, and 0- otherwise (if surface water or river)); and finally the third choice situation presenting also two alternatives (1- if household chooses an improved sanitation facility, and 0- if open nature is the main source of sanitation facility).

Therefore, we assume that each household acts as a decision making unit, faced with three choice situations i (with $i = 1$ if Energy choice, $i = 2$ if Drinking Water choice, and $i = 3$ if Sanitation choice, where the household must choose between two alternatives indexed respectively with zero (0)- (or unimproved alternative), and one (1)- (or improved alternative), according to which one provides the greatest utility/well-being. Additive random utility modeling (ARUM) specifies the utilities of alternatives 0 and 1 in each choice situation i for $i = 1, 2, 3$ as:

$$\begin{aligned} U_{i0} &= V_{i0} + \epsilon_{i0}, \\ U_{i1} &= V_{i1} + \epsilon_{i1}, \end{aligned} \tag{1}$$

where V_{i0} and V_{i1} are deterministic components of utility with ϵ_{i0} and ϵ_{i1} being the random components of utility. We observe $y_i = 1$, if $U_{i1} > U_{i0}$, that is if alternative 1 has the highest utility of the two. Because of the presence of the random components of utility this is a random event with

$$\begin{aligned} Pr[y_i = 1] &= Pr[U_{i1} > U_{i0}] \\ &= Pr[V_{i1} + \epsilon_{i1} > V_{i0} + \epsilon_{i0}] \\ &= Pr[\epsilon_{i0} - \epsilon_{i1} < -(V_{i0} - V_{i1})] \\ &= F(V_{i0} - V_{i1}), \end{aligned} \tag{2}$$

where $F(.)$ is the cumulative distribution function of the error differences $(\epsilon_{i0} - \epsilon_{i1})$. giving

$$Pr[y_i = 1] = F(X^{'}\beta_i) \; if \; V_{i0} - V_{i1} = X^{'}\beta_i \tag{3}$$

The ARUM requires a scale normalization since, if $U_{i1} > U_{i0}$ then $aU_{i1} > aU_{i0}$. This is usually done by specifying the variance of $(\epsilon_{i0} - \epsilon_{i1})$. Different parametric specifications for the distributions of the error terms (ϵ_{i0}) and (ϵ_{i1}) give different $F(.)$ and hence different discrete choice models. The Logit model or logistic regression is obtained when $F(X^{'}\beta_i) = \Lambda(X^{'}\beta_i)$, that is the type 1 extreme value cumulative distribution function. On the other hand, the Probit model is obtained when $F(X^{'}\beta_i)$ is assumed to be the standard normal cumulative distribution function. Since we have three interrelated choice situations, the overall problem becomes a tri-variate modeling situation with a system of 3 equations to be estimated jointly using appropriate multivariate methods as described next.

4. Trivariate Probit Model of Wealth and Cooking Fuel, Water and Sanitation

Given our interest in modeling the relative influence of Wealth on households joint decisions on cooking fuel, drinking water and sanitation services, following (Niankara and Niankara, 2017) we let each of the three decision variables be binary with $D_1 = 1$ if the chosen cooking fuel is a "Wood-Substitute" and $D_1 = 0$ if the chosen cooking fuel is "Wood"; $D_2 = 1$ if drinking water comes from an "Improved Source" and $D_2 = 0$ if drinking water comes from an "Unimproved Source"; finally $D_3 = 1$ if "Improved Sanitation" type facility, and $D_3 = 0$ if the type of sanitation facility is "Open Nature". We can model the joint effects of wealth on the three decision variables (D_i, $for\ i = 1, 2, 3$) using a trivariate probit framework, as above described in the Data Generating Process. The general specification (with the individual subscript suppressed for simplicity) for the multivariate probit model with three dependent variables and Wealth fixed effect is

$$D_i^* = \beta_{0i} + \beta_{1i}Wealth_i + \beta_i^{'}X_i + \epsilon_i, \quad i = 1, 2, 3 \tag{4}$$

Where D_i^* is an unobserved variable representing the latent utility (well-being) under decision i, and $Wealth_i$ captures the fixed contribution of household's Wealth to the well-being of household's members under decision i, while $\mathbf{X}_i$ is a vector of observed household characteristics, believed to be relevant to decision i, β_{0i} is the intercept coefficient, that is the minimum level of well-being not accounting for any household characteristics. β_i is a vector of unknown coefficients to be estimated. The last term ϵ_i represents the impact of unobserved household characteristics on household's members well-being under decision i. ϵ_i is assumed normally distributed with mean μ_i and variance σ_i, and a variance-covariance matrix of :

$$\Sigma = \begin{bmatrix} \sigma_1 & \theta_{12} & \theta_{13} \\ & \sigma_2 & \theta_{23} \\ & & \sigma_3 \end{bmatrix} \tag{5}$$

Therefore, the stochastic component of the general multivariate probit specification in equation(4) with the three latent (unobserved) continuous variables D_i^* follow the trivariate normal distribution:

$$\begin{pmatrix} D_1^* \\ D_2^* \\ D_3^* \end{pmatrix} \sim N_3 \left[\begin{pmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{pmatrix}, \begin{pmatrix} \sigma_1 & \theta_{12} & \theta_{13} \\ & \sigma_2 & \theta_{23} \\ & & \sigma_3 \end{pmatrix} \right] \tag{6}$$

where μ_i and σ_i are respectively the mean and variance for D_i^* and θ_{ij} are scalar correlation parameters. In this formulation each triplet of decision outcomes (Y_{i1}, Y_{i2}, Y_{i3}) has 2x2x2=8 potential outcomes, $(Y_{i1} = 1, Y_{i2} = 1, Y_{i3} = 1)$, $(Y_{i1} = 1, Y_{i2} = 1, Y_{i3} = 0)$, and $(Y_{i1} = 1, Y_{i2} = 0, Y_{i3} = 1)$, and $(Y_{i1} = 0, Y_{i2} = 1, Y_{i3} = 1)$, and $(Y_{i1} = 0, Y_{i2} = 1, Y_{i3} = 0)$, and $(Y_{i1} = 0, Y_{i2} = 0, Y_{i3} = 1)$, and $(Y_{i1} = 1, Y_{i2} = 0, Y_{i3} = 0)$, $(Y_{i1} = 0 Y_{i2} = 0, Y_{i3} = 0)$. The joint probability for each of these eight outcomes is modeled with six systematic components: the marginal probabilities $Pr(Y_{i1} = 1)$, $Pr(Y_{i2} = 1)$, and $Pr(Y_{i3} = 1)$ and the correlation parameters θ_{12}, θ_{13}, and θ_{23} for the three marginal distributions. For identification purposes, the standard probit model restricts the diagonal elements (variances) σ_i, $i = 1, 2, 3$ in equation(6) to 1. Since the correlation parameters do not correspond to one of the decision outcomes, the model estimates $\theta_{12}, \theta_{13}, \ and \ \theta_{23}$ as constants by default. Hence, only the three means equations (average well-being μ_1 under the cooking fuel decision; and the average well-being μ_2 under water decision; and the average well-being μ_3 under the sanitation decision) are required. Each of these systematic components are modeled as functions of the sets of explanatory variables. The following observation mechanism links the observed decision outcomes, D_i, with the latent variables (well-being) D_i^*

$$D_i = \begin{cases} 1 & \text{if } D_i^* \geq 0 \\ 0 & \text{Otherwise.} \end{cases} \tag{7}$$

Thus the joint probability of a triplet of decision outcomes $\{D_i = d_i, i = 1, 2, 3\}$, conditioned on parameters β_0, $Wealth$, Σ and a set of explanatory variables X, can be written as

$$Pr\left[D_i = d_i, i = 1, 2, 3 | Wealth, \beta, \Sigma\right] = \int_{A_1}\int_{A_2}\int_{A_3} \phi(z_1, z_2, z_3, \theta_{12}, \theta_{13}, \theta_{23}) dz_3 dz_2 dz_1 \tag{8}$$

where ϕ is the standard multivariate normal density function with mean 0 and variance-covariance matrix Σ, and A_i is the interval $(-\infty, \beta_{0i} + \beta_{1i}Wealth_i + \beta_i^{'}X_i)$ if $d_i = 1$ and $(\beta_{0i} + \beta_{1i}Wealth_i + \beta_i^{'}X_i, \infty)$ if $d_i = 0$ following (Chib and Greenberg, 1998). In the fully parametric travariate probit representation as in equation (4), the parameters $\beta_{0i}, \beta_{1i}, \beta_i^{'}$ and the three correlations of the error terms can be estimated via maximum likelihood methods. However, here we consider a more flexible specification in the form of a semi-parametric trivariate probit model as shown in equation (9) below:

$$D_i^* = \beta_{0i} + \beta_{1i}Wealth_i + \beta_i^{'}X_i + g(\beta_{2i}AgeHead_i, \epsilon_i), \quad i = 1, 2, 3 \tag{9}$$

Where everything is as previously defined for equation (4), with the only added exception being $g(.)$ an unknown function to be estimated, along with the β parameters without specifying a complete parametric distribution for ϵ_i. This specification allows us to relax the linearity assumption of the former specification in regards to the numerical variable "AgeHead" . This variable represents the age of the head of household and is likely to have life-cycle effects with non-linear influences on the three decisions. Imposing a priori linear relationship on this variable could mean failing to capture its true and more complex relationship. The coefficients of the flexible semi-parametric trivariate probit model in equation (9) are estimated using penalized maximum likelihood methods as described in the library Wojtys et al. (2016) of the R Statistical Software (R Core Team, 2015).

5. Data and Variables Description

The data used in this analysis was extracted from the 2014 Burkina Faso Malaria Indicator Survey (MIS 2014) administered by the National Institute for Statistics and Demography (INSD)

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in collaboration with the National Malaria Control Program (NMCP) in Burkina Faso, and the United States Agency for International Development's Global DHS Program (USAID) (INSD - NMCP - IFC - USAID, 2015). It is a representative sample of 6500 Households covering the 13 administrative regions in Burkina Faso, and was collected from September 29 to November 28, 2014. The use of revealed preference data as opposed to the stated preference data, allows us to characterize revealed health consciousness as opposed to sated health consciousness which past studies have documented to not always align with actual real life behavior (Hiramatsu et al., 2015). This survey data was made available through the world bank micro-data library home and DHS data portal. Our analysis uses a total of 8068 observations from the individual recode component of the survey. For more information on survey instruments see (Measure, 2014). Because malaria is a disease with strong environmental roots, the survey includes information on the environmental conditions and households characteristics, as well as the demographic and socio-economic profile of the population of these households.

Among those characteristics recorded is the main independent variable of interest in this study, the wealth index score, calculated using data on household's ownership of selected assets. It is a composite measure of a household's cumulative living standard, and is generated with a statistical procedure known as principal components analysis, and places individual households on a continuous scale of relative wealth. The wealth index factor, derived from the wealth index score separates all interviewed households into five wealth quintiles (going from the poorest (1) to the rishest (5)). For our analysis we combine the first two quintiles and the last two quintiles to get the wealth index factor as a nominal variable with three levels (1-Poor, 2-Middle, 3-Rich). The table(1) below provides further description and summary statistics for the variables used in this analysis.

6. Results

Given our interest in modeling the relative influence of wealth on households joint decisions on cooking fuel, drinking water and sanitation, we've specified and estimated three regression models. The first model as a univariate regression assumes independence of the three decisions, and captures the effects of Wealth individually on each decision. The second specification acknowledges the potential interactions between the three decisions, and models them jointly, while assuming complete linearity of the effects of all parametrically entering co-variates. The third and last specification goes one step further to relax the linearity assumption in the previous two models, by specifying a general form for the parametrically entering numerical variable "agehead". In doing so, the three models correspond respectively to "(1) the binary univariate probit model", "(2) the fully parametric trivariate probit model", and "(3) the semi-parametric trivariate probit model". The results are presented in tables(2) (3) (4) respectively for the decisions on cooking fuel, drinking water, and sanitation services respectively. The value of these three specifications is in allowing us to test the robustness of the relationship between wealth and each of these three household decision variables.

6.1. Cooking Fuel Equation Results

Starting with the results from the cooking fuel equation, as shown in table (2), the second column contains the results of the univariate probit model, the third column those of the fully parametric trivariate probit model, and the fourth column presents the results for the semi-parametric trivariate probit model.

The correlation coefficients $\hat{\theta}_{12} = 0.090$, $\hat{\theta}_{13} = 0.038$, $\hat{\theta}_{23} = 0.125$ in the third column suggest that the unobserved factors affecting the within household's decisions on Cooking fuel, drinking water and sanitation services are positively and significantly correlated as shown by their respective 95% confidence intervals (0.030, 0.184) , (0.028, 0.106) , (0.070, 0.171). As such, the independence assumption through the univariate probit formulation (as shown in the second column) is not as appropriate as the trivariate probit representation. Comparing now the fully parametric trivariate probit representation to the semi-parametric trivariate probit, we note that the latter is a better model based on the AIC criteria ($AIC_{full} = 18430.42 > AIC_{semi} = 18406.96$). These results suggest that relaxing the independence assumption, along with the linearity assumption for the parametrically entering numerical covariate "agehead" yields a better model for describing the three households' decisions processes.

Focusing on our primary independent variable of interest, the Wealth factor, its statistically positives and significant effects on the choice of cooking fuel is fairly stable and consistent across all three specifications. In fact, as shown in the fourth column of table (2), households in the middle and rich wealth categories are respectively 25.1% and 107% more likely to choose a wood-substitute as their main source of cooking fuel compared to households in the poor wealth category. The increasing respective effects of wealth here are suggesting that the likelihood of choosing a wood-substitute as the main source of culinary energy increases with increasing levels of household wealth. More specifically, the marginal rate of increase of these effects as we move from one wealth category to the next is 25.1% between the poor and middle wealth categories, and 81.9% between the middle and rich wealth categories. With regards to the other variables entering parametrically the cooking fuel equation, the results in the fourth column of table (2) suggests that:

Households' headed by females have 34.3% more chances of choosing a wood-substitute as their main source of cooking fuel, compared to those headed by males. Also, for every one year increase in the head of household's education, the likelihood of choosing a wood-substitute as the main source of cooking fuel increases by 2.9%. Furthermore, households living in rural areas are 1.012 times less likely to choose a wood-substitute as their main source of cooking fuel, compared to those living in urban areas. On the other hand, households with a telephone have 35% more chances of using a wood-substitute as their main source of culinary energy, compared to those without telephone. As household size, and number of children under five in the household increase

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respectively by one person, the likelihood of using a wood-substitute as main source of cooking fuel decreases by respectively 4.4% for household size, and 10.7% for the number of children under five in the household. Finally, in regards to the number of women in the household, as this number increase by one person the likelihood of using a wood-substitute as main source of cooking fuel increases by 14.4% .

For the smoothed numerical variable "agehead", representing the head of household's age, and calculated as discussed in section 2.3 of (Wojtys et al., 2016), the result in the fourth column of table (2) with p-value = $(1.21e{-}05)$, suggest it has a statistically significant effect on the likelihood of choosing a wood-substitute as main source of cooking fuel. This result is also supported by the smooth function estimate and 95% confidence band on the variable as shown in the left panel of figure(1).

6.2. Drinking Water Equation Results

Moving to the results from the drinking water equation, as shown in table (3), the second column contains the results of the univariate probit model, the third column those of the fully parametric trivariate probit, and the fourth column the results of the semi-parametric trivariate probit model.

As previously mentioned for the cooking fuel equation, the statistically significant correlation coefficients $\hat{\theta}_{12} = 0.090$, $\hat{\theta}_{13} = 0.038$, $\hat{\theta}_{23} = 0.125$, along with the AIC criteria ($AIC_{full} = 18430.42 > AIC_{semi} = 18406.96$) suggest that relaxing the independence assumption, along with the linearity assumption for the parametrically entering numerical variable "agehead" yields the best model for describing the process of choosing a drinking water source.

Focusing on our primary independent variable of interest, the Wealth factor, its statistically positives and significant effects on the choice of improved drinking water source is fairly stable and consistent across all three specifications. In fact, as shown in the fourth column of table (3), households in the middle and rich wealth categories are respectively 12.6% and 45% more likely to choose an improved source of drinking water compared to households in the poor wealth category. These increasing respective effects of wealth are suggesting that the likelihood of choosing an improved source of drinking water increases with increasing level of household wealth. More specifically, the marginal rate of increase of these effects as we move from one wealth category to the next is 12.6% between the poor and middle wealth categories, and 32.4% between the middle and rich wealth categories. With regards to the other variables entering the drinking water equation parametrically, the results in the fourth column of table (3) suggests that:

Households' headed by females have 14.8% more chances of choosing an improved source of drinking water, compared to those headed by males. Although the effect of religion is not significant for Muslim households, Christian households seem to have 17.8% more chances of choosing an improved source of drinking water, compared to other religions (animists and agnostics). Also, for every one year increase in the head of household's education, the likelihood of choosing an

 doi:10.20944/preprints201802.0093.v1

improved source of drinking water increases by 1.7%. Furthermore, households living in rural areas are 46.8% less likely to choose an improved source of drinking water compared to those living in urban areas. Also, households with a telephone seem to have a paradoxical 22.3% less chance of using an improved source of drinking water, compared to those without telephone. As household size increases by one person, the likelihood of using an improved source of drinking water increases by 2%, while it decreases by 7.9% for every one person increase in the number of children under five in the household. Finally, in regards to the time spent to get to the main source of drinking water, every minute increase leads to a lesser chance of choosing a clean source of drinking water.

For the smoothed numerical variable "agehead", representing the head of household's age, the result in the fourth column of table (3) with p-value = (0.009), suggest it has a statistically significant effect on the likelihood of choosing a clean source of drinking water. This result is also supported by the smooth function estimate and 95% confidence band on the variable as seen in the middle panel of figure(1).

6.3. Sanitation Equation Results

The results from the sanitation equation are also shown in table (4), the second column contains the results of the univariate probit model, the third column those of the fully parametric trivariate probit model, and the fourth column the results of the semi-parametric trivariate probit model.

As previously mentioned for the equations describing the choice of cooking fuel and drinking water, the statistically significant correlation coefficients $\hat{\theta}_{12} = 0.090$, $\hat{\theta}_{13} = 0.038$, $\hat{\theta}_{23} = 0.125$, along with the AIC criteria ($AIC_{full} = 18430.42 > AIC_{semi} = 18406.96$) suggest that relaxing the independence assumption, along with the linearity assumption for the parametrically entering numerical variable "Agehead" yield the best model for describing the choice of sanitation facility. As such, we choose it as our preferred model in this analysis.

Focusing on our primary independent variable of interest, the Wealth factor, its statistically positives and significant effects on the choice of an improved sanitation facility, over open nature defecation is fairly stable and consistent across all three specifications. In fact, as shown in the fourth column of table (4), households in the middle and rich wealth categories are respectively 99.4% and 200.3% more likely to choose an improved sanitation facility compared to households in the poor wealth category. The respective increasing effects of wealth are suggesting that the likelihood of choosing an improved sanitation facility increases with increasing level of household wealth. More specifically, the marginal rate of increase of these effects as we move from the lowest wealth category to the highest is 99.4% between the poor and middle wealth categories, and 100.9% between the middle and rich wealth categories. With regards to the other variables entering the sanitation equation parametrically, the results in the fourth column of table (4) suggests that:

The effect of religion is positive and significant for both Muslim and christian households, with the two household types having respectively 37.6% and 23.3% more chances of choosing an improved sanitation facility compared to other religions (animists and agnostics). In relation to education, for every one year increase in the head of household's education level, the likelihood of choosing an improved sanitation facility increases by 1.6%. Furthermore, households living in rural areas are 84% less likely to choose an improved sanitation facility compared to those living in urban areas. The similar paradox observed in the choice of drinking water source, is present here as households with telephone seem to have 26.4% less chance of using an improved sanitation facility, compared to those without telephone. Household size as well does not seem to have a significant impact on households' sanitation decisions in Burkina Faso.

For the smoothed numerical variable "agehead", representing the head of household's age, the result in the fourth column of table (4) with p-value = (0.0009), suggest it has a statistically significant effect on the likelihood of choosing an improved sanitation facility over open nature. This results is also supported by the smooth function estimate and 95% confidence band on the variable which suggest a positive effect, as seen in the right panel of figure(1).

Finally comparing the marginal effects of wealth, across all three household's decisions, using the semi-parametric trivariate probit model estimates in the fourth columns of tables (2) (3) and (4) we note that the effects of wealth for those in the middle wealth category is relatively greater for the sanitation facility decision (99.4%), followed by the cooking fuel decision (25.1%), and finally the drinking water decision (12.6%). Similarly, this effect for households in the rich category is relatively greater for the sanitation decision (200.3%) followed by the cooking fuel decision (107%) and finally the drinking water decision (45%). Hence, the ordinal ranking of the wealth effects are consistent across all wealth categories, with the greatest relative effect always recorded for the choice of improved sanitation facility, followed by that of wood-substitute fuels, and finally by the choice of improved drinking water source. The implications in terms of preference ranking is that, as households wealth increase in Burkina Faso, the first priority is in addressing sanitation needs, followed by energy needs, and finally by water needs. This preference ranking is most likely a reflection of the differences in public access to these three basic services in the country. The most privately used service of the three being sanitation, and the most publicly used being water, most of which through public water fountains.

7. Conclusions

The motivation for this empirical analysis was the desire to characterize and investigate the inter-linkages between health consciousness and environmental consciousness, and their relationship with wealth in a low income country context. Health consciousness and environmental consciousness as unobservable households characteristics, were characterized using observed binary indicator variables indexing households choices of improved alternatives of culinary energy, drinking water and sanitation services in Burkina Faso. From an economic theory stand point, the random utility framework was assumed to be guiding the data generating process, leading to

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a trivariate probit specification for the econometric model. We then proceeded to test whether or not wealth has significant effects on health and environmental consciousness in the form of healthier and environmentally friendlier choices of cooking fuel, drinking water, and sanitation facility. We also checked whether the within household health and environmental consciousness effects of wealth if any, are significantly related.

Using data from the 2014 Burkina Faso Malaria Indicator Survey, the estimated correlation coefficients suggested that the unobserved household characteristics affecting these three choice situations correlate positively. Based on the AIC values the semi-parametric trivariate probit was chosen as the best model over its fully parametric counterpart. Although the results from all three models were pretty consistent, focusing on the most preferred specification, it was found that wealth has positive relative marginal effects on households joint decisions on cooking fuel, drinking water, and sanitation. In fact, its relative marginal effect for those in both, middle and rich wealth categories was relatively greater for the choice of improved sanitation facilities, followed by that of wood-substitute fuels and finally by that of improved drinking water sources.

Therefore, in relation to our first formulated hypothesis $H_0(1)$ we can assert that the evidence is enough to reject this null hypothesis, and conclude that wealth has positive and significant effects on households joint choices of wood substitute fuels, improved drinking water sources, and improved sanitation facilities in Burkina Faso. In other words, wealth does influence positively households' health and environmental consciousness in the country. Based also on the statistically significant correlation coefficients 0.089 , 0.036, and 0.124 between the equations representing each of the three households choice situations, we can safely reject the second null hypothesis $H_0(2)$ and conclude that households choices of wood substitute fuels, improved drinking water sources, and improved sanitation facilities are all positively and significantly related in Burkina Faso.

These hypothesis tests results show that in a low income country context, increased wealth level has the potential to raise households health and environmental consciousness, while leaving the relative preference ordering over the elements in the household consumption basket unchanged. The results has implications for dealing with the social and economic consequences of poor cooking fuel, drinking water, and sanitation using multi-sectoral approaches at the consciousness level. That is to say for example that social campaigning that raises population awareness on environmental issues will be successful at raising health and environmental consciousness, and thereby successfully reducing the observed health burden from environmentally rooted health pathologies. For these campaigning policies to be much more effective however, they will have to be aligned with households wealth creation and accumulation incentives, such as improved labor market conditions and better job opportunities. Also, Innovative delivery platforms, such as conditional cash transfers and community driven development programs shown to be successful in other development areas, have the potential to increase access and adoption of the improved alternatives in those three service sectors, at little marginal cost. These approaches can also provide the solution for reducing disease burden linked to household air pollution from wood based cooking fuels, and

 doi:10.20944/preprints201802.0093.v1

diarrheal diseases from inadequate water and sanitation in the low income world.

Although this analysis has adopted a demand side approach to dealing with health and environmental issues through improved consumers' consciousness, it's important to point out that this responsibility is equally shared by the supply side. Consumers can only choose improved (healthy and environmentally friendlier) consumption alternatives when they are available and relatively affordable. Both availability and affordability of improved alternatives are greatly influenced by the supply side of the economy, which in most low income countries is very weak. For our special case of household energy, water and sanitation services consumption, availability and affordability puts a significant constraint on household choices in low income countries, forcing them to resort to the unimproved options. This means in the case of cooking fuel the choice of biomass, such as firewood and charcoal (Howells et al., 2005; Schlag et al., 2008; Jumbe et al., 2009) – an option that is economically inefficient and environmentally devastating (Witold, 2006; Ibitoye, 2013; United Nations, 2015). Although availability and affordability of clean water has improved with 6.6 billion people, or 91 percent of the global population, using improved drinking water sources in 2015, it was still inaccessible for an estimated 663 million people, most of which in low income countries (World Health Organization et al., 2015). In regards to sanitation services, availability and affordability still constraints an estimated 2.4 billion people globally to resort to unimproved sources, most of whom rely on open nature defecation in the developing world (World Health Organization et al., 2015).

This study, along with past studies seem therefore to suggest that meeting the various sustainable development goals (SDGs) targets by year 2030, will require a concerted effort, from both the demand side through improved health and environmental consciousness, but also the supply side through increased availability and affordability of improved consumption alternatives. It will also be the co-responsibility of governments and policy makers alike to coordinate the various markets to ensure this becomes a reality.

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Table 1: Summary Description of the Variables used in the Econometric Modeling

	8068	Mean	SD
Wealth	wealth index factor, equals 1 if Poor, 2 if Middle, 3 if Rich	1.967	0.884
CookingFuel	equals to 1 if "Wood Substitute " and 0 if "Wood"	1.879	0.326
Water	equals to 1 if "Improved Source" and 0 if "Unimproved Source"	1.234	0.423
Sanitation	equals to 1 if "Flushed toilet or Latrine" and 0 if "Open Nature"	1.535	0.499
AgeHead	the age in years of household's head	44.92	13.986
SexHead	equals to 1 if household head is "Female", and 0 otherwise	1.096	0.294
Religion	equals to 0 if "Others", 1 if "Muslim", 2 if "Christian"	2.193	0.565
Educ	number of years of education completed	2.054	0.740
Region	equals to 1 if household lives in "Rural area", and 0 if "Urban area"	1.794	4.414
Phone	equals to 1 if household has a "Telephone", 0 otherwise	0.109	0.827
HhSize	number of people living in the household	8.191	4.467
nChild5H	number of children under five in the household	1.771	1.438
nWomenH	number of women living in the household	2.042	1.233

Source: 2014 Burkina Faso Malaria Indicator Survey (MIS 2014) Data set.

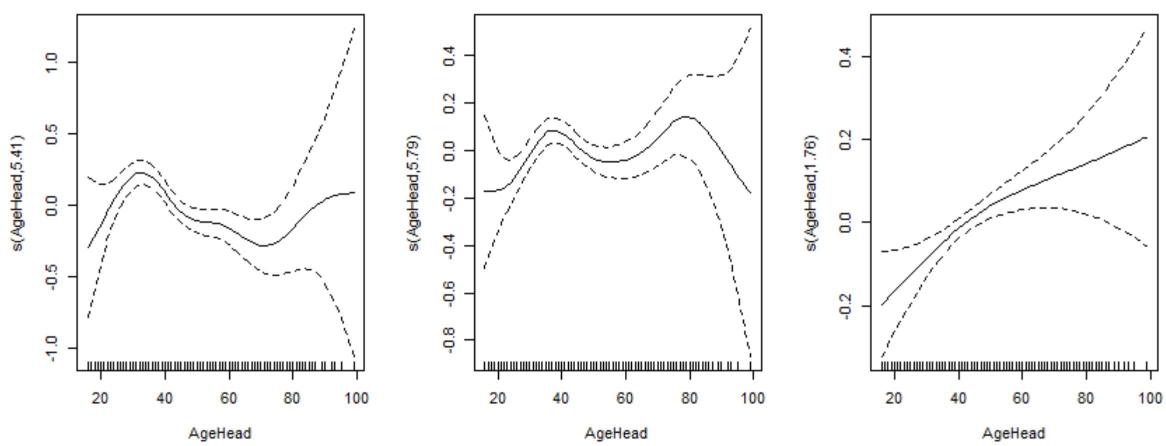

Figure 1: Smooth function estimates and 95% confidence bands for the numerical "agehead" covariate in the Cooking Fuel equation (left panel), the Water Equation (middle panel), and the Sanitation Equation (right panel)

Table 2: Fully-Parametric and Semi-parametric Trivariate Probit Estimates for the Cooking Fuel Equation

Cooking Fuel	Binary Univariate Probit (1)	Fully-Parametric Trivariate Probit (2)	Semi-Parametric Trivariate Probit (3)
CONST	-0.749*** (0.156)†	-0.745*** (0.158)	-1.152*** (0.138)
WealthMidlle	0.258** (0.098)	0.263** (0.098)	0.251* (0.099)
WealthRich	1.081*** (0.078)	1.078*** (0.078)	1.070*** (0.078)
AgeHead	-0.009*** (0.002)	-0.009*** (0.002)	p-val $=1.21e-05$*** (edf = 5.406)
SexHeadFemale	0.324*** (0.069)	0.329***(0.069)	0.343*** (0.069)
ReligionMuslim	-0.219 (0.113)	-0.215 (0.113)	-0.218 (0.113)
ReligionChristian	0.051 (0.116)	0.047 (0.117)	0.036 (0.117)
EducN	0.029*** (0.004)	0.029*** (0.004)	0.029*** (0.004)
RegionRural	-1.025*** (0.056)	-1.022 (0.055)	-1.012*** (0.056)
Phone	0.357*** (0.023)	0.351*** (0.020)	0.350*** (0.020)
HhSize	-0.045*** (0.012)	-0.044*** (0.012)	-0.044*** (0.012)
nChild5H	-0.093*** (0.028)	-0.092*** (0.028)	-0.107*** (0.028)
nWomenH	0.139*** (0.030)	0.134*** (0.030)	0.144*** (0.030)
$\hat{\theta}_{12}$		0.090	0.089
		(0.030, 0.184)††	(0.006, 0.165)
$\hat{\theta}_{13}$		0.038	0.036
		(0.028, 0.106)	(0.050, 0.093)
$\hat{\theta}_{23}$		0.125	0.124
		(0.070, 0.171)	(0.078, 0.161)
AIC	3415.367	18430.42	18406.96

† standard deviation of the parameters in parentheses

†† The 95% confidence intervals for the theta correlations

*** is 0.01% level significance; ** is 1% level significance ; * is 5% level significance

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Table 3: Fully-Parametric and Semi-parametric Trivariate Probit Estimates for the Water Equation

Water	Binary Univariate Probit (1)	Fully-Parametric Trivariate Probit (2)	Semi-Parametric Trivariate Probit (3)
CONST	0.875*** (0.098)†	0.888*** (0.098)	0.936*** (0.086)
WealthMidlle	0.130** (0.041)	0.128** (0.041)	0.126** (0.041)
WealthRich	0.451*** (0.044)	0.451*** (0.044)	0.450*** (0.044)
AgeHead	0.001 (0.001)	0.001 (0.001)	p-val= 0.009** (edf = 5.786)
SexHeadFemale	0.140* (0.059)	0.141*(0.059)	0.148* (0.059)
ReligionMuslim	0.038 (0.057)	0.034 (0.056)	0.039 (0.057)
ReligionChristian	0.177** (0.062)	0.176** (0.062)	0.178** (0.062)
EducN	0.016** (0.053)	0.016*** (0.005)	0.017*** (0.005)
RegionRural	-0.467*** (0.058)	-0.475*** (0.057)	-0.468*** (0.057)
Phone	-0.223*** (0.021)	-0.222*** (0.020)	-0.223*** (0.020)
HhSize	0.020*** (0.006)	0.019*** (0.006)	0.020*** (0.006)
nChild5H	-0.072*** (0.016)	-0.072*** (0.016)	-0.079*** (0.016)
TimeWaterSource	-0.0005*** (0.00005)	-0.0005*** (0.00005)	-0.0005*** (0.00005)
$\hat{\theta}_{12}$		0.090	0.089
		(0.030, 0.184)††	(0.006, 0.165)
$\hat{\theta}_{13}$		0.038	0.036
		(0.028, 0.106)	(0.050, 0.093)
$\hat{\theta}_{23}$		0.125	0.124
		(0.070, 0.171)	(0.078, 0.161)
AIC	3415.367	18430.42	18406.96

† standard deviation of the parameters in parentheses

†† the 95% confidence intervals for the theta correlations

*** is 0.01% level significance; ** is 1% level significance ; * is 5% level significance

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Table 4: Fully-Parametric and Semi-parametric Trivariate Probit Estimates for the Sanitation Equation

Sanitation	Binary Univariate Probit (1)	Fully-Parametric Trivariate Probit (2)	Semi-Parametric Trivariate Probit (3)
CONST	-0.898*** (0.104)†	-0.893*** (0.104)	-0.664*** (0.093)
WealthMidlle	0.992*** (0.042)	0.993*** (0.042)	0.994*** (0.042)
WealthRich	2.003*** (0.045)	2.002*** (0.045)	2.003*** (0.045)
AgeHead	0.005*** (0.001)	0.005*** (0.001)	p-val= 0.0009*** (edf =1.763)
SexHeadFemale	0.116 (0.064)	0.113 (0.063)	0.116 (0.063)
ReligionMuslim	0.374*** (0.066)	0.374*** (0.066)	0.376*** (0.066)
ReligionChristian	0.233** (0.071)	0.232** (0.071)	0.233** (0.071)
EducN	0.015*** (0.004)	0.016*** (0.004)	0.016*** (0.004)
RegionRural	-0.836*** (0.048)	-0.841*** (0.057)	-0.840*** (0.057)
Phone	-0.269* (0.025)	-0.263*** (0.023)	-0.264*** (0.023)
HhSize	-0.003 (0.004)	-0.003 (0.004)	-0.004 (0.004)
$\hat{\theta}_{12}$		0.090	0.089
		(0.030, 0.184)††	(0.006, 0.165)
$\hat{\theta}_{13}$		0.038	0.036
		(0.028, 0.0.106)	(0.050, 0.093)
$\hat{\theta}_{23}$		0.125	0.124
		(0.070, 0.171)	(0.078, 0.161)
AIC	3415.367	18430.42	18406.96

† standard deviation of the parameters in parentheses

†† the 95% confidence intervals for the theta correlations

*** is 0.01% level significance; ** is 1% level significance ; * is 5% level significance

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