

## Using Household Production Models to Understand Environmental Health Outcomes in Developing Countries

Karnjana Sanglimsuwan<sup>1</sup>

This research article presents a conceptual model to study the relationship between environment, health and economics. The main economic theories behind this study are the household production model and the utility maximization model. From the literature, health can be considered as a commodity that directly contributes to individual's utility. The constraints for this study are both the income constraint and the health production constraint. This study proposes that any household can derive utility from the children in the household being healthy, and a composition of good consumption. In addition, a child's health is conditioned by care giving, demographic factors and environmental factors. Hence, how changes in environmental quality impact on the household production function can be measured from this model. This research article could be useful for the future studies related to analyze the linkages between health, environment and economics. Further research under the household production theory will benefit the policy maker in terms of understanding household behavior in order to improve public policies.

**Keywords:** household production model, utility maximization, environmental health

The approach to reducing poverty has evolved over the past 50 years in response to deepening understanding of the complexity of development. Twenty years ago, multilateral development agencies such as the World Bank Group had already begun to articulate the understanding that physical capital was not enough, and argued that improvements in health were important not only in their own right, but also to support growth in the incomes of the poor people. Ill health and poverty are closely linked with the cause-and-effect running in both directions. That is, sick people are more likely to become poor, and poor people often are more likely to fall sick. For example, poor people are less able to reduce their exposure to health risks and to treat their sickness. On the opposite end, sick people become poor because of the direct costs of both prevention and treatment and the indirect cost including lost productivity or income associated with illness or death. Thus improving health is the important part a poverty reduction strategy. Like improving health, better environmental management can reduce the poverty. A polluted environment, particularly unclean water and air pollution, affects the poor adversely. Countries that degrade their environment heavily also risk inhibiting their future economic growth (see Table 1).

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<sup>1</sup> Lecturer, School of Economics, Bangkok University, Bangkok, Thailand

The above discussion suggests the policy makers to integrate poverty environment-health concern. In order to design efficient and equitable efficient policies to improve poverty, health and environment, the policy makers need a better understanding of the household behavior. Such behaviors impact both health status of household members and the natural environment that surrounds them. While there has some research on the economic impact of natural resource, little is known about how environmental transformations impact public health especially in household units. In the developing countries, the most significant environmental transformations of rural landscapes come from the widespread and rapid deforestation and forest degradation. Deforestation, with subsequent changes in land use and household settlement patterns, has coincided with adverse consequences, for example, the loss in biodiversity, the decreased water availability in many water scarce regions, increased risk of floods, increased incidence of heat stress mortality, and the number of people exposed to vector-borne diseases, such as malaria and water-borne diseases such as cholera. In addition to developing a general understanding of the linkages between these issues, in this paper we wish to use a household production model to conceptualize this problem.

Table 1

*Major Pathways through which Good Health Contribute to Economic Development*

Economic Development	Impacts of Health on Economic Development
Higher Labor Productivity	Healthier workers physically and mentally more productive, earn higher wage, and miss fewer days than those who are chronically ill.
Higher Rate of Investment and Saving	People who live longer are more likely to put away fund for retirement, which in turn provides fund for capital investment.
Higher Education Attainment Demographic Change	Healthier children are better able to learn and miss fewer days of school. Improvement in health leads to lower rate of fertilities and mortality in the population.
Reduce Disruption in Enterprise Productivity	The disruption may be caused by reduced in investment opportunity and by illness and early death of key workers.
Reduce Macroeconomics Instability	Instability may be caused by reducing in tax revenue and rising burden of health expenditure
Less Costly Household Outlay	Healthier people can reduce cost for treatment of disease and injury

Household production model (HPM) is appropriate in this setting because HPM provides a framework for analyzing household behavior that integrates three decisions (production, consumption and work allocation). Environmental health outcomes can be conceptualized as a commodity that directly contribute to utility and as the output of a household health production function. Good health can also indirectly contribute to utility by increasing productivity, making time available for market and non-market activities, and decreasing costs of prevention and treatment of illnesses. Thus household's maximize utility comprising of goods and health subject to the income constraint and health production constraint. This study develops household production model involved with household behavior based on the assumption of either a substitute and a complementary relationship between the environmental good or service and other commodities. The objective of study is to analyze how changes in environmental quality influence the household production function, and thus the welfare of the household.

### **Theories and Literature Review**

The idea of basic household production model started from Becker (1965) which is the best known for modeling household decisions and resource allocation. The household production model postulated that households combine time and market goods to produce more basic commodities that directly enter their utility functions. Later, Chiappori (1988, 1992) postulated an efficient sharing rule without attempting to derive it from an underlying model of family or household collective choice, which was a midway between Becker's efficiency-based approach and explicit model of household collective choice.

The household production model is based on the assumption that utility is derived from the consumption of  $N$  commodities ( $Z_i$ ,  $i = 1, N$ ). The commodities that enter into the utility function are not necessarily directly available in the market. Some commodities have to be produced within the household with a combination of market goods, human capital, and the consumer's time.

### **Household Production Model**

Consider the following assumptions and definitions:

$$U = U(Z_i)$$

where,  $U$  = level of utility

$Z_i$  = level of production and consumption of activity  $i$ . ( $i = 1, 2, \dots, n$ )

It is assumed that  $Z_i$  is produced according to the production function given by:

$$Z_i = f(t_i, x_i)$$

where,  $t_i$  = amount of time devoted to producing commodity  $i$

$x_i$  = quantity of purchased inputs used to produce and consume commodity  $i$

This is a composite commodity that is an index of all of the goods and services that must be purchased to produce  $Z_i$

### Time and Goods Constraints

The time constraint is given by

$$\sum_{j=1}^N t_i + t_w = T$$

where,  $t_i$  = time in activity  $i$

$t_w$  = time spent at work

$T$  = total time available

$j$  = household

$N$  = number of household

This time constraint simply states that the sum of the time spent in all household production activities and time spent at work must add up to the total time available.

The goods constraint is given by

$$\sum_{j=1}^N p x_i = w t_w$$

where,  $p$  = price index for  $x$

$x_i$  = quantity of purchased input used to produce and consume  $Z_i$

$w$  = wage

This goods constraint states that the sum of the nominal expenditures on purchased inputs must equal nominal income (This is a single period model for simplicity so there is no borrowing or lending possibilities).

The solution to this maximization problem gives the conditions of household equilibrium. Following Batty (1976), to maximize utility, a Lagrangian ( $L$ ) is constructed:

$$L = U(Z_1, Z_2, Z_3, \dots, Z_N) + \psi \{\text{time and good constraints}\}$$

where,  $\psi$  is the undetermined Lagrangian multiplier

Differentiating above Lagrangian with respect to each  $Z_i$  and setting the resulting equations equal to 0, gives the first-order conditions for a maximum.

### **Household Production of Health**

Grossman (1972) developed a model of household production with health capital. In this framework, health is treated as a durable item because one can produce health today and can still use it tomorrow. Hence, health stock (also called “health capital”) is used in the analysis.

$$U = U(Z_i, H)$$

where,  $U$  = level of utility

$Z_i$  = level of production and consumption of activity  $i$

$H$  = stock of health

The study assumes that individual inherits an initial shock of health that determines functionally. The model is formulated within framework of utility maximization. We distinguish between goods that directly contribute to utility, goods that indirectly contribute to utility by production function.

The household production of health has been introduced as conceptual framework for analysis of health status and health change which helps to frame research questions and intervention strategies. Berman, Kendall, & Bhattacharyya (1994) defines it as a dynamic behavioral process through which households combine their (internal) knowledge, resources, and behavioral norms and patterns with available (external) technologies, services, information, and skills to restore, maintain and promote the health of their members. Health is a valued goal of household life one which can be achieved or restored and maintained through a variety of mechanisms available to households. The study labels the process of household behaviors and use of resources, both internal and external, to attain the household production of health. The households exist within a social and economic environment which includes factors specific to each household as well as community and socioeconomic factors affecting a larger number of households such as household income, education, social status, the availability of clean water and quality of the natural environment. Physical access to health services, transportation, and other community-level variables also make up part of the social and economic environment.

The model is focused on the trade-offs between own-time and purchased goods and services in producing commodities. For example, the inputs to producing healthy children include food and feeding behavior, willingness to seek health care for prevention, clean water, an uncontaminated household

environment, care and attention, etc. All of these inputs require household application of time, skills, and sometimes purchased goods applied through household patterns of behavior. Different combinations of these inputs might produce equally healthy children.

The study introduces diarrhea disease, which has been a major focus of international health programs since 1978 as behavior approach case. The study shows the estimation from the impacts of interventions such as improving sanitation facilities and promoting personal and domestic hygiene. The study uses observational data to demonstrate how mothers' use of the sari to clean their children was related to the incidence of certain illnesses. The study also shows reductions in the incidence of gastrointestinal illness related to increased frequency of hand-washing with soap.

### **A Child's Health Production Function**

Cebu Study Team (1991) followed the models suggested by Rosenzweig & Schultz (1982, 1983). The objectives of study were to assess the effects of underlying social factors and proximate behavioral and biomedical factors on infant morbidity, growth and mortality. Data was collected from 3,000 children in Cebu, Phillipines during 1983-1985. This study showed if conventional statistical techniques which do not take such behavior into account are used, the estimates of effect of the risk factors on health are incorrect. Cebu study represented the correct implication, which showed how maternal education induces behavioral change, and how these changes induce change in the prevalence of children diarrhea. Later, Rosenwig & Wolpin (1988) applied and improved the child health production function to study how maternal education induces behavioral changes, and how these changes induce change in the prevalence of childhood diarrhea as represented below.

$$H_{it} = H(Y_{t-1}, H_{t-1}, Z_{it})$$

where,  $H_{it}$  = the health of child  $i$  at time  $t$

$Y_{it}$  = a set of health-related consumer goods

$Z_{ti}$  = a set of exogenous variable that directly affect child health e.g., Sex

The utility function for family  $i$  at time  $t$  can be written where  $X$  represents a vector of non-health related consumer goods and associates with the following budget constrained.

$$I_{ti} = Y_{ti} P_{ti} + X_{ti} P_{ti}$$

where,  $P_{Yti}$  = a vector of prices associated with the health-related variables

$P_{xti}$  = a vector of prices associated with health neutral goods

$I_{ti}$  = household income

If parents are assumed to maximize their utility over some time horizon, the demand equations for  $X$  and  $Y$  (the input demand equations) can be derived to be functions of the price vectors, income, the  $Z$  variables and the lagged value of  $H$  and  $Y$ .

The study finds that production of diarrhea seems to be affected most systematically by exposure of the infant to pathogens in Cebu, Philippines.

### **Household Production Model in Environmental Health**

From the utility maximization and the household production model literature above, this study can draw the conceptual model to understand how environment and health factors are linkage together. Health may be considered as a commodity that directly contributes to utility (i.e., sickness causes disutility). Good health can also contribute to utility by (a) increasing productivity, (b) making time available for market and non-market activities, and (c) decreasing costs of prevention and treatment of illnesses. Health outcomes, however, are not necessarily exogenously determined because households can combine time, money, and knowledge to improve and maintain their health. Thus, health can be conceptualized, like other goods, as the output of a household health production function (Grossman, 1972). A household can thus be viewed as maximizing utility comprising of desirable goods, including self produced health, given an income constraint and the health production constraint.

In study model is scoped the population to only children and infection disease to only malaria because of the following reasons. First and foremost, children are most vulnerable among all sub-populations to health hazards. For example, bearing the burden of between 75 and 90 percent of the mortality and morbidity attributed to malaria. Second, relative to an adult, a child's health depends primarily on parental decisions and external factors, rather than the child's personal choices and behaviors. This translates into a relatively simpler modeling task because the estimation model does not include endogenous variables that can result in biased estimates. Third, many analysis of individual malaria cannot adequately model factors related to acquired immunity to the disease because of inadequate data. By focusing on children, we mitigate this potential source of bias, because they are unlikely to have developed immunity to malaria in their short lifespan.

Given this focus, this study develops a model of children's health. This study assumes that parents derive utility from their children and produce child health, for example, by investing time ( $L_{ch}$ ) and money on nutrition,

medical care, and disease prevention. This bundle of purchased inputs for child health production is labeled as ‘care giving’ (CG). While this study focuses on children’s health, the household production logic still holds, such that parent’s health can be included with all other commodities that contribute to household utility. The model below illustrates the key insights of this approach.

$$U = U (Z_i, CH; \theta)$$

where,  $U$  = level of utility

$Z_i$  = a composite consumption goods

$CH$  = child health;  $\theta$  is preference

A typical household maximizes utility comprising of child health (CH) and a composite consumption goods (Z), for example, money. This utility is conditional on preference parameters,  $\theta$ , that measure the shape of the utility curve and could be proxied by socio-economic data on parental age and education. Utility is maximized subject to two constraints. First, the household faces a child health production function that is twice-differentiable, continuous, and convex; CH is a vector of child health that depends on care giving (CG) and is conditioned by demographic factors, D, and environmental factors, (F). The parental ability to prevent diseases such as malaria by using bed nets and prophylactics is made easier or more difficult by the extent to which a child is exposed to malaria risks (e.g., mosquitoes) through deforestation and other forest disturbance, for example. Moreover, it is their perceptions of these environmental influences that dictate their actual choices.

$$CH = CH (CG_i, D, F)$$

where,  $CH$  = child health production function

$CG_i$  = a composite of care giving

$D$  = demographic factors

$F$  = environmental factors

Second, the household faces a budget constraint where expenditures on Z and CH are no greater than the sum of exogenous ( $I_e$ ) and earned income. Without loss of generality, the model will assume that the earned income is a function of household labor and forest quality. In rural areas adjoining large tracts of forest, the primary sources of earned income are agriculture, wage labor, and forestry; all of which require labor input.

$$Z + P \cdot CH = I_e + I$$

The Lagrangian for this research is set as



$$L_{CH,Z,CG} = U(Z_i, CH; \theta) + \lambda [CH(CG; D, F)] + \mu [I_e + I - P^* CH - Z] \dots$$

In which  $\lambda$  and  $\mu$  are the Lagrangian multipliers,  $\lambda$  is the marginal utility of child health, and  $\mu$  is the marginal utility of income.

The first-order conditions of this utility maximization are presented below.

Simultaneous solution of these first-order conditions determines optimal consumption of CH and Z based on the optimal allocation of care giving. Time and money are allocated so that marginal opportunity costs are equal to marginal utility of consumption generated by these efforts.

$$\begin{aligned} L_{CH} = 0 &= U_{CH} + \lambda CH_{CH} = > CH^*(p, \theta, D, F, I_e) \\ L_Z = 0 &= U_Z - \mu = > Z^*(p; \theta, D, F, I_e) \\ L_{CG} = 0 &= \mu * p + \lambda CH_{CG} = > CG^*(p, CH^*, D, F, I_e) \end{aligned}$$

A child's health can thus be described as a function of the cost of care giving inputs, individual demographic characteristics, environmental factors, and exogenous income. Because care giving is a household production activity and is not a commodity that is entirely purchased in the marketplace at an exogenously determined price, the cost of care giving will depend on parental and household economic factors and community level infrastructure, which all exogenous to the child.

This study model can also apply to estimate how changes in forest conditions impact child malaria in rural forested areas with limited access to public health and other infrastructure. Analytically speaking, researcher can conduct comparative statics in the above model, for example, by taking total derivatives of first derivative equations with respect to CH and F and evaluating  $\partial CH / \partial F$ . The main idea of this applied model is to find the relationship between malaria and forest condition in order to find efficient policies. The model also takes in to account several factors such as demographic, price of care giving and household wealth.

### Conclusion

This study proposes the household production model to analyze the relationships between environmental issues and health status. The model assumes that any household can derive utility from the children in the household being healthy and a composition of good consumption; meanwhile child health is conditioned by care giving, demographic factors and environmental factors. Hence, how changes in environmental quality can impact

on the household production function can be measurable from this model. Living in malaria-endemic regions places an economic burden on households even if they do not actually suffer an episode of malaria. Households living with endemic malaria are less likely to have access to economic opportunities and may have to modify household behavior to adapt to their disease environment. This study aims to use the household production and utility maximization model to analyze the linkage of health, environment and economics. The literature of the household production model helps us in develop the conceptualize model for this study. Understanding the household behavior will benefit the policy maker in the form of improving efficiently policies. The household production model can help the policy maker identify factors that are most significant in producing child health. Policy intervention could then be aimed at supporting these factors.

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