ABSTRACT

SANGLIMSUWAN, KARNJANA. Environmental Health: Evidence at Three Scales. (Under the direction of Erin O. Sills and Subhrendu K. Pattanayak).

This dissertation consists of three essays, each presenting empirical analysis of environmental health at a different scale. The first essay explores the interrelationships between health status, income and environment at the national level, using data on 63 countries in 1990, 1995, and 2000. The relationship between economic growth (GDP) and environmental quality follows the inverted-U shape predicted by the Environmental Kuznets Curve for only some environmental indicators. I find evidence of N-shaped relationships between GDP and CO_2 and CH_4 in developing countries. In the environmental health models, I find that higher levels of CO2, PM and BOD lead to higher infant and child mortality rates.

The second essay considers incidence of waterborne diseases at the provincial level in Thailand, adding information on preventive measures (access to safe water and sanitation). In panel models estimated with ten years of data, I once again do not find the inverted-U relationship between economic growth (GPP) and water pollution, and surprisingly, I find no significant relationship between GPP and preventative measures. When I include preventative measures in a model of health outcomes, I confirm that broader access to safe water leads to lower incidence of diarrhea. Increasing GPP consistently lowers the incidences of all water borne diseases. However, the statistical evidence on the water quality indicators are mixed. For example, higher BOD unexpectedly decreases incidence of diarrhea and dysentery, but higher total coliform bacteria has the expected positive impact on the dysentery rate.

The third essay models environmental and occupational health outcomes of 2656 individuals from 600 households in Orissa, India. These households are from 20 villages located at varying distances from mines, which have become highly controversial in Orissa. Part of the controversy is over their health impacts, which can occur through both environmental and occupational health channels. Proximity of residence to the mine is associated with higher incidence of waterborne diseases, typhoid and fever – most likely associated with changes in water quality and distribution, whereas employment in the mines is clearly associated with acute respiratory infections as might be expected from working in dusty conditions with no protection.

Environmental Health: Evidence at Three Scales

by
Karnjana Sanglimsuwan

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APPROVED BY:

Dr. Frederick W. Cubbage

Dr.Daniel J. Robison

Dr. Sujit K. Ghosh

Dr. Subhendu K. Pattanayak
Co-Chair of Advisory Committee

Dr. Erin O.Sills
Chair of Advisory Committee

DEDICATION

To my family, my teachers, and my friends

BIOGRAPHY

Karnjana Sanglimsuwan was born in 1978 in Bangkok, Thailand. She completed her Bachelor degree in Economics at Chulalongkorn University in Bangkok, Thailand. She obtained Master degree in Economics from the same university. After she finished her Master degree, she received a scholarship and came to North Carolina State University. She earned Master degree in Economics in 2004 and joined the doctoral program in the Department of Forestry Environmental Resource. Her major research interests are Environmental Health, Conservation, Sustainable Development and REDD.

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Chapter 1 Introduction

1.1. The Concept of Environmental Health

The concept of environmental health has become a topic of worldwide discussion in recent years. This dissertation addresses environmental health by examining the impact of environmental factors - such as air quality, water quality, and proximity to mining operations - on overall indicators of health status and the incidences of specific diseases. This is broadly consistent with the various definitions of environmental health that have been put forth by different organizations. According to the World Health Organization (WHO), environmental health comprises those aspects of human health, including quality of life, that are determined by chemical, physical, biological, social, and psychosocial factors in the environment. Environmental health also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can adversely affect the health of present and future generations (WHO - draft definition developed at a WHO consultation in Sofia, Bulgaria, 1993). As used by the WHO Regional Office for Europe, the term includes both the direct pathological effects of chemicals, radiation, and some biological agents, and the effects (often indirect) of the broad physical, psychological, social, and aesthetic environment, which includes housing, urban development, land use, and transport (World Health Organization, 1999). The World Bank's Africa Environmental Health team proposes using a broad definition that covers all activities to prevent health risks through control of human exposure to: (a) biological agents, such as bacteria, viruses, and parasites; (b) chemical agents, such as heavy metals, particulate matter, pesticides, and fertilizers; (c) disease vectors, such as mosquitoes and snails; and (d) physical and safety hazards, such as traffic accidents, fire, extremes of heat and cold, noise, and radiation. The National Environmental Health Association defines environmental health and protection as protection against environmental factors that may adversely impact human health or the ecological balances essential to long-term human health and environmental quality, whether in the natural or man-made environment (National Environmental Health Association, 1996).

1.2. The Importance of Environmental Health

Health problems in term of illness, disability and death related to the environment have become a major concern all over the world. Pruss-Ustun & Corvalan (2006) estimated that environmental factors have an important role in more than 80 of the major diseases and injuries around the world with diarrheal diseases and respiratory infections heading the list. Each year there are approximately 4 billion cases of diarrhea, and 2.2 million deaths due to diarrhea worldwide, mostly children in developing countries. More than three million children under the age of five die each year from environment-related causes, such as polluted indoor and outdoor air, contaminated water and lack of adequate sanitation (WHO, 2002). To motivate the importance of environmental impacts on human health, this section briefly discusses two environmental factors addressed in this dissertation: outdoor air quality and water quality.

1.2.1. Outdoor air quality

Clean air is one of basic requirements of human health. According to WHO (2008), more than 2 million premature deaths each year are attributed to the effects of urban outdoor air pollution and indoor pollution caused by the burning of solid fuels. About 40% of lower respiratory infections in developing countries are related to environmental conditions. Furthermore, air quality is also related to the incidence and severity of asthma, heart and lung diseases, allergies, and several types of cancers. Outdoor air pollution mostly originates from point sources, for example, factories, forest fires, and fossil fuel burning for transportation and energy production. Pollutants include particulates, carbon dioxide, sulfur oxides, and lead. In most cases, the effects depend on level and length of exposure. Chronic exposure to particulates increases the risk of developing cardiovascular, respiratory disease and lung cancer. Air pollutants also significantly contribute to decreased life expectancy and increased infant mortality rates due to long term exposure especially in developing countries where air quality regulations are often unenforced.

1.2.2. Water Quality

Contamination of water can come from point or nonpoint sources, or a combination of both. Examples of point sources include industrial plants, commercial businesses and wastewater treatment plants while examples of nonpoint source include runoff from agriculture field, construction, mining, and failing on-site wastewater treatment systems.

Physical, biological and chemical contamination significantly reduces the use value of surface waters and can lead to increased morbidity and mortality rates of waterborne disease. Pruss-Ustun, Bos, Gore, & Bartram, (2008) reports that more than 3.4 million people die every year from water related diseases, which are the leading causes of illness and death especially in the developing world. Diarrheal disease alone is responsible for the illness of four billion people and the deaths of 1.8 million people every year (World Health Organization, 2010). Ninety percent of these are children under the age of five, mostly in developing countries. In comparison, there are approximately 396 million people who are infected with malaria and about 1.3 million people who die from malaria each year.

1.3. The Importance of Occupational Health

Occupational health is the health burden or suffering caused by working conditions or employment. People worldwide face occupational health and safety hazard on a daily basis. Potential sources of occupational health risks include environmental conditions in the workplace, such as indoor air pollution, toxic chemicals, pesticides, excessive noise levels, mechanical dangers, inadequate heating, cooling and sanitation. According to WHO and International Labor Organization (ILO), approximately 2.9 billion workers are exposed to hazard risks at their workplace, and there are about 2 million workers who lose their lives through occupational-accidents and work-related diseases each year. The leading occupational causes of death are unintentional injuries, chronic obstructive pulmonary disease, and cancer. Especially when workers live close to their workplace and the production activities in which they are employed have negative environmental externalities, occupational and environmental health problems may be similar and reinforce one another.

1.4. Organization of this dissertation

Since both economic development and environmental degradation play important roles in human health status, it is important to evaluate interrelationships environment, health and income. This dissertation will explains the concept of environmental health in three different scales (1) cross-countries level; (2) regional level: Thailand; (3) household level: India. The overall objective of this study is to improve understanding of the concept of environmental health in order to enhance optimal development and sustainable growth for developing countries.

Environmental quality indicators and health outcomes are different in three different levels. In cross countries level, life expectancy, infant and child mortality rate, which are standard country's health status are used to find the impacts of environmental degradation. Most of air quality indicators, such as, carbon dioxide (CO_2), nitrogen dioxide (NO_2) and particulate matter (PM), are used as environmental indicator since air pollutants are likely to increase when economy changes from rural to urban or agricultural production to industrial production. The Environmental Kuznets Curve hypothesis has been used to explain the relationship between environmental quality and economic development. Other interesting variables, such as climate change and socio-economic factor have also been analyzed as determinant impacting health status in cross countries level. I use a three-period dataset and analyze each relationship by using pooled OLS, fixed-effects, and random effects specification.

In regional level, I can focus on one important issues of environmental health. I select Thailand, where water pollution is considered a severe threat to Thai people as shown in high incidence rates of waterborne diseases. I spend time compiling ten year panel data from several sources. There are 366 water quality monitoring station across 76 provinces in Thailand. Water quality indicators in this study are biochemical oxygen demand (BOD), dissolved oxygen (DO) and total coliform bacteria (TCB); whereas incidences of waterborne diseases are diarrhea and dysentery. In this regional study, I consider access to safe water and sanitation as the prevention indicators. However, there are limited data on prevention indicator and data have not changed much over time. I employ the new econometric technique, which is called fixed effect vector decomposition, in order to be able to explain unvaried prevention indicators.

In household level, I can examine occupational health that is health burden from working in mine industry in the state of Orissa. I took advantage of existing household data set that I helped examine as part of Research Triangle Institute project funded by the World Bank to investigate the impacts of mining on health. Mining generates income through employment to local community; however, mining also causes environment degradation that eventually affects on local community's health. The incidences of several diseases, such as waterborne disease, acute respiratory infection, fever, tuberculosis are used health indicator. The distance from mine is used as an indicator for environmental health; while employment in mine is use as an indicator for occupational health. I employ regular probit and bivariate probit which can estimate endogenous dummy variables in this study.

1.5. References

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Chapter 2 Cross-Country Analysis

2.1. Introduction

This chapter of my dissertation focuses on the relationships between health indicators and environmental variables in cross-sections of countries with widely varied levels of development. In recent years, there has been increased interest in the interrelationships between economics, environment, and health.

Health and per capita income are closely linked, with the causal relation running in both directions. The positive correlation between health and income per capita is one of the best-known relationships in international development. More developed countries (countries with higher income per capita) have greater control over many of the goods and services that promote good health, such as better nutrition and access to safe water, sanitation, and good-quality healthcare service.

The relationship between environmental quality and income per capita has been tested and described in numerous empirical studies of the Environmental Kuznets Curve (EKC). The EKC hypothesizes the following relationship between per capita income and environmental degradation: as development and industrialization progress, environmental damage increases due to greater use of natural resources, more emission of pollutants, the operation of less efficient and relatively dirty technologies, and disregard for the environmental consequences of growth. However, as economic growth continues, the heavy industries are shifted to knowledge-based and service industries which are cleaner. As income rises and life expectancies increase, cleaner water, improved air quality, and a generally cleaner environment also become more valuable as people make choices at the margin about how to spend their incomes.

Interest in the relationship between environment and health is motivated by the observation that almost every human disease is influenced or caused by an environmental exposure, meaning direct human contact with a pollutant (e.g., through breathing contaminated air, drinking contaminated water, or eating a contaminant). Measurements of exposures to contaminants can help identify which pollutants may cause health problems and at what levels.

In sum, common hypotheses addressed in the literature include: (a) increasing environmental stress or pollution levels reduces the health status of a country; (b) faster economic growth or higher GDP per capita deteriorate environment quality or cause higher pollution; and (c) faster economic growth or higher GDP per capita lead to better health status of the country. These hypotheses reflect the complexity and potentially contradictory impacts of economic growth on the environment and health, and feedbacks to income.

Although there are largely analyzed related to environmental health using cross-country data, most of those studies focus either within one country or one-one relationship which excludes other factors that affect health status such as education, temperature, etc.

This chapter reviews key concepts in environmental health and analyzes the link between health indicators and environmental variables for a cross-section of countries widely dispersed on the economic development spectrum. Most developing countries face high rates of natural resource depletion, pollution emission, and ecosystem deterioration, which all potentially impact the spread of diseases, health outcomes, and productivity of human resources. Because these effects of could be substantial, the concept of environmental health should be considered central to development.

The remainder of this chapter is structured as follows. The next section reviews previous literature at the cross country level. Section three presents the conceptual framework and empirical method of this study. Section four describes the data. Section five presents the empirical results, followed by discussion and conclusions.

2.2. Literature related to the cross-country study

2.2.1. Effect of environment on health

Good environmental quality contributes to good health. Almost every human disease is influenced or caused by an environmental exposure, meaning direct human contact with a pollutant (e.g., through breathing contaminated air, drinking contaminated water, or eating a contaminant). Measurements of exposures to contaminants can help identify which pollutants may cause health problems and at what levels. Factors such as particulate matter in the air, water pollution, and other environmental degradation damage the health of thousands of people every year. Particularly in developing countries, environmental hazards and pollution are major contributors to childhood deaths, illnesses and disability from acute respiratory disease, diarrheal diseases, physical injuries, poisonings, insect-borne diseases and perinatal infections (WHO, 2005). The links between environment and health have been examined mostly at the micro-level in epidemiological studies.

There are very limited but suggestive studies at the cross country level. This is primarily due to the lack of a coherent, consistent, and comprehensive dataset describing the extent and distribution of ill health worldwide (Smith & Ezzati, 2005). Most cross-country studies have used measurements of ambient pollutant concentrations (e.g., concentrations of particulate matter, nitrogen oxides, sulfur dioxide, and bacteria in water) as explanatory variables. For example, Chay & Greenstone (2003) estimated the impact of total suspended particulates on infant mortality during 1970-1980. Smith & Mehta (2003) used four different methods to estimate the burden of disease due to indoor air pollution from household solid fuel use in developing countries. The study found that acute respiratory infections in children under five years of age are the largest category of deaths and disability adjusted life years from indoor air pollution. Although different health outcomes were estimated from different exposure methods, all estimations suggested that around 1.6 million deaths are associated indoor air pollution each year. Speizer & Kass (2004) found that both mortality and morbidity are related to outdoor air pollution in developing countries of Asia.

Similar to the relationship between air pollution and health, people tend to be at greatest risk from infectious waterborne diseases when they have a poor-quality water supply (Eisenberg, Bartram, & Hunter, 2001; Payment & Hunter, 2001). Waterborne diseases are caused by organisms that are directly spread through water. Water transmission has played a key role in the epidemic cholera and dysentery, especially in countries in South Asia and Africa where most of the deaths have occurred. Kick, Nasser, Davis & Bean. (1990) showed the strong relationship between infant mortality and access to safe water. In attempting to identify the impact of water pollution on health at the cross-country level, some researchers have focused on controlling for the impact of a country's level of development (e.g., measured as per capita GDP).

Deforestation and changes in land use influence human health in diverse ways. For instance, loss of rainforest may cause in damage to habitat, biodiversity loss and aridity as well as the emergence of new infections due to changes in the environment (Taylor, 1997). Deforestation improves conditions for breeding by some species of mosquitoes, which may lead to malaria epidemics (Heggenhougen, Hackethal, & Vivek, 2003; Patz et al., 2004; Saker, Lee, Cannito, Gilmore, & Campbell-Lendrum, 2004). In the longer term, cutting and burning of forests also causes loss of potential medicines and more pollutants in air and water. Deforestation also contributes to global climate change and its expected adverse effects on health.

Smith, Corvalán, & Kjellström (1999) employ the concept of the Global Burden of Disease (GBD) to estimate the impact of the environment on disease. Diseases in the GBD have been grouped according to biological criteria (e.g. parasitic worms), presumed common mechanism (e.g. malignant neoplasms), organ system (e.g. cardiovascular), age (e.g. perinatal), sex (e.g. maternal conditions), type of intervention (e.g. child cluster), location (e.g. tropical cluster), cause (e.g. road accidents), and motive (e.g. intentional harm vs. unintentional accidents). Assuming that environmental improvements are made before other interventions are undertaken, the study found that the burden of acute respiratory infections can be substantially reduced through environmental and nutritional improvements, even without the administration of relevant antibiotics and vaccines. Environmental improvements can decrease rates of diseases in 22 categories, including child cluster diseases, malignant neoplasms (cancer), depression, malnutrition, cerebrovascular disease, congenital effects (birth defects), malaria, and suicide.

2.2.2. Effect of income on health

Income and human health move together: higher income enhances health, which in turn contributes to higher productivity and economic growth. Many empirical studies in disciplines ranging from economics to sociology to epidemiology have found a strong relationship between income and health. This empirical relationship between income and life expectancy has been recognized and named as Preston Curve after Samel H. Preston. Preston

(1975) plotted life expectancy against per capita income at the cross-country level to show an increasing and concave relationship. The slope is much steeper among the poorest countries than among the rich, although there continues to be a positive slope even among the rich. Rodgers (1979) investigated this relationship between individual income and life expectancy by using cross-sectional data from 56 countries. He found a statistically significant relationship between life expectancy and income up to a life expectancy of around 73-75 years. Prichett & Summers (1996) estimated the effect of per capita income on health using cross-country, time-series data. The study found that over a half a million child deaths in the developing countries in 1990 can be attributed to the poor economic status in the 1980s. Deaton (2001) found that the effect of income on reducing the mortality rate at the bottom of the income distribution is much greater than its effect at the top of the distribution.

Recent empirical studies between health and income are broader in term of alternative measure of income. Wagstaff (2000) showed that child mortality is higher among households with lower household with lower total household per capita expenditure. Wagstaff & Watanabe (2003) found that indicators of child malnutrition are decreasing with higher expenditure or higher asset-index household. In the same year, Haddad et al (2003) found that child malnutrition is lower when national income is higher. Moser, Leon & Gwatkin (2005) used index of durable goods ownership as measure of income and found that it is negatively correlated with infant and child mortality.

The Preston Curve can also be applied to a broader conception of development. Lin, Rogot, Johnson, Sorlie & Arias (2003) studied effects of education, income, employment and marital status on life expectancy. The study presented that the lower life expectancy found among poor income, less education, unemployed and unmarried group. Thus, the Preston Curve can be generalized to any form of socioeconomics factor reducing deaths, with the greatest impacts at the lowest levels of those factors. This relationship reflects the combination of economic and socio-economic development that rises with income such as literacy, improvement in nutrition, the quality of institution, access to clean water and sanitation, and public health service, all enhancing a country's health status as measured in terms of reductions in infant mortality rates and improvements in life expectancy. This relationship is reinforced by the positive feedback of health contributing to economic growth via higher productivity.

2.2.3. Effect of Income on the Environment

The relationship between income and environmental quality has been studied for many years. The Environmental Kuznets Curve (EKC) is a hypothesized inverted-U shape relationship between measures of environmental degradation and per capita income. The EKC is named after Simon Kuznets who discovered that income inequality first increases and then decreases with economic development. In the early 1990s, this concept was transferred to the income-pollution relationship and labeled as the EKC. The hypothesis is that environmental degradation will increase until some income threshold is passed and then afterward decrease. Grossman & Krueger (1991) first estimated the EKC for SO_2, dark matter, and suspended particles (SPM) using cross country data. They found the inverted-U relationship for SO_2 and dark matter. Shafik & Bandyopadhyay (1992) estimated the EKC for ten environment quality indicators. Local air pollution indicators conformed to the EKC hypothesis, while water pollution tended to increase with income at all income levels. Selden & Song (1994) re-analyzed two air pollutants studied by Grossman & Krueger (1991), SO_2 and SPM. They obtained broadly consistent results but with higher turning point.

By the mid-1990s, a new line of research was finding and emphasizing problems with the EKC. Cole, Rayner, & Bates, 1997 used emission data from OECD countries and found no evidence of EKC for nitrates, methane and municipal waste. In the same year, Horvath (1997) found that energy use per capita rises steadily with an increase in income. Besides air and water quality, researchers have tested a wide array of environmental indicators, such as deforestation, toxic waste, and indoor air pollution, against the EKC hypothesis, in general finding little evidence in support of the EKC hypothesis. For example, Koop & Tole (1999) used data from 76 developing countries to examine the relationship between deforestation and per capita GDP. They found no statistically significant relationship between them except with restrictive assumptions.

Besides the traditional inverted-U shape relationship, an N shape relationship, which indicates that pollution increases as a country develops, decreases once the threshold GDP is reached, and then begin increasing as national income continues to increase, has been found in some studies. Grossman & Krueger (1994), Shafik (1994), and Grossman (1995) found evidences of N shaped curve for some water pollution such as mercury and arsenic. Torras and Boyce (1998) showed N shape relationship between SO_2 and per capita income; Galetotti, Manera, & Lanza (2009) suggested that using of a cubic specification is important. They found evidence of N shaped curve relationship between CO2 and GDP.

In recent EKC studies, researchers have included additional explanatory variables such as democracy, literacy, and income inequality. Torras & Boyce (1998) used the same data as Grossman & Kruger (1993), adding political freedom or democracy. They find that higher political and civil liberties as well as increased literacy rate are associated with better environmental quality. However, Barrett & Graddy (2000) also used the same data and found statistical evidence for a negative link between civil and political freedom and air and water pollution. In sum, the empirical literature on the relationship between environment and income provides inconclusive evidence based on the EKC hypothesis, suggesting that further study is merited.

2.3. Conceptual Framework and Empirical Methods

2.3.1. A Conceptual Model of Impacts of Environmental Change on Human Health at the National Level

According WHO's definition of environmental health, not only natural environmental factors, but also climatic, economic, socio-demographic, and institutional factors must be considered to assess impacts on human health. In this study, the dependent variables are mortality and morbidity rates in each country. The main determinants of human health have been divided into five domains: (a) natural environment; (b) economic factors and human health; (c) economic factors and environment; (d) socio-economic; and (e) climate. For each factor, the challenge is to find specific measures, or variables, available for a large cross-section of countries across multiple years. The final dataset includes 63 countries, three years (1990, 1995, 2000) and the following factors:

(a) Environment stress factors. Environmental parameters available at the national level for both developed and developing countries include ambient air pollutant concentrations, water pollutant indices, hazardous substances, deforestation, and land use changes.

(b) Economic factors. People with low income are more likely to be exposed to harmful environmental influences, for reasons including inadequate housing, poor nutrition, and poor sanitation, all of which increase the risk of infection. Poor

housing, for example, is often associated with respiratory illnesses and waterborne diseases. At the national level, measures include both economic growth and income distribution.

(c) *Socio-economic factors.* There are several socio-economic factors that directly and indirectly impact human health, including education level (cf., Weiss, Hart & McGee,1992; Baker, Parker, Williams, Clark & Nurss, 1997), and population density (cf., Levy & Herzog, 1974).

(d) *Climate factors.* The impacts of climate on human health are many and complex. For example, global warming is expected to increase heat-related health problems, which often affect people with pre-established cardiovascular and respiratory disorders. Furthermore, climate change affects the range and abundance of species carrying diseases and pathogens (Bosello, Roson & Tol, 2006). Measures of climate available at the national level include temperature and precipitation rate. Increases in temperature can directly cause acute adverse health effects (e.g., in Europe in summer of 2003), and regional epidemics, such as cholera, occur seasonally and are associated with periods of excessive rainfall (Colwell & Patz, 1998; Shope, 1991; Lipp, Huq & Colwell, 2002).

2.3.2. Empirical Specification

The relationship between environmental change and human health is analyzed using panel data. Based on the literature review and conceptual framework, the empirical approach postulates that heath status, H_{it}, is related to per capita income X_{it}, (such as per capita GDP), a country's environment E_{it}, (such as CO_2, NO_2, and deforestation), preventive measures Y_{it}, (such as access to safe water and sanitation), socioeconomic status, S_{it} (such as the population density, number of physician, enrollment rate and government effectiveness), and climate, C_{it} (such as temperature and rainfall). In addition, unobserved factor control variables are represented in term of time specific (τ) and country specific (ρ) effects while i = 1,…., n province and t = 1,…., T years. The relationships discussed above are summarized in the following general model:

$$H_{it} = f\,(X_{it}, E_{it}, Y_{it}, S_{it}, C_{it}\,;\, \tau, \rho) \qquad (1)$$

This model can divide to three following component models; EKC, investments in prevention and preston curve. The equation (2) estimates the EKC model curve that the country's environment quality (E_{it}) depends on its per capita GDP level (X_{it}). Third, the equation (3) estimates the prevention model that the country's prevention level (Y_{it}) depends on its income level (X_{it}) as in equation (3). Fourth, the Preston model that the country's health status (H_{it}) depends on its per capita GDP level (X_{it}).

$$E_{it} = f\,(X_{it}\,;\, \tau, \rho) \qquad (2)$$

$$Y_{it} = f(X_{it}; \tau, \rho) \quad (3)$$

$$H_{it} = f(X_{it}; \tau, \rho) \quad (4)$$

The estimation consists of the following steps. I first estimate models from data pooled over time. Because each country has unique characteristics, it is important to capture unobserved country specific factors. Thus, I next estimate fixed and random effects models. For both fixed and random effects models, time dummies and time trend variables are sequentially added to the specification and tested. By examining, the relevant statistics, I determine which specification is appropriate. I also tested for different functional forms and determined that log-linear provides the best fit. Finally, the final model re-estimates equation (1) but with each environment indicators in each model. The step of testing model is shown in Figure 2.1.

2.4. Data

The data set consists of the information from 63 countries for 1990, 1995, 2000. The complete list of countries covered is provided in Table A2.1 of the Appendix. In this section, each variable is explained in detail including its full definition, the source of the data, previous use in the literature, and expected sign of the regression coefficient.

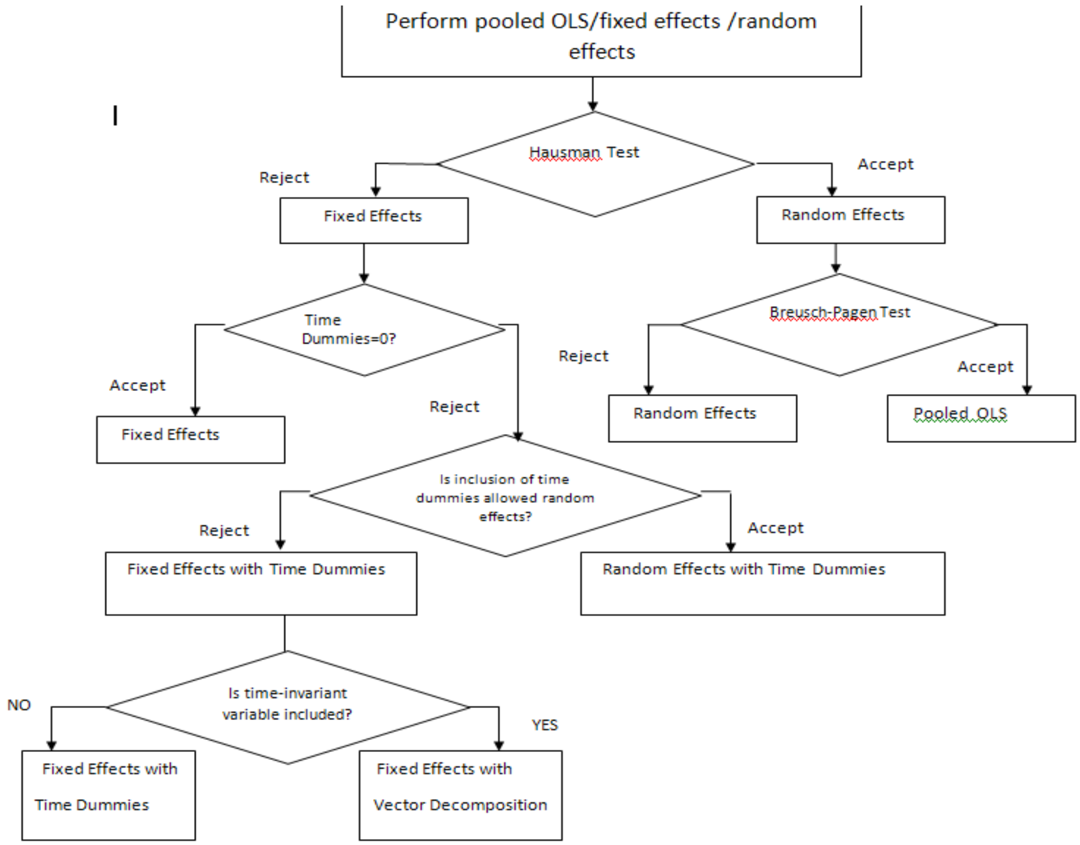

Figure 2.1 Step of Selecting Estimation Model

2.4.1. Heath Status Indicators (H_{it})

The indicators of the overall health of a country's population are as follows.

- Life expectancy (LEXP) is average number of years that a newborn is expected to live if current mortality rates continue to apply. Life expectancy at birth reflects the overall mortality level of a population. It summarizes the mortality pattern that prevails across allage groups; children and adolescents, adults and the elderly.

The source of LEXP data is the World Development Indicator Database (2007). World Bank staff estimated this index from various sources including census reports, the United Nations Statistics Division's Population and Vital Statistics Report, country statistical offices, and Demographic and Health Surveys from national sources and Macro International. LEXP is often used as a health status indicator. Messias (2003) used LEXP as a health indicator in Brazil to find the relationship between incomes, income disparities and illiteracy rates. Results indicated found that income disparities and illiteracy rates were negatively correlated with LEXP while GDP per capita was positively correlated with LEXP.

- Infant mortality rate (IMR) is the number of infants dying before reaching one year of age, per 1000 live births. Infant mortality is a good alternative indicator for health status because it avoids the potential reverse-causation problems associated with the relationship between adult health and income growth. IMR is obtained from the World Development Indicator Database (2007), which harmonizes estimates from WHO, UNICEF, and the World Bank, based mainly on household surveys, censuses, and vital registration, supplemented by World Bank estimates. Chay & Greenstone (2003) used IMR to estimate the impact of total suspended particulates on infant mortality.

- Child mortality rate (CMR) is the number of children who die by the age of five, per 1,000 live births. Data on CMR come from the World Bank's World Development Indicators Database (2007)

2.4.2. Environmental Stress Indicators (E_i)

The following measures of environmental stress are broadly available across countries, in part because they are of concern for global warming:

- Carbon dioxide emissions (CO_2) per capita are metric ton of Carbon dioxide emissions produced per capita. CO_2 emissions are those stemming from the burning of fossil fuels and the manufacture. These include CO_2 emissions produced during consumption of solid, liquid, and gas fuels and from gas flaring. The data are taken from the World Development Indicator Database (2007), which obtained CO_2 emission data from Dioxide Information Analysis Center of Environmental Sciences Division located at Oak Ridge National Laboratory in Tennessee. Population data, which counts all residents regardless of legal status or citizenship, is taken from the census reports by the United Nations Population Division's World Population Prospects.
- Nitrogen oxide emission (NO_2) per capita is measured in metric tons. NO_2 is a measure of the total release of nitrous oxide into the Earth's atmosphere as a result of human activities. Anthropogenic sources of NO_2 include fossil fuel burning,

agricultural processes (e.g., fertilizer production), livestock management, biomass burning, and industrial acid production. NO_2 has been identified by the Intergovernmental Panel on Climate Change (IPCC) as one of five non-CO_2 greenhouse gases (GHGs) that contribute significantly to global warming. The data source for NO_2 is World Resources Institute (WRI) database, which is calculated based on the Emission Database for Global Atmospheric Research (EDGAR) reports. Population data are taken from the census reports by the United Nations Population Division's World Population Prospects.

- Particulate matter concentration (PM) are micrograms per cubic meter of tiny particles less than 10 microns in diameter that are capable of penetrating deep into the respiratory tract and causing significant health damage. The data are from World Development Indicator Database (2007)
- Methane per capita (CH_4) is metric ton of methane produced per capita. CH_4 is a measure of total release of methane into the Earth's atmosphere as a result of human activities. Methane data are obtained from WRI's Climate Analysis and Indicator Tool (CAIT) 2009, while population data are taken from the census reports by the United Nations Population Division's World Population Prospects.
- Percent change in forest area (FOREST) is the percent change in forest area during the period specified during 1990-2000. Forest area is determined both by the presence of trees and the absence of other predominant land uses. The FAO considers forest to

be areas of at least 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent (at maturity) including areas under reforestation and areas temporarily unstocked but expected to regenerate. The data source is the WRI database, which draws changes in forest area from Global Forest Resource Assessment (FRA) 2005. Forest-related activities, such as clear-cutting, road building, and mining, may increase exposure to some human vector-borne diseases, for example, exposure to the vectors of yellow fever, leishmaniasis.

- Organic Water Pollutant emission (BOD) is measured by biochemical oxygen demand (kg per day per capita), which refers to the amount of oxygen that bacteria in water will consume in breaking down waste. This is a standard water-treatment test for the presence of organic pollutants. The data source is the World Development Indicator Database 2007, which draws from World Bank data. Freshwater resources all over the world are threatened by discharge of untreated waste, dumping of industrial effluent, and run-off from agricultural fields. It is a generally accepted fact that polluted water like chemicals in drinking water cause health problems and lead to water-borne diseases.

2.4.3. Economic Indicator (X_i)

- GDP per capita based on purchasing power parity (GDP) refers to gross domestic product converted to international dollars using purchasing power parity rates and divided by total population. An international dollar has the same purchasing power in a country as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current international dollars. The data source is the World Development Indicator Database 2007.

2.4.4. Socioeconomic and Other Factors (S_{it})

- Population Density (POPDEN) is mid-year population divided by land area in square kilometers. The definition of population is all residents regardless of legal status or citizenship. Land area is a country's total area, excluding area under inland water bodies. The sources for estimates of land area and population data are the Food and Agriculture Organization (FAO) and World Bank, respectively. Population pressure is likely to have multiple influences. For example, it could drive up the demand for forest products and alternative land uses, and eventually lead to higher deforestation, which in turn impacts human health.

- Urban Population Density (URBAN) is the midyear population of areas defined as percent of population that is in urban area in each country (% of total) and reported to the United Nations. The data source is the World Development Indicator Database

2007, which obtains this data from World Urbanization Prospects Division of the United Nations. Urban Population Density measures the degree of urbanization. Moore, Gould & Keary (2003) stated that urban growth is often associated with poverty, environmental degradation and population demands that outstrip service capacity. These conditions place human health at risk.

- The Number of Physicians (PHY) is defined as number of graduates of any facility or school of medicine who are working in the country in any medical field (practice, teaching, research). Data is expressed as physician per 1,000 people. The data source is the World Development Indicator Database 2007, which obtains these data from the World Health Organization (WHO), Organization for Economic Co-operation and Development (OECD), and the United Nations Children's Fund (UNICEF)
- Government Effectiveness Index (GOV) is a measure of the quality of public service provision, the quality of the bureaucracy, the competence of civil servants, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies. This is measured in units ranging from about -2.5 to 2.5, with higher values corresponding to better governance outcomes. The data source for this variable is Kaufmann, Krayy & Mastruzzi (2007). High government effectiveness increases the chances of good policies, implementation of policies, and provision of public goods such as health services and medical care. All of these factors have direct effects on public health.

2.4.5. Prevention Factors (S_{it})

- Improved Water Source (WATER) refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, or rainwater collection. This is in contrast to unimproved sources such as vendors, tanker trucks, and unprotected wells and springs. The data source is the World Development Indicator Database 2007, which obtained these data from the WHO and Meeting the MDG Water and Sanitation Target of the United Nations Children's Fund.
- Improved Sanitation Source (SANIT) refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. The data source is the World Development Indicator Database 2007, which obtained these data from WHO and United Nations Children's Fund.

2.4.6. Climate Factors (C_{it})

- Temperature (TEMP) is the average annual temperature of each country (in Celsius). Temperature influences the range, survival, growth and spread of pathogenic microbes. Occurrences of diseases such as malaria, yellow fever, dengue and cholera are all impacted by to climate. Many are spread by insects like mosquitoes, which prefer a wetter, warmer world. Doctors and scientists around the world are becoming increasingly alarmed over the impact of global warming on human health (Campbell-Lendrum & Woodruff, 2007). The temperature dataset is from the Climate Research Unit (CRU) at the University of East Anglia, and Mitchell, Carter, Jones, Huleme, & New (2003).

- Precipitation (RAIN) is the average annual millimeters of water released from cloud in the form of rain, freezing rain, sleet, or hail. Like changes in temperature, changes in precipitation may affect the amount and quality of food and drinking water as well as the growth, survival and transmission of vector borne infectious diseases. The precipitation dataset is from the Climate Research Unit (CRU) at the University of East Anglia, and Mitchell, Carter, Jones, Huleme, & New (2003).

2.5. Results

Descriptive statistics and correlation coefficients are found in Table 2.1, 2.2 and 2.3 Results of the models linking health, environment, and income are report in Table 2.4 through Table 2.16. These estimations do not include some variables that I collected, tested, but then excluded from the analysis for several reasons. First, some variables – such as diarrhea, malaria, respiratory disease, solid fuel use and income inequality – are not available for the years that we study. Second, some variables – such as DPT immunization – show very little variation. Third, some variable – such as enrollment rate, the number of hospital beds, corruption rate and other government performance indices – are highly correlated with variables included in the analysis. Finally, some countries and years are deleted from the sample to be able to compile panel data.

In Table 2.1 and Table 2.2 countries are grouped according to their incomes. They are divided into high income ("developed") vs. low, lower middle and upper middle income ("developing") according to the World Bank's definition. We estimate the model separately for the two different income groups since there are different paths of economic development from a mainly agricultural structure to an intensively industrial structure to prevalently service industrial structure. We expect the relationship between income, environment degradation and health to vary across different stages of development.

Consistent with expectations, the average rate of life expectancy is lower in developing countries group. The average rate of infant mortality rate and child mortality rate are approximately 39.58 and 54.75 deaths per 1,000 live births in the developing countries group, while those of developed countries group are approximately 6.37 and 7.75 deaths per 1,000 live births.

In term of environmental indicators, carbon dioxide emissions per capita (CO_2) is significantly higher for developed countries group compared to that of the developing countries group. Nitrogen dioxide per capita (NO_2) and methane per capita (CH_4) are slightly higher for developed countries group than for the developing countries group. Particulate matter (PM) for the developing countries groups is twice as high as that for developed countries group. This could be a result of better environmental regulations targeting particulate matter in developed countries group. There is increasing forest area in developed countries group, whereas there is deforestation in developing countries group. This implied greater awareness of forest conservation and stricter forest protection regulations in developed countries group. In term of water quality, the most organic water pollutant emissions per capita (BOD) are concentrated in developed countries group (approximately 4.58kg per day) compared to developing countries group (approximately 1.98kg per day).

In term of socioeconomic and other factors, population density (POPDEN) in developing countries group is higher compared to that of developed countries group. However, developed countries group has higher urban population density than the developing countries group. As expected, the number of physician and government effectiveness index are significantly higher for developed countries group. Likewise, the access to safe water and sanitation, which represent effective prevention efforts are higher for developed countries group compared to developing countries group. These correspond to the fact that people in low income or developing countries have a lower standard of living with limited access to safe water and sanitation than people in high income countries. Since most countries in developed countries group are in Europe and North America, the average temperature for those is lower than the developing countries group which most countries are in Africa, Asia and South America. Similar to the temperature, the average precipitation in developed countries group is also lower than in the developing countries group, which is most likely to be tropical region.

Table 2.3 represents the correlation between various environmental indicators in our empirical model. CO_2 emissions, NO_2 emission, and CH_4 are reported to have a very high positive correlation, while both CO_2 emissions and NO_2 emissions have weak negative relationships with the emission level of PM. Hence, we estimate separate empirical models for each environmental indicator in order to tease out their effects.

2.5.1. Environmental Health

As proposed in the empirical model, we begin by estimating the basic model which examines the relationship between health indicators (life expectancy, infant mortality rate and child mortality rate) and all explanatory variables, such as income, socioeconomic factors, and other related factor as well as climate factors. For each indicator, two sets of results are presented for developing and developed countries. We did also estimate the models with pooled data. Table A2.2 presents the results from the equation (1) with all environmental indicators and all countries are included. In these models, few variables are significant. We hypothesized that was partly because of different effects at different stages of development, and therefore divided the dataset. We estimate several versions of model (1).

(1) Using pooled ordinary least square (OLS), there is not much difference in the statistical significance of the estimated coefficients between regression without time

Table 2.1 Descriptive Statistics for Developing Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
Life Expectancy Rate (year)	123	66.96	8.00	42.48	77.79
Infant Mortality Rate (per 1000 births)	123	39.58	29.69	7.30	134.94
Child Mortality Rate (per 1000 births)	123	54.75	49.07	8.40	200.57
Per Capita GDP ($1000)	123	4.54	2.74	0.29	11.56
Per Capita CO2 (metric ton)	123	2.71	3.07	0.03	19.87
Per Capita NO2 (metric ton)	123	0.02	0.02	0.00	0.11
Particulate Matter (microgram/m^3)	123	68.46	46.66	12.13	237.31
Per Capita CH4 (metric ton)	123	1.26	1.04	0.20	5.58
Percentage Change in Forest Area (%)	123	-0.58	6.84	-23.23	27.85
Biochemical Oxygen Demand (kg/day)	123	1.98	1.55	0.10	6.51
Population Density (person/sq.km)	123	126.05	172.78	6.15	1081.41
Urban Population Density (% of total)	123	49.37	21.60	6.30	91.30
The Number of Physicians (per 1000 people)	123	1.24	1.10	0.01	4.41
Government Effectiveness Index	123	-0.10	0.55	-1.74	1.39
Improved Water Source (%)	123	85.81	14.60	36.00	100.00
Improved Sanitation Source (%)	123	71.18	23.86	9.00	100.00
Temperature (celsius)	123	20.09	6.79	6.70	28.50
Precipitation (millemeters)	123	1.45	0.83	0.03	3.14

Table 2.2 Descriptive Statistics for Developed Countries

Variable	Obs	Mean	Std.Dev.	Min	Max
Life Expectancy Rate (year)	66	76.81	2.23	69.32	81.08
Infant Mortality Rate (per 1000 births)	66	6.37	2.22	2.90	14.80
Child Mortality Rate (per 1000 births)	66	7.75	2.57	3.70	16.90
Per Capita GDP ($1000)	66	20.30	6.11	8.78	36.08
Per Capita CO2 (metric ton)	66	9.18	3.94	4.28	20.01
Per Capita NO2 (metric ton)	66	0.05	0.03	0.02	0.15
Particulate Matter (microgram/m^3)	66	31.89	15.58	13.24	76.47
Per Capita CH4 (metric ton)	66	1.72	1.73	0.16	7.34
Percentage Change in Forest Area (%)	66	3.17	4.99	-0.98	26.00
Biochemical Oxygen Demand (kg/day)	66	4.58	1.59	1.46	9.94
Population Density (person/sq.km)	66	103.22	93.93	2.22	348.07
Urban Population Density (% of total)	66	74.88	10.78	47.90	92.20
The Number of Physicians (per 1000 people)	66	2.71	0.61	1.60	4.30
Government Effectiveness Index	66	1.62	0.49	0.61	2.32
Improved Water Source (%)	66	99.47	1.14	96.00	100.00
Improved Sanitation Source (%)	66	99.17	2.23	90.00	100.00
Temperature (celsius)	66	9.85	6.29	-5.50	22.10
Precipitation (millemeters)	66	0.85	0.39	0.34	1.79

Table 2.3 Correlation between environment indicators

	CO_2	NO_2	PM	CH_4	FOREST	BOD
CO_2	1					
NO_2	0.678	1				
	0					
PM	-0.279	-0.2693	1			
	0.0001	0.0002				
CH_4	0.4016	0.5902	0.028	1		
	0	0	0.7023			
FOREST	0.1562	0.0741	0.1794	0.134	1	
	0.0319	0.3109	0.0135	0.066		
BOD	0.5282	0.294	-0.33	0.1384	0.4411	1
	0	0	0	0.0575	0	

dummies and regression with time dummies as shown in column (a) and (b) from Table A2.3 to A2.8. Since the pooled OLS treats the data as if it comes from a single set of data, it cannot capture the difference between different year and country. Thus, the pooled OLS specification may be inappropriate for this study.

1) The fixed effects specification can eliminate the unobserved country-effects and unobserved time-effects from each country. The fixed effects estimator is consistent since its error term does not contain the unobserved effect from unique characteristics of each country that might be correlated with the observations. For life expectancy among developing countries group, the F-test for individual country effect without and with time dummies as shown in Table A2.3 are 21.42

and 21.30 respectively. For infant mortality rate among developing countries group, the F-test for individual country effect without and with time dummies as shown in Table A2.4 are 16.08 and 15.11 respectively. For child mortality rate among developing countries group, the F-test for individual country effect without and with time dummies as shown in Table A2.5 are 14.12 and 13.56 respectively. Comparing with the critical value, the statistics suggest that there are country-specific effects. Likewise, the F-test among developed countries group for all health indicators also suggest that the pooled OLS specification is insufficient at best as shown in Table A2.6 to A2.8.

2) The random effects specification is applied and evaluated against the fixed effects specification by the Hausman test. For infant mortality rate and child mortality rate among developing countries group, the significant p-values of the Hausman tests in Table A2.4 and Table A2.5 show that fixed effects model is preferred. Meanwhile the p-value of the Hausman test for the life expectancy among developing countries group in Table A2.3 is larger than 0.05, therefore providing insufficient evidence to reject random effects model. For all health indicators among developed countries group, the p-value of the Hausman test is lower than 0.05. Hence, the fixed effects model is preferred for all health indicators in developed countries group.

3) After we select fixed effects, the next question is whether to include time dummies. First, we run fixed effects including the time dummies and then test against the null hypothesis that the time dummies are not jointly significant. For infant mortality rate and child mortality rate among developing countries group as shown in Table A2.4-2.5, there is insufficient evidence to reject the null hypothesis that the time dummies are not jointly significant. Hence, the fixed effects model without time dummies is more appropriate for these models. Turning to life expectancy among developing countries group as shown in Table A2.3, we run the random effects with time dummies and then test for time dummies. The p-value for the null hypothesis that the time dummies are not jointly significant is larger than 5%, and as a consequence the random effects with no time dummies are more appropriate for this study. Meanwhile the fixed effect with time dummies are tested and accepted for all health indicators among developed countries group as shown in Table A2.6-A2.8.

The results from the most appropriate models in each health indicator are present in Table 2.4 and Table 2.5. Although the fixed effects with time dummies are the most preferred among developed countries group, the time dummies absorb the significance of key variables, such as per capita GDP. Hence, the fixed effects without time dummies are presented instead in Table 2.5 in order to interpret the relationships between income, environment and human health.

a) Environmental Health in Developing Countries Group

As show in column (a) in Table 2.4, the estimated coefficient of per capita GDP (GDPK) is positive and significant at the 5% level. Higher per capita GDP increases life expectancy rate. In term of environment indicators, none of the estimated coefficient of environment indicator is significant. In term of socio-economic variables, only the estimated coefficient of level of urban population density is positive and significant. In term of prevention factors, higher access to safe water is significantly associated with higher life expectancy. Both temperature and rainfall show no significant effect.

The results for infant mortality rate, found in column (b) Table 2.4, are relatively stronger compared to life expectancy. Higher per capita GDP can significantly lower infant mortality rate. The estimated coefficients of CO_2 and BOD are positive and significant. These are implied that higher CO_2 in the air and higher BOD in the water can cause high infant mortality rate as expected. However, the negative sign on the estimated coefficient of CH_4 is unexpected. Both urban population and population density are shown to be negative and statistically significant.

In terms of prevention factors, higher access to sanitation is significantly associated with lower infant mortality rate. Again, none of climate factor shows significant effect. Similar to the results for infant mortality rate, higher GDP per capita is also associated with lower child mortality as shown in column (c) Table 2.4. Both estimated coefficient of CO_2

Table 2.4 Results from the best models for equation (1) when all environmental indicators are included in all countries

	Health Indicator					
	Lnlexp		Lnimr		Lncmr	
	(a)		(b)		(c)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0077	0.02	-0.088	0.00	-0.0805	0.00
Per capita CO_2	-0.0002	0.95	0.0676	0.00	0.0607	0.01
Per capita NO_2	-0.4777	0.14	1.8874	0.32	1.8677	0.37
Particulate Matter	-0.0001	0.58	-0.0005	0.66	0.0001	0.91
Per capita CH_4	0.0076	0.52	-0.1458	0.08	-0.144	0.11
Change in Forest Area	0.0007	0.53	0.0031	0.56	0.0019	0.74
BOD	0.0036	0.38	0.0382	0.06	0.0369	0.09
Population Density	0.0001	0.26	-0.0016	0.03	-0.0016	0.05
Urban Population	0.0019	0.01	-0.0131	0.05	-0.0172	0.02
Physician	0.0056	0.60	-0.0386	0.49	-0.0446	0.47
Government Effective	-0.0083	0.46	-0.0044	0.93	-0.0226	0.69
Safe Water	0.0026	0.01	-0.0034	0.58	-0.0051	0.46
Sanitation	0.0007	0.31	-0.0167	0.01	-0.0173	0.01
Temperature	-0.0013	0.56	-0.0345	0.40	-0.0236	0.60
Rainfall	0.0259	0.14	0.0688	0.64	0.0674	0.68
Constant	3.7622	0.00	6.7401	0.00	7.1038	0.00
R-squared	0.72		0.78		0.77	
N	123		123		123	
F-test for individual effect	11.22	0.00	16.08	0.00	14.12	0.00

and BOD are positive and significant. The negative signs on the estimated coefficients of urban population and population density as well as access to sanitation are consistent with the results from infant mortality rate.

The lack of statistical significance in the above models could be due to multicollinearity among environmental variables. Thus, in the next section, we estimate the regression for each environmental variable separately.

b) Environmental Health in Developed Countries Group

As show in column (a) Table 2.5, the estimated coefficient on per capita GDP is positive and statistically significant, indicating that a one unit change in per capita GDP leads to 0.21 percent increase in life expectancy. In term of environment variables, none of the estimated coefficient is statistically significant. The estimated coefficients on government effectiveness index and the number of physician are positive and statistically significant as expected. The better government and increasing number of physician can increase life expectancy. In addition, better access to sanitation is significant determinant of higher life expectancy as expected. For infant mortality rate in column (b) of Table 2.5, lower infant mortality is apparently supported by higher per capita GDP. The estimated coefficients on the number of physician and access to sanitation are significant and show the expected negative sign. Populations with better access to physicians and sanitation are likely to have lower infant mortality rate. Similar to the results for infant mortality rate, the results for child mortality rate are also weak as shown in column (c) Table 2.5. None of environmental variables shows significant impact. Child mortality rate is associated with higher per capita GDP, larger number of physicians, and better access to sanitation. In addition, higher government effectiveness can lower child mortality rate. Both temperature and rainfall show no significant effect. As for developing countries, we improve on this analysis by estimating relationships in each linkage as in equation (2) - (4). Finally, we run the basic model as in equation (1) for each environmental variable.

2.5.2. Environmental Kuznets Curve

The relationship between environmental degradation and the level of economic development is the focus of an ever-growing literature on the environmental Kuznet's curve. Many empirical studies have tested the EKC hypothesis of an inverted U shaped relationship between GDP per capita and environmental degradation. In this section, I examine whether the indicators of environmental degradation used in this chapter display either inverted U shaped or N shaped relationship with per capita GDP. Following similar specification steps as in earlier section, first the collected data are pooled and the results of the pooled OLS specification are shown in column (a) and (b) of Table A2.9-Table A2.20. Second, fixed and random effects specifications are estimated and tested. For the fixed effects models in both country groups, the p-value of the F-test that testing individual country is less than 0.05 as shown in column (c) and (d) of Table A2.9-Table A2.20. Hence, the pooled OLS specification would be biased and inconsistent. Third, Hausman test is used to compare fixed effects with random effects specification. For the low, lower middle, and upper middle income group, the insignificant p-values of Hausman tests for PM, CH_4, FOREST, and BOD

Table 2.5 Results from the best models for equation (1) when all environmental indicators are included in developed countries group

	Health Indicator					
	lnlexp		lnimr		Lncmr	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0021	0.00	-0.0381	0.01	-0.042	0.00
Per capita CO_2	-0.0028	0.10	0.0134	0.73	0.0225	0.54
Per capita NO_2	0.0515	0.55	1.0159	0.61	1.3768	0.47
Particulate Matter	-0.0002	0.50	0.0083	0.14	0.0055	0.30
Per capita CH_4	-0.0096	0.11	-0.0308	0.82	-0.0308	0.81
Change in Forest Area	-0.0005	0.63	0.0033	0.90	-0.0049	0.84
BOD	-0.0015	0.56	0.0276	0.64	0.0092	0.87
Population Density	-0.0003	0.19	0.0069	0.13	0.0069	0.11
Urban Population	-0.0015	0.50	0.0528	0.30	0.0623	0.19
Physician	0.0151	0.03	-0.2873	0.06	-0.3321	0.03
Government Effective	0.0139	0.05	-0.2361	0.14	-0.2723	0.07
Safe Water	-0.0017	0.49	0.0072	0.90	-0.0195	0.72
Sanitation	0.0082	0.01	-0.1436	0.05	-0.1437	0.04
Temperature	-0.0002	0.92	0.0869	0.11	0.0789	0.12
Rainfall	-0.0223	0.43	0.5391	0.41	0.3928	0.53
Constant	3.811	0.00	10.7533	0.07	13.4746	0.02
R-squared	0.92		0.86		0.88	
N	66		66		66	
F-test for individual effect	16.08	0.00	25.96	0.04	28.15	0.01

‘

as shown in column (c) of Table A2.11-Table A2.14 show that we should use random effect for those studies. The fixed effects are suggested by Hausman test for CO_2 and NO_2 as shown in column (c) of Table A2.9 and Table A2.10. Consequently, the time dummies are added and tested in each model. The results show that the random effects model with time dummies is appropriate for the study of PM, CH_4, and BOD. The random effects model without time dummies is appropriate for the study of FOREST, while the fixed effects model with time dummies is appropriate for study of CO_2 and NO_2. For the high income group, the insignificant p-value of Hausman test as shown in column (c) of Table A2.15-Table A2.20 suggests us to use random effects model for all environment indicators. In the next step, time dummies are added and tested in each model. The random effects with time dummies is more appropriate for CO_2, and BOD while the random effects without time dummies is more appropriate for the rest of environmental indicators.

a) EKC in Developing Countries Group

In Table 2.6, we present a set of estimated coefficients of environmental indicators' relationship with per capita GDP, its squared term and its cubic term (if it is significant) for low, low-middle, and upper-middle income country group. There are 41 countries in the sample overall. The results are selected from the most appropriate model for each study based on the criteria mentioned above. CO_2 emissions increase as country with low per capita GDP grows richer. The estimated coefficient on the square term and cubic term of per capita GDP-squared are negative, and positive respectively. The estimated coefficients indicate that CO_2 increases as a country develops, decreases once the threshold GDP is reached, and then begins increasing as GDP continues to increase (an N-shaped relationship). Both NO_2 and BOD, show an inverted-U shape relationship with per capita GDP. These results are supporting the EKC hypothesis, which NO_2 and BOD increase with per capita GDP, but the effects decrease with increasing per capita GDP. The points at which an increase in per capita GDP affects NO_2 and BOD negatively are estimated to be $9,290 and $9,250, respectively.

Similar to CO_2, the pattern of CH_4 can also be described by N-shaped curve[1] since the estimated coefficients of all income variables are significant in the cubic equation. When change in forest area is a dependant variable, the estimated coefficients are also significant for the cubic polynomial, representing the N-shaped figure. In addition, we found the monotonically decreasing linear relationship between PM and per capita GDP as shown in Table 2.6.

b) **EKC in Developed Countries Group**

Table 2.7 represents the results from the most appropriate model for the EKC studies in the high income group. The empirical results for CO_2, NO_2 and BOD appear to support the EKC hypothesis. The coefficients for per capita GDP and its quadratic term are statistically significant with positive and negative signs, respectively. Using the quadratic specification, we obtain the turning points of \$37,180, \$29,550 and \$40,800 for CO_2, NO_2 and BOD, respectively. When PM is environmental indicator, the empirical result shows a U-shaped relationship between per capita GDP and PM. PM first declines and then increase with respect to an increase in per capita GDP after reaching \$28,290. In the case of CH_4, the result reveals a monotonically decreasing relationship indicating that rising per capita GDP is associated with decreasing level of CH_4. The reason behind this might be the technological progress in the high income countries. Similar to CH_4, the change in forest area and per capita

[1] N-shaped curves are consistent with pollution increasing as a country develops, decreasing once the threshold GDP is reached, and then increasing again as national income continues to increase. Hence, there are two turning points.

GDP also shows monotonically decreasing relationship indicating that the change in forest area is predicted to turn down at very high level of per capita GDP.

2.5.3. Prevention and Income

Wealthier countries can provide better access to safe water, sanitation and hygiene. We estimate the relationships between income and such preventive measures, and the results are given in Table A2.21 to A2.24. The results from the pooled OLS specification show that homogeneity of the country effects is rejected at the 1% level of significance as shown in column (c) of Table A2.21 to A2.24. Hence, pooled OLS estimates are inefficient at best. The Hausman statistic rejects the null hypothesis for both improved water source and sanitation studies in developing countries group as shown in column (c) of Table A2.21 and A2.22. Hence, the fixed effects specification is more efficient for those studies. However, the random effects specification appears appropriate for both improved water source and sanitation studies in developed countries group as shown in column (c) of Table A2.23 and A2.24. Next, time dummies are added and tested to each model. We found that the fixed effects specification with time dummies is appropriate for both studies in developing countries group. Meanwhile, the random effects specification without time dummies is appropriate for both studies in developed countries group since the tests for time dummies are rejected. Table 2.8 presents the results from the most appropriate specification for the prevention study.

In developing countries group, an N-shaped curve[2] is observed for improved water source as shown in Column (a) of Table 2.8. The estimated coefficients signs of per capita GDP variables are positive, negative and positive for liner, quadratic and cubic term respectively. From the estimated coefficient in Column (b) of Table 2.8, the quadratic relationship of per capita GDP and improved sanitation source exists for developing countries group. The per capita GDP level of improved sanitation source turning point is $7075.

Similar to the results from developing countries group, per capita GDP in developed countries group shows an N-shaped relationship with the improved water source since the cubic polynomial functional form holds the statistical significances as shown in Column (c) of Table 2.8. In term of improve sanitation source in the high income group, we also found the inverted-U shape relationship between improved sanitation source and per capita GDP. A relative rapid rate of increasing in improved sanitation source is indicated at low per capita GDP with a slower rate of increase at per capita GDP greater than $26,303 as shown in Column (d) of Table 2.8.

[2] The N-shaped curve is consistent with access to improved water sources increasing as a country develops, decreasing once a threshold GDP is reached, and then increasing again as national income continues to increase.

2.5.4. Health and Income Relationship

The relationship between health and income – of the so-called Preston Curve – is estimated and shown in Table A2.25 to Table A2.30. Following the earlier specification steps, we find that the estimates from the pooled OLS for both income level groups are inefficient because their F-tests for country specific effect are significant as shown in column (c) of Table A2.25 to Table A2.30. Hence, both fixed and random effects specifications are applied for the study. The Hausman tests for life expectancy and child mortality rate in developing countries group indicates that fixed effects specification is more appropriate for these studies as shown in column (c) of Table A2.25 and Table A2.27. However, we accept the random effects specification for infant mortality rate study in developing countries group as shown in column (c) of Table A2.26. In the high income group, the random effects specification is appropriate for life expectancy study because we accept the null hypothesis of the Hausman test as shown in column (c) of Table A2.28.

Meanwhile the fixed effects specification is more efficient and consistent for infant mortality rate and child mortality rate in developed countries group due to the significant p-values of Hausman test as shown in column (c) of Table A2.29 to Table A.2.30. After adding and testing time dummies, the time dummies test fails to reject for infant mortality rate and child mortality rate in developing countries group as well as all health indicators in high income group. Hence, time dummies will be included in random effects specification for infant mortality rate in developing countries group. The fixed effects specification with time dummies is the most efficient for child mortality rate, while the fixed effects specification without time dummies is more appropriate for life expectancy in developing countries group. In high income group, the random effects specification with time dummies is more appropriate for life expectancy.

Meanwhile, the fixed effects specification with time dummies is more efficient for infant mortality rate and child mortality rate in high income group. The results from the best described models for each study are presented in Table 2.9 and Table 2.10.

a) **Health and Income Relationship in Developing Countries Group**

Looking across estimated coefficients for per capita GDP, its squared term and its cubic term, countries in low and low-middle income group exhibit an inverted U shaped relationship with life expectancy as shown in column (a) of Table 2.9. In other words, we observe that life expectancy increases with an increase in per capita GDP at relatively low levels of income. Beyond per capita GDP at $9,798, life expectancy decreases with anincrease in per capita GDP. Contrary to life expectancy relationship, both infant mortality rate and child mortality show the U shape relationship with per capita GDP. We observe that both infant mortality rate and child mortality rate first decrease with an increase in per capita GDP until reaching per capita GDP threshold at $9,132 and $8,749 in per capita GDP

Table 2.6 Result from the best models for equation (2) EKC in developing countries group

	Dependent Variables											
	CO_2		NO_2		PM		CH_4		FOREST		BOD	
	Coef.	lP>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	3.387	0.00	0.0127	0.00	-4.6221	0.00	0.4739	0.01	3.0762	0.03	0.6145	0.00
Per capita GDP^2	-0.4184	0.00	-0.0007	0.01			-0.062	0.04	-0.5386	0.03	-0.0332	0.01
Per capita GDP^3	0.0206	0.00					0.003	0.06	0.0268	0.05		
Year dummy1995	-0.6125	0.00	-0.0052	0.04			-0.1286	0.04			-0.622	0.00
Year dummy2000	-1.4139	0.00	-0.0002	0.95			-0.1544	0.04			-0.804	0.15
Constant	-4.3603	0.00	-0.0171	0.09	89.4187	0.00	0.3426	0.29	-4.7904	0.05	0.6036	
R-squared	0.59		0.28		0.08		0.1		0.09		0.26	
T-point			9.29								9.25	
N	123		123		123		123		123		123	

* the fixed effects specification with time dummies are used for co2, no2 and bod

* the random effects specification without time dummies is used for pm an FOREST

* the random effects specification with time dummies is used for ch4

Table 2.7 Result from the best models for equation (2) EKC in developed countries group

	Dependent Variables											
	CO_2		NO_2		PM		CH_4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.6341	0.00	0.0044	0.04	-4.1487	0.00	-0.0170	0.01	-0.0838	0.00	0.2151	0.02
Per capita GDP^2	-0.0085	0.02	-0.0001	0.10	0.0733	0.00					-0.0026	0.08
Per capita GDP^3												
Year dummy1995	-1.1266	0.00									-1.0121	0.00
Year dummy2000	-2.026	0.01									-1.4979	0.00
Constant	1.1903	0.67	-0.0112	0.64	83.1873	0.00	2.0103	0.00	4.8722	0.00	2.2373	0.06
R-squared	0.09		0.08		0.27		0.01		0.01		0.05	
T-point	37.18		29.55		28.29						40.80	
N	66		66		66		66		66		66	

* the random effects specification without time dummies is used for no2, pm ch4 and FOREST

* the random effects specification with time dummies is used for co2 and bod

Table 2.8 Result from the best models for equation (3) Prevention Model

	Developing Countries Group				Developed Countries Group			
	Water		Sanit		Water		Sanit	
	(a)		(b)		(c)		(d)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	5.6759	0.00	2.4968	0.01	1.2515	0.00	0.3113	0.00
Per capita GDP^2	-0.845	0.00	-0.1764	0.01	-0.0501	0.00	-0.0059	0.00
Per capita GDP^3	0.0368	0.01			0.0006	0.00		
Year dummy1995	1.9581	0.00	1.6594	0.01				
Year dummy2000	4.0135	0.00	3.9757	0.00				
Constant	74.4155	0.00	62.9216	0.00	89.6535	0.00	95.5042	0.00
R-squared	0.57		0.51		0.33		0.09	
T-point			7.075				26.303	
N	123		123		66		66	

*the fixed effects specification with time dummies is used for all case in low, lower middle and upper middle income group

* the random effects specification with no time dummies is used for all case in high income group

until reaching per capita GDP threshold at $9,132 and $8,749 respectively. Once per capita GDP exceeds those threshold levels, infant mortality rate and child mortality rate increase with per capita GDP.

b) **Health and Income Relationship in Developed Countries Group**

In column (a) of Table 2.10, we find an N-shaped curve relationship between life expectancy and per capita GDP. This relationship appears only in high income group. The possible explanation of this is the combination of an increase in health initiatives, a rising in new pandemic such HIV/AIDS, and a follow up of another health and scientific achievement when per capita GDP is increasing. When infant mortality rate and child mortality rate have been used, the coefficient of per capita GDP is significantly negative and the coefficient of its square term is significantly positive. The positive coefficient of its square term confirms the existence of U shape curve relationship which is consistent with the findings in developing countries group. An increase in per capita GDP initially leads to lower both infant and child mortality rate, yet after $19,091 and $17,846 further increase in per capita GDP leads to higher infant mortality rate and child mortality rate respectively. Hence, we can summarize that health status is intimately related with per capita GDP at the global level in either in low or high income group.

2.5.5. Full model by each environment indicator

The primary focus of this chapter is environmental health: the impact of environmental degradation on health status at the country level. One challenge to assessing this relationship is the multi-collinearity among environmental indicators.

To address this, we estimate equation (1) with each environmental indicator in a separate model. We repeat the specification steps described above, including pooled-OLS, fixed effects and random effects with and without time dummies in order to identify the best specification for both low and middle low income group and upper middle and high income group. The results are presented in Table A2.32 to Table A2.67.

Table 2.9 Result from the best models for equation (4) Preston Curve in developing countries group

	Lnlexp		Lnimr		Lncmr	
	(a)		(b)		(c)	
	Coef.	P>t	Coef.	P>z	Coef.	P>t
Per capita GDP	0.0359	0.00	-0.2437	0.00	-0.1591	0.00
Per capita GDP^2	-0.0018	0.01	0.0133	0.00	0.0091	0.00
Year dummy1995			-0.0674	0.01	-0.116	0.00
Year dummy2000			-0.1869	0.00	-0.2692	0.00
Constant	4.0844	0.00	4.2599	0.00	4.2814	0.00
R-squared	0.31		0.65		0.74	
T-point	9.7979		9.1324		8.7486	
N	123		123		123	

*the fixed effects specification without time dummies is used for LEXP

*the random effects specification with time dummies is used for IMR

*the fixed effects specification with time dummies is used for CMR

Table 2.10 Result from the best models for equation (4) Preston Curve in developed countries group

	Lnlexp		lnimr		Lncmr	
	(a)		(b)		(c)	
	Coef.	P>z	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0026	0.05	-0.0255	0.44	-0.021	0.48
Per capita GDP^2	-4.4E-05	0.04	0.0007	0.19	0.0006	0.21
Year dummy1995	0.0105	0.00	-0.3022	0.00	-0.2988	0.00
Year dummy2000	0.0242	0.00	-0.5232	0.00	-0.5426	0.00
Constant	4.2969	0.00	2.2889	0.00	2.4388	0.00
R-squared	0.35		0.87		0.90	
T-point	29.3869		19.0911		17.8458	
N	66		66		66	

*the random effects specification with time dummies is used for LEXP

*the fixed effects specification with time dummies is used for IMR and CMR

According to significance of F-test from testing specific country effect, the estimated coefficient from pooled-OLS specification is insufficient in all studies as shown in column (c) of Table A2.32 to Table A2.67. Hence, we consider two main approaches: fixed effects and random effects. For life expectancy with any environmental indicator in developing countries group, Hausman tests and time dummies tests show that the fixed effects with time dummies are the most appropriate specification. However, Table 2.11 shows the fixed effects specification without time dummies for life expectancy since the time dummies absorbed the significance of important explanatory variables. For both infant mortality and child mortality rate in developing countries group, Hausman tests show that the fixed effect specifications are most appropriate. Time dummies are tested and accepted for these studies. However, if time dummies absorb the explanation power, we present the results from the fixed effects without time dummies instead as shown in Table 2.12 and Table 2.13. Similar to life expectancy model in developing countries group, Hausman and time dummies for life expectancy study in developed countries group show that fixed effects specification with time dummies is the most appropriate for all environmental indicator studies. For expository reasons, the results from fixed effects specification without time dummies as shown in Table 2.14 are used to discuss the relationships of interest. Turning to infant mortality rate in high income group, Hausman and time dummies tests show that fixed effects specification with time dummies is appropriate for CO_2 and PM. For the rest of environmental indicators such as NO_2, CH_4, FOREST and BOD, the random effects specification with time dummies is more suitable. The results from the most appropriate specification without time dummies for these studies are presented in Table 2.15. Repeating the statistical test steps for child mortality rate in high income group, we found that the fixed effects specification with time dummies is suitable for CO_2, PM and CH_4. On the other hand, the random effects specification with time dummies is best for NO_2, FOREST and BOD. Although time dummies are significant, they absorb the significance of other explanatory variables. Hence, we present the results for child mortality rate in developed countries group with their best specification without time dummies as shown in Table 2.16.

a) Environmental health by each environment indicator in developing countries group

Table 2.11 presents the results when life expectancy is used as the health indicator. In general, some environmental indicators such as CO_2, NO_2, and BOD have expected sign (negative) but are insignificant. Per capita GDP is found to be significant in CO_2 and NO_2. In addition, the coefficients for population density and the percent of population in urban area are always positive and significant for all cases. Surprisingly, we find that government effectiveness index has significantly negative effects on life expectancy for all cases except $CH_{4.}$ This is possibly because countries in developing countries group with higher government effectiveness index do not focus their government policies on improving health status. Meanwhile, the number of physician and the prevention indicators show no significance on life expectancy. In term of climate indicators, the estimated coefficients of temperatures are positive but insignificant for all cases. Similar to temperature, the estimated coefficients of rainfall are positive but insignificant for all cases except CO_2.

When infant mortality rate is taken as the health indicator, we find that increases in per capita GDP can lower infant mortality rate with statistically significance for all environmental cases as shown in Table 2.12. In term of environmental indicators, the impact of CO_2 on infant mortality rate is positive. An increase in CO_2 emission by 1 unit is associated with 6.38 percent increase in infant mortality rate. The estimated coefficients of PM and BOD are also positive and statistically significant. One unit increase in PM and BOD is associated with 0.23 percent and 6.41 percent increase in infant mortality rate, respectively. Other environmental indicators are positive; however, they are statistically insignificant. The estimated coefficients for population density have negative coefficient and are significant for CO_2 and BOD. This result supports the earlier life expectancy study. In contrary to life expectancy study, the estimated coefficient of the percentage of improved sanitation is negative and significant for all cases. This can explain that basic infrastructure can lower infant mortality rate in low, lower middle and upper middle income country group. The percentage of urban population, the number of physicians and the government effectiveness as well as climate indicators show no significant impact on infant mortality rate.

When child mortality rate is taken as the health indicator, the signs of coefficients of per capita GDP are also negative and statistically significant for all environmental cases as show in Table 2.13. The finding confirms that improvement in health can be attained through increases in country's income. In term of environmental indicators, all environmental indicators show positive sign, but only estimate coefficients of CO2, PM and BOD are significant. Child mortality rate is inversely related with higher urban population and higher population density for CO_2 and BOD cases. The reason behind this is that urban city usually offers better employment, education, and health care infrastructure. Meanwhile, countries with higher percentage of improved sanitation significantly have lower child mortality rate as show in all environmental cases. Unexpectedly, we found no significant impact of the number of physicians, government effectiveness, and the percentage of improved water source as well as climate variables on child mortality rate.

b) Environmental Health by each environment indicator in developed countries group

Table 2.14 to Table 2.16 confirm that increases in per capita GDP tend to increase health status- positive sign on life expectancy and negative sign on infant mortality rate and child mortality rate for all environmental cases. In term of environmental indicator, the estimated coefficients on CO_2, PM and CH_4 describes an expected negative relationship with respect to life expectancy while the estimated coefficients on the rest of environmental variables have no significant effects on life expectancy. The estimated coefficients on population density and the percentage of urban population on life expectancy are negative. These relationships are opposite to the results in developing countries group, which urban city leads to higher life expectancy rate. This can explain that once country has very high income level, higher population density and urbanization mean more hazard to life expectancy. In addition, the estimated coefficients on the number of physicians, government effectiveness, and the percentage of improved sanitation are positive for environmental cases. Together, these indicate that higher number of physicians, better government and better sanitation amenities are basic requirements to increase in life expectancy in high income countries.

When infant mortality rate is used as health indicator, the estimated coefficients on CO_2, PM and BOD are positive and statistically significant. These results are consistent with the results from developing countries group. The estimated coefficient on population density is positive and statistically significant for PM case. Consistent with life expectancy, the estimated coefficients on the number of physicians and government effectiveness are positive for all case. The higher number of physicians and better government can lower the infant mortality rate and improve country's health status. Turn into prevention indicators, the percentage of improved water source can significantly lower infant mortality rate in all case but CO_2. The percentage of improved sanitation shows negative relationship with infant mortality rate; when CO_2 and PM are used as environmental indicator. We also found that higher temperature causes higher infant mortality when CO_2 and PM are used as environmental indicator.

When child mortality rate is used as health indicator, we find that the relationships between environmental indicators and child mortality rate are similar to the results from infant mortality rate. Higher air and water emissions from CO_2, PM and BOD are associated with higher child mortality rate. Meanwhile the number of physicians and government effectiveness also show negative impact on child mortality rate in all environmental case which is consistent with the results from life expectancy and infant mortality rate. Higher on population density and the percentage of urban population are associated with higher child mortality rate when PM is used as environmental indicator. Turn into prevention indicators, the percentage of improved water source can significantly lower child mortality rate when NO_2, FOREST and BOD are used as environmental indicators. Similar to infant mortality rate, higher percentage of improved sanitation is associated with lower child mortality rate when CO_2 and PM are used as environmental indicator.

2.6. Conclusion

This study explores the complex interrelationships between health status, income and environment at the national level. While the correlation patterns among these factors are well known, causality is more difficult to tease out. This study takes a step in that direction by compiling a panel dataset and careful testing to identify the most appropriate econometric model, including fixed and random effects with country and time dummy variables.

As shown by the empirical evidence, different environmental indicators have different relationships with per capita GDP. This implies that an increase in income does not always reduce all pollution levels. The empirical evidence shows the EKC hypothesis of an inverted U-shaped relationship is valid for CO_2 in developed countries, and NO_2 and BOD in both developing and developed countries. The evidence of N-shaped relationship for CO2, CH4, and FOREST in developing countries seems to imply that at very high income levels of developing countries, the negative impact of higher income (reflecting higher production and consumption) on the environment cannot be compensated by the positive impacts of environment-friendly technology and a shift toward green service. This is a signal that policy action must take into account. A misdirected policy action based on the EKC hypothesis could have negative effects in these developing countries. The monotonic decreasing

Table 2.11 Results from the best models for equation (1) when each environmental indicator is included in developing countries group : life expectancy

	LNLEXP											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0058	0.07	0.005	0.09	0.0042	0.14	0.0039	0.18	0.004	0.16	0.0041	0.15
Envi-indicator	-0.0037	0.23	-0.2766	0.29	0.0001	0.79	0.0032	0.75	-0.0005	0.67	-0.0011	0.77
Pop density	0.0005	0.00	0.0005	0.00	0.0005	0.00	0.0005	0.00	0.0005	0.00	0.0005	0.00
Urban pop	0.0042	0.00	0.0043	0.00	0.0042	0.00	0.0042	0.00	0.0042	0.00	0.0042	0.00
Physician	0.0147	0.21	0.0145	0.22	0.0115	0.32	0.0106	0.37	0.0104	0.38	0.0116	0.32
Government	-0.0195	0.08	-0.0216	0.06	-0.0189	0.09	-0.018	0.12	-0.0189	0.09	-0.019	0.09
Safe Water	0.0004	0.76	0.0004	0.79	0.0004	0.74	0.0004	0.75	0.0004	0.77	0.0003	0.80
Sanitation	-0.0005	0.64	-0.0002	0.83	-0.0001	0.92	-0.0002	0.88	-0.0001	0.90	-0.0002	0.87
Temperature	0.0092	0.27	0.0075	0.38	0.0092	0.29	0.0101	0.24	0.0101	0.24	0.0102	0.24
Rainfall	-0.0011	0.97	0.0044	0.89	0.0011	0.97	0.0002	1.00	0.0001	1.00	0.0005	0.99
Constant	3.7069	0.00	3.7122	0.00	3.6703	0.00	3.6575	0.00	3.6652	0.00	3.668	0.00
R-squared	0.50		0.50		0.50		0.50		0.50		0.50	
N	123		123		123		123		123		123	

*the fixed effects specification without time dummies is used for all environmental cases

Table 2.12 Results from the best models for equation (1) when each environmental indicator is included in developing countries group : infant mortality rate

	LNIMR											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	-0.0934	0.00	-0.0361	0.02	-0.0626	0.00	-0.0333	0.04	-0.0324	0.04	-0.0608	0.00
Envi-indicator	0.0638	0.00	1.3099	0.30	0.0023	0.02	0.0075	0.88	0.004	0.44	0.0641	0.00
Pop density	-0.0015	0.05	-0.0003	0.71	-0.0007	0.41	-0.0003	0.66	-0.0003	0.68	-0.0014	0.06
Urban pop	-0.0079	0.21	-0.0054	0.40	-0.0074	0.28	-0.0048	0.47	-0.0051	0.44	-0.0106	0.11
Physician	-0.0472	0.39	-0.0408	0.47	0.015	0.79	-0.0278	0.62	-0.0173	0.76	-0.0017	0.98
Government	0.0095	0.85	0.0346	0.52	-0.0033	0.95	0.0228	0.67	0.0209	0.69	0.0068	0.90
Safe Water	-0.0086	0.15	0.0016	0.81	-0.0095	0.14	0.0009	0.89	0.0012	0.85	-0.0035	0.59
Sanitation	-0.0124	0.03	-0.0117	0.04	-0.0136	0.03	-0.0119	0.04	-0.0127	0.03	-0.02	0.00
Temperature	-0.0027	0.95	-0.0181	0.66	-0.0274	0.52	-0.0265	0.52	-0.032	0.43	-0.0444	0.28
Rainfall	0.074	0.62	0.0239	0.88	0.0707	0.67	0.0436	0.78	0.049	0.75	0.0486	0.76
Constant	5.8868	0.00	5.0579	0.01	6.2326	0.00	5.2284	0.00	5.3672	0.00	6.8398	0.00
R-squared	0.75		0.75		0.70		0.74		0.74		0.73	
N	123		123		123		123		123		123	

*the fixed effects specification without time dummies is used for CO2, PM, CH4 and BOD

*the fixed effects specification with time dummies is used for NO2 and FOREST

Table 2.13 Results from the best models for equation (1) when each environmental indicator is included in developing countries group: child mortality rate

	LNCMR											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	-0.088	0.00	-0.0287	0.09	-0.058	0.00	-0.0628	0.00	-0.0598	0.00	-0.0566	0.00
Envi-indicator	0.0611	0.00	1.2301	0.36	0.0027	0.01	0.0243	0.66	0.0057	0.35	0.0642	0.00
Pop density	-0.0016	0.05	-0.0003	0.67	-0.0007	0.39	-0.0013	0.14	-0.0012	0.15	-0.0015	0.06
Urban pop	-0.0123	0.08	-0.0094	0.18	-0.0117	0.11	-0.0119	0.13	-0.0124	0.10	-0.015	0.04
Physician	-0.056	0.35	-0.056	0.35	0.0046	0.94	-0.0074	0.91	0.0101	0.88	-0.0129	0.83
Government	-0.0074	0.90	0.0191	0.74	-0.0201	0.73	-0.0109	0.86	-0.0167	0.79	-0.0096	0.87
Safe Water	-0.0099	0.13	0.0014	0.84	-0.0108	0.12	-0.0107	0.14	-0.01	0.17	-0.0047	0.49
Sanitation	-0.014	0.02	-0.0126	0.04	-0.0144	0.03	-0.019	0.00	-0.0202	0.00	-0.0214	0.00
Temperature	0.0115	0.79	-0.007	0.87	-0.0158	0.73	0.01	0.83	-0.0006	0.99	-0.0301	0.50
Rainfall	0.069	0.68	0.0252	0.88	0.0706	0.69	0.0384	0.83	0.048	0.79	0.0448	0.79
Constant	6.3077	0.00	5.3544	0.00	6.6004	0.00	6.7054	0.00	6.9545	0.00	7.2378	0.00
R-squared	0.74		0.75		0.71		0.69		0.69		0.73	
N	123		123		123		123		123		123	

*the fixed effects specification without time dummies is used for CO2, PM,CH4, FOREST and BOD

*the fixed effects specification with time dummies is used for NO2

Table 2.14 Results from the best models for equation (1) when each environmental indicator is included in developed countries group: life expectancy

	LNLEXP											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0023	0.00	0.0027	0.00	0.0028	0.00	0.0024	0.00	0.0026	0.00	0.0025	0.00
Envi-indicator	-0.0037	0.00	-0.0782	0.27	-0.0005	0.01	-0.0088	0.07	-0.0004	0.74	-0.0031	0.25
Pop density	-0.0003	0.07	-0.0005	0.01	-0.0005	0.00	-0.0004	0.01	-0.0004	0.02	-0.0004	0.02
Urban pop	-0.0022	0.22	-0.0042	0.03	-0.0045	0.01	-0.0032	0.09	-0.004	0.04	-0.0035	0.07
Physician	0.0206	0.00	0.0212	0.00	0.0141	0.01	0.0194	0.00	0.0195	0.00	0.0185	0.00
Government	0.0169	0.00	0.0196	0.00	0.0149	0.02	0.02	0.00	0.0201	0.00	0.0159	0.03
Safe Water	-0.0015	0.48	-0.0012	0.59	-0.003	0.20	-0.0007	0.76	-0.0006	0.80	-0.0018	0.46
Sanitation	0.0097	0.00	0.0102	0.00	0.0102	0.00	0.0089	0.00	0.0093	0.01	0.0093	0.00
Temperature	-0.0017	0.38	-0.0025	0.25	-0.0017	0.41	-0.0021	0.32	-0.0028	0.21	-0.0017	0.47
Rainfall	-0.0135	0.62	-0.0055	0.86	-0.0209	0.46	-0.0111	0.70	-0.0088	0.77	-0.0068	0.82
Constant	3.6469	0.00	3.7061	0.00	3.9491	0.00	3.7181	0.00	3.718	0.00	3.8091	0.00
R-squared	0.91		0.89		0.90		0.89		0.88		0.89	
N	66		66		66		66		66		66	

*the fixed effects specification without time dummies is used for all environmental cases

Table 2.15 Results from the best models for equation (1) when each environmental indicator is included in developed countries group: infant mortality rate

	LNIMR											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	-0.0315	0.01	-0.0301	0.00	-0.0398	0.00	-0.0292	0.00	-0.0296	0.00	-0.0258	0.00
Envi-indicator	0.0564	0.05	0.6653	0.63	0.0102	0.01	-0.009	0.82	-0.0022	0.81	0.052	0.07
Pop density	0.0042	0.23	-0.0001	0.89	0.0082	0.02	-0.0003	0.73	-0.0002	0.79	-0.0002	0.76
Urban pop	0.0221	0.58	0.0037	0.45	0.0609	0.10	0.0046	0.41	0.0043	0.38	0.0018	0.71
Physician	-0.4041	0.00	-0.2310	0.00	-0.27	0.03	-0.2383	0.00	-0.2252	0.00	-0.2434	0.00
Government	-0.3366	0.01	-0.1707	0.09	-0.2756	0.04	-0.1725	0.09	-0.1653	0.11	-0.1591	0.11
Safe Water	-0.0342	0.47	-0.083	0.02	0.001	0.98	-0.0842	0.02	-0.0844	0.02	-0.0749	0.04
Sanitation	-0.1309	0.04	-0.0205	0.39	-0.1414	0.02	-0.0197	0.41	-0.0191	0.42	-0.0215	0.35
Temperature	0.1083	0.02	-0.0027	0.77	0.1006	0.03	-0.0009	0.93	-0.0021	0.81	0.0046	0.63
Rainfall	0.4259	0.49	-0.1114	0.44	0.6128	0.31	-0.1118	0.46	-0.1237	0.38	-0.1857	0.20
Constant	16.4184	0.00	13.4142	0.00	10.4672	0.02	13.4438	0.00	13.3935	0.00	12.58	0.00
R-squared	0.85		0.57		0.85		0.57		0.58		0.56	
N	66		66		66		66		66		66	

*the fixed effects specification without time dummies is used for co2

* the fixed effects specification with time dummies is used for PM

* the random effect with no time dummies is used for no2, ch4, FOREST, and bod

Table 2.16 Results from the best models for equation (1) when each environmental indicator is included in developed countries group: child mortality rate

	LNCMR											
	CO_2		NO_2		PM		CH4		FOREST		BOD	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	-0.036	0.00	-0.0309	0.00	-0.0433	0.00	-0.0384	0.00	-0.0300	0.00	-0.0265	0.00
Envi-indicator	0.0525	0.05	0.8577	0.51	0.0082	0.04	0.065	0.51	-0.0028	0.74	0.0467	0.08
Pop density	0.0045	0.18	-0.0001	0.93	0.008	0.01	0.0064	0.06	-0.0002	0.75	-0.0002	0.76
Urban pop	0.0368	0.32	0.0038	0.41	0.0716	0.05	0.0566	0.14	0.0044	0.33	0.0022	0.63
Physician	-0.3826	0.00	-0.2400	0.00	-0.274	0.02	-0.3714	0.00	-0.2357	0.00	-0.2525	0.00
Government	-0.3285	0.01	-0.1608	0.09	-0.2857	0.02	-0.3739	0.00	-0.1549	0.10	-0.1511	0.10
Safe Water	-0.0517	0.24	-0.0824	0.02	-0.0246	0.60	-0.0616	0.19	-0.0825	0.02	-0.0755	0.02
Sanitation	-0.1234	0.03	-0.0197	0.37	-0.1317	0.02	-0.1168	0.06	-0.0191	0.38	-0.0202	0.35
Temperature	0.0892	0.04	0.0001	1.00	0.0853	0.05	0.1003	0.03	0.001	0.90	0.0069	0.43
Rainfall	0.3584	0.53	-0.0476	0.72	0.4983	0.39	0.3031	0.00	-0.0591	0.65	-0.12	0.36
Constant	16.7924	0.00	13.4064	0.00	11.879	0.01	15.8402	0.61	13.3321	0.00	12.6467	0.00
R-squared	0.87		0.59		0.87		0.85		0.60		0.59	
N	66		66		66		66		66		66	

*the fixed effects specification without time dummies is used for co2, PM and ch4

* the random effect with no time dummies is used for no2, FOREST, and BOD

relationship between per capita GDP and PM in developing countries, as well as CH4 and FOREST in developed countries is most likely explained by technological and structural factors.

In terms of investment in prevention, I find both access to safe water and sanitation increase with increasing per capita GDP. I also confirm the Preston Curve relationship, finding that per capita GDP has a strong influence on health status especially in the developing countries group.

The results from the full model show the marginal effects of environmental indicators on health status. In both developing and developed countries, I found a consistent and significant negative relationship between environmental indicators such as CO_2, PM and BOD and health status such as infant mortality rate and child mortality rate. However, the environmental indicators are significantly related with life expectancy only in the developed countries. In this model, per capita GDP has a smaller effect on health, perhaps due to the effects of environmental quality. I also find interesting differences in the relationship between population density and health status in developing countries vs. developed countries. These results help explain the different perceptions of urbanization in developing countries and developed countries. Overall, the different results for developing and developed countries are a reminder that policies must be appropriate to a country's level of development.

Although decreased infant and child mortality rate can be obtained through increasing per capita GDP, higher GDP is also likely to lead to higher levels of CO_2, PM and BOD, which in turn are followed by increases in infant and child mortality rate. Hence, the impact of an increase in income on reduction in infant and child mortality rate appears to be partly absorbed by air and water pollution indicators. This study points out that policies in economic development, environment and health are clearly interdependent, and better coordination could lead to a sustainable development. Integrating environmental protection into economic development plans is a must, including policies such as effluent taxes on pollutants, natural resource management. Tax on pollutants could not only reduce pollutants and its direct effects like health damage, but government can use the revenue to support environmentally friendly technology or even expand a country’s economy. Finally, since this study represents just an exploration of the interrelationships between economics, environment and health, more detailed empirical work to evaluate specific policies should be considered in future study.

2.7. References

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2.8 Appendix

2.8.1 Appendix 2.1 Countries included in the study

Albania	Cyprus	Jamaica	Spain
Argentina	Czech Republic	Japan	St. Kitts and Nevis
Australia	Denmark	Kenya	St. Lucia
Austria	Ecuador	Latvia	Sweden
Bangladesh	Egypt, Arab Rep.	Malaysia	Switzerland
Belize	El Salvador	Mauritius	Thailand
Bolivia	Finland	Mexico	Trinidad and Tobago
Brazil	France	Moldova	Tunisia
Bulgaria	Germany	Mozambique	Turkey
Burundi	Greece	Nepal	Ukraine
Canada	Grenada	New Zealand	United Kingdom
Chile	Guatemala	Norway	United States
China	Hungary	Panama	Uruguay
Colombia	Iceland	Portugal	Venezuela, RB
Costa Rica	Indonesia	Romania	Zambia
Croatia	Israel	Senegal	

2.8.2 Appendix 2.2 Results for equation (1) when all environmental indicators and all countries are included

	Lnlexp		Lnimr		Lncmr	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0019	0.03	-0.0392	0.00	-0.0393	0.00
Per capita CO_2	-0.0048	0.05	0.0364	0.02	0.037	0.02
Per capita NO_2	-0.3418	0.09	0.9775	0.45	0.9985	0.44
Particulate Matter	0.0002	0.26	0.0007	0.54	0.0011	0.33
Per capita CH_4	0.0187	0.06	-0.0626	0.33	-0.0639	0.33
Change in Forest Area	-0.0005	0.57	0.0025	0.66	0.0013	0.82
BOD	-0.0018	0.57	0.0516	0.01	0.0474	0.02
Population Density	0.0006	0	-0.0012	0.14	-0.0013	0.13
Urban Population	0.0051	0	-0.0154	0.03	-0.0179	0.01
Physician	0.0192	0.02	-0.1415	0.01	-0.1498	0.01
Government Effective	-0.0109	0.18	-0.0377	0.47	-0.049	0.35
Safe Safe water	3.90E-05	0.97	-0.0055	0.44	-0.0079	0.27
Sanitation	0.0005	0.58	-0.0173	0.01	-0.0171	0.01
Temperatureetature	0.0073	0.12	0.0093	0.76	-0.0009	0.98
Rainfall	0.0024	0.93	0.1071	0.52	0.0934	0.58
Constant	3.6644	0	5.8678	0.00	6.6518	0.00
R-squared	0.54		0.75		0.76	
N	189		189		189	

2.8.3 Appendix 2.3 Results for equation (1) when all environmental indicators are included : life expectancy in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0029	0.52	0.0019	0.70	0.0091	0.01	0.0121	0.01	0.0077	0.02	0.0102	0.01
Per Capita CO_2	0.0092	0.00	0.0098	0.00	-0.0101	0.02	-0.0116	0.01	-0.0002	0.95	-0.0013	0.72
Per Capita NO_2	-0.9923	0.04	-1.1227	0.03	-1.062	0.01	-0.9433	0.03	-0.4777	0.14	-0.3797	0.28
Particulate Matter	-0.0003	0.14	-0.0003	0.16	0.0004	0.13	0.0002	0.40	-0.0001	0.58	-0.0002	0.30
Per Capita CH_4	-0.0094	0.33	-0.0091	0.35	0.0469	0.01	0.0448	0.01	0.0076	0.52	0.0065	0.59
Change in Forest Area	0.005	0.00	0.005	0.00	-0.0001	0.93	-0.0001	0.93	0.0007	0.53	0.0007	0.53
BOD	-0.0009	0.87	-0.0002	0.98	-0.0004	0.93	-0.0019	0.66	0.0036	0.38	0.0019	0.66
Population Density	-0.0001	0.16	-0.0001	0.14	0.0006	0.00	0.0007	0.00	0.0001	0.26	0.0001	0.14
Urban Population	0.0018	0.00	0.0018	0.00	0.0055	0.00	0.0058	0.00	0.0019	0.01	0.002	0.01
Physician	-0.0075	0.51	-0.0085	0.46	0.0218	0.07	0.0185	0.14	0.0056	0.60	0.0043	0.69
Government Effective	-0.0021	0.90	-0.0019	0.91	-0.0191	0.09	-0.0168	0.14	-0.0083	0.46	-0.0088	0.43
Safe Safe water	0.0039	0.00	0.0038	0.00	-0.0003	0.81	0.0006	0.70	0.0026	0.01	0.003	0.00
Sanitation	0.0003	0.55	0.0003	0.55	0.0002	0.87	0.0004	0.76	0.0007	0.31	0.0006	0.39
Temperatureerature	-0.0031	0.03	-0.0031	0.03	0.0064	0.47	0.0067	0.45	-0.0013	0.56	-0.0011	0.61
Rainfall	0.0533	0.00	0.0543	0.00	0.0083	0.79	0.0061	0.85	0.0259	0.14	0.02	0.27
Year 1995 dummy			-0.0041	0.78			-0.0107	0.18			-0.0085	0.22
Year 2000 dummy			0.0088	0.61			-0.0178	0.20			-0.0132	0.19
constant	3.7757	0.00	3.7754	0.00	3.6131	0.00	3.5164	0.00	3.7622	0.00	3.7434	0.00
R-squared	0.8		0.8		0.57		0.58		0.72		0.72	
N	123		123		123		123		123		123	
Hausman					7.95	0.89						
F-test for time dummies			0.35	0.71			0.97	0.38			1.90	0.39
F-test for individual effect					21.42	0.00	21.3	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.4 Appendix 2.4 Results for equation (1) when all environmental indicators are included : infant mortality rate in developing countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0396	0.03	-0.0204	0.27	-0.088	0.00	-0.0656	0.00	-0.0797	0.00	-0.058	0.00
Per Capita CO_2	0.0088	0.49	-0.0004	0.97	0.0676	0.00	0.0533	0.01	0.036	0.01	0.0245	0.10
Per Capita NO_2	-1.0885	0.57	0.8476	0.67	1.8874	0.32	3.3192	0.10	-1.1303	0.43	0.1168	0.94
Particulate Matter	0.0015	0.05	0.0012	0.13	-0.0005	0.66	-0.0013	0.26	0.0016	0.05	0.0008	0.33
Per Capita CH_4	0.0554	0.16	0.0511	0.18	-0.1458	0.08	-0.1666	0.04	0.0143	0.77	0.0052	0.92
Change in Forest Area	-0.0037	0.48	-0.0027	0.59	0.0031	0.56	0.003	0.57	-0.001	0.84	-0.0008	0.86
BOD	-0.0447	0.07	-0.0685	0.01	0.0382	0.06	0.0332	0.10	0.0046	0.80	-0.0067	0.72
Population Density	0.0003	0.10	0.0004	0.02	-0.0016	0.03	-0.0012	0.13	-0.0001	0.80	0.0001	0.63
Urban Population	0.0018	0.39	0.0005	0.79	-0.0131	0.05	-0.0123	0.06	0.0002	0.96	0.0001	0.99
Physician	-0.1304	0.01	-0.1083	0.02	-0.0386	0.49	-0.0587	0.30	-0.0538	0.24	-0.0578	0.20
Government Effective	-0.2766	0.00	-0.2806	0.00	-0.0044	0.93	0.0163	0.75	-0.0613	0.22	-0.0626	0.20
Safe Safe water	-0.0096	0.00	-0.0091	0.00	-0.0034	0.58	0.0029	0.67	-0.0128	0.00	-0.0098	0.02
Sanitation	-0.0072	0.00	-0.0075	0.00	-0.0167	0.01	-0.0157	0.01	-0.0102	0.00	-0.0112	0.00
Temperatureerature	0.0088	0.12	0.0088	0.11	-0.0345	0.40	-0.0303	0.45	0.0125	0.16	0.0142	0.10
Rainfall	-0.1427	0.00	-0.1605	0.00	0.0688	0.64	0.0303	0.84	-0.0449	0.52	-0.0941	0.18
Year 1995 dummy			-0.0982	0.09			-0.0393	0.28			-0.0431	0.15
Year 2000 dummy			-0.2115	0.00			-0.1175	0.06			-0.1112	0.01
constant	4.9106	0.00	5.0057	0.00	6.7401	0.00	6.0874	0.00	5.294	0.00	5.1683	0.00
R-squared	0.88				0.78		0.79		0.81		0.83	
N	123		123		123		123		123		123	
Hausman					33.6	0.00						
F-test for time dummies			5.06	0.01			2.11	0.13	0.13		6.93	0.03
F-test for individual effect					16.08	0.00	15.11	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.5 Appendix 2.5 Results for equation (1) when all environmental indicators are included: child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0441	0.02	-0.025	0.20	-0.0805	0.00	-0.0523	0.02	-0.0749	0.00	-0.0502	0.00
Per Capita CO_2	0.0039	0.77	-0.0052	0.70	0.0607	0.01	0.0437	0.05	0.0284	0.07	0.016	0.32
Per Capita NO_2	-1.0996	0.59	0.791	0.70	1.8677	0.37	3.4834	0.11	-1.1385	0.46	0.1792	0.91
Particulate Matter	0.0019	0.02	0.0015	0.06	0.0001	0.91	-0.0009	0.46	0.0021	0.02	0.0012	0.19
Per Capita CH_4	0.0453	0.27	0.0411	0.31	-0.144	0.11	-0.1682	0.06	0.0116	0.83	0.0022	0.97
Change in Forest Area	-0.0079	0.15	-0.0069	0.19	0.0019	0.74	0.0018	0.76	-0.0029	0.57	-0.0027	0.60
BOD	-0.0417	0.10	-0.0657	0.01	0.0369	0.09	0.0287	0.20	0.0051	0.79	-0.0092	0.64
Population Density	0.0002	0.22	0.0004	0.06	-0.0016	0.05	-0.0011	0.22	-0.0001	0.62	0.0001	0.76
Urban Population	0.0012	0.57	0	1.00	-0.0172	0.02	-0.0159	0.03	-0.0011	0.71	-0.0012	0.68
Physician	-0.1217	0.01	-0.0997	0.04	-0.0446	0.47	-0.0713	0.25	-0.0528	0.28	-0.0572	0.23
Government Effective	-0.2737	0.00	-0.2777	0.00	-0.0226	0.69	0.0019	0.97	-0.0799	0.14	-0.0826	0.11
Safe Safe water	-0.0108	0.00	-0.0103	0.00	-0.0051	0.46	0.0029	0.70	-0.0146	0.00	-0.0113	0.01
Sanitation	-0.0091	0.00	-0.0093	0.00	-0.0173	0.01	-0.016	0.01	-0.0118	0.00	-0.0129	0.00
Temperatureerature	0.0149	0.01	0.0148	0.01	-0.0236	0.60	-0.019	0.67	0.017	0.07	0.0187	0.04
Rainfall	-0.1835	0.00	-0.2011	0.00	0.0674	0.68	0.0262	0.87	-0.0759	0.30	-0.1298	0.08
Year 1995 dummy			-0.1059	0.09			-0.0616	0.13			-0.0582	0.07
Year 2000 dummy			-0.2116	0.00			-0.1513	0.03			-0.1287	0.01
constant	5.3644	0.00	5.463	0.00	7.1038	0.00	6.268	0.00	5.802	0.00	5.6731	0.00
R-squared	0.89		0.9		0.77		0.78		0.85		0.86	
N	123		123		123		123		123		123	
Hausman					11.76	0.00						
F-test for time dummies			4.6	0.01			2.53	0.09	2.53		8.01	0.02
F-test for individual effect					14.12	0.00	13.56	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.6 Appendix 2.6 Results for equation (1) when all environmental indicators are included : life expectancy in developed countries group

Lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Per capita GDP	0.0027	0.00	0.0023	0.02	0.0021	0.00	-0.0005	0.37	0.0018	0.00	-0.0003	0.57
Per Capita CO_2	-0.0022	0.05	-0.0019	0.12	-0.0028	0.10	-0.0024	0.04	-0.0017	0.15	-0.0016	0.10
Per Capita NO_2	0.2025	0.20	0.1832	0.28	0.0515	0.55	0.0142	0.80	0.0386	0.62	0.0229	0.71
Particulate Matter	0.0004	0.11	0.0004	0.10	-0.0002	0.50	-3.72E-0.5	0.81	-0.0001	0.62	-3.7E-0.5	0.81
Per Capita CH_4	0.0021	0.54	0.0017	0.63	-0.0096	0.11	-0.0047	0.23	-0.0043	0.26	-0.0042	0.23
Change in Forest Area	0.0014	0.01	0.0014	0.02	-0.0005	0.63	0.0011	0.16	-0.0007	0.42	-0.0001	0.91
BOD	-0.0092	0.00	-0.0093	0.00	-0.0015	0.56	0.0009	0.60	-0.0044	0.04	-0.0013	0.50
Population Density	-2.00E-05	0.65	-2.50E-05	0.58	-0.0003	0.19	-0.0002	0.12	-3.40E-05	0.58	-2.10E-05	0.73
Urban Population	-0.0001	0.76	-0.0001	0.81	-0.0015	0.50	-0.0007	0.62	0.0007	0.20	0.0008	0.14
Physician	-0.0017	0.76	-0.0018	0.75	0.0151	0.03	0.0054	0.25	0.0099	0.05	0.002	0.67
Government Effective	0.0032	0.72	0.0057	0.57	0.0139	0.05	0.0076	0.11	0.0096	0.09	0.0064	0.16
Safe Safe water	0.0114	0.00	0.0114	0.00	-0.0017	0.49	-0.0041	0.02	0.0012	0.59	-0.0015	0.37
Sanitation	-0.0021	0.13	-0.0022	0.12	0.0082	0.01	0.0063	0.00	0.0022	0.21	0.0023	0.11
Temperature	-0.0001	0.92	-0.0001	0.90	-0.0002	0.92	-0.0018	0.29	0.0013	0.15	0.0004	0.66
Rainfall	0.0279	0.03	0.0298	0.02	-0.0223	0.43	-0.0246	0.21	0.0141	0.34	0.0053	0.70
Year 1995 dummy			0.0018	0.00			0.0126	0.00			0.0111	0.00
Year 2000 dummy			0.0047	0.56			0.0331	0.00			0.0274	0.00
constant	3.3843	0.00	3.3876	0.00	3.811	0.00	4.2268	0.00	3.9046	0.00	4.1957	0.00
R-squared	0.78		0.78		0.92		0.97		0.46		0.18	
N	66		66		66		66		66		66	
Hausman					16.08	0.00						
F-test for time dummies			0.17	0.84			22.11	0.00			23.6	0.00
F-test for individual effect					19.57	0.00	49.78	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.7 Appendix 2.7 Results for equation (1) when all environmental indicators are included: infant mortality rate in developed countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0396	0.03	-0.0204	0.27	-0.088	0.00	-0.0656	0.00	-0.0797	0.00	-0.058	0.00
Per Capita CO_2	0.0088	0.49	-0.0004	0.97	0.0676	0.00	0.0533	0.01	0.036	0.01	0.0245	0.10
Per Capita NO_2	-1.0885	0.57	0.8476	0.67	1.8874	0.32	3.3192	0.10	-1.1303	0.43	0.1168	0.94
Particulate Matter	0.0015	0.05	0.0012	0.13	-0.0005	0.66	-0.0013	0.26	0.0016	0.05	0.0008	0.33
Per Capita CH_4	0.0554	0.16	0.0511	0.18	-0.1458	0.08	-0.1666	0.04	0.0143	0.77	0.0052	0.92
Change in Forest Area	-0.0037	0.48	-0.0027	0.59	0.0031	0.56	0.003	0.57	-0.001	0.84	-0.0008	0.86
BOD	-0.0447	0.07	-0.0685	0.01	0.0382	0.06	0.0332	0.10	0.0046	0.80	-0.0067	0.72
Population Density	0.0003	0.10	0.0004	0.02	-0.0016	0.03	-0.0012	0.13	-0.0001	0.80	0.0001	0.63
Urban Population	0.0018	0.39	0.0005	0.79	-0.0131	0.05	-0.0123	0.06	0.0002	0.96	0.0001	0.99
Physician	-0.1304	0.01	-0.1083	0.02	-0.0386	0.49	-0.0587	0.30	-0.0538	0.24	-0.0578	0.20
Government Effective	-0.2766	0.00	-0.2806	0.00	-0.0044	0.93	0.0163	0.75	-0.0613	0.22	-0.0626	0.20
Safe Safe water	-0.0096	0.00	-0.0091	0.00	-0.0034	0.58	0.0029	0.67	-0.0128	0.00	-0.0098	0.02
Sanitation	-0.0072	0.00	-0.0075	0.00	-0.0167	0.01	-0.0157	0.01	-0.0102	0.00	-0.0112	0.00
Temperatureerature	0.0088	0.12	0.0088	0.11	-0.0345	0.40	-0.0303	0.45	0.0125	0.16	0.0142	0.10
Rainfall	-0.1427	0.00	-0.1605	0.00	0.0688	0.64	0.0303	0.84	-0.0449	0.52	-0.0941	0.18
Year 1995 dummy			-0.0982	0.09			-0.0393	0.28			-0.0431	0.15
Year 2000 dummy			-0.2115	0.00			-0.1175	0.06			-0.1112	0.01
constant	4.9106	0.00	5.0057	0.00	6.7401	0.00	6.0874	0.00	5.294	0.00	5.1683	0.00
R-squared	0.88				0.78		0.79		0.81		0.83	
N	123		123		123		123		123		123	
Hausman					33.6	0.00						
F-test for time dummies			5.06	0.01			2.11	0.13	0.13		6.93	0.03
F-test for individual effect					16.08	0.00	15.11	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.8 Appendix 2.8 Results for equation (1) when all environmental indicators are included: child mortality rate in developed countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0296	0.00	-0.0043	0.64	-0.042	0.00	-0.0035	0.82	-0.0325	0.00	-0.0022	0.79
Per Capita CO_2	0.0333	0.02	0.014	0.24	0.0225	0.54	0.0025	0.94	0.0243	0.14	0.0089	0.53
Per Capita NO_2	-2.1101	0.27	-1.2439	0.46	1.3768	0.47	1.3993	0.39	0.3621	0.81	-0.0512	0.97
Particulate Matter	0.0049	0.08	0.0028	0.22	0.0055	0.30	0.0049	0.28	0.0048	0.12	0.0027	0.29
Per Capita CH_4	-0.0165	0.70	0.0164	0.64	-0.0308	0.81	-0.0652	0.56	-0.0158	0.77	0.0283	0.55
Change in Forest Area	-0.0116	0.10	-0.01	0.08	-0.0049	0.84	-0.0246	0.27	-0.007	0.50	-0.0033	0.72
BOD	0.0225	0.34	0.0206	0.31	0.0092	0.87	-0.0581	0.26	0.0465	0.13	-0.0051	0.86
Population Density	-0.0004	0.49	0.0001	0.87	0.0069	0.11	0.0059	0.10	-0.0005	0.53	0.0002	0.82
Urban Population	0.0047	0.21	0.0029	0.35	0.0623	0.19	0.0572	0.16	0.0032	0.58	0	1.00
Physician	-0.0273	0.68	-0.0099	0.86	-0.3321	0.03	-0.1148	0.39	-0.1595	0.04	-0.0295	0.68
Government Effective	0.0905	0.40	-0.0836	0.40	-0.2723	0.07	-0.109	0.41	-0.0689	0.48	-0.096	0.22
Safe Safe water	-0.114	0.00	-0.1179	0.00	-0.0195	0.72	0.016	0.73	-0.0709	0.04	-0.0628	0.02
Sanitation	-0.0042	0.81	0.007	0.62	-0.1437	0.04	-0.1024	0.08	-0.0203	0.39	-0.0022	0.92
Temperature	0.0077	0.25	0.0081	0.14	0.0789	0.12	0.0534	0.29	0.0052	0.63	0.0064	0.52
Rainfall	0.0392	0.79	-0.1149	0.37	0.3928	0.53	0.0905	0.87	0.0823	0.67	-0.0625	0.71
Year 1995 dummy			-0.2234	0.00			-0.2905	0.00			-0.2438	0.00
Year 2000 dummy			-0.3763	0.00			-0.5423	0.00			-0.4188	0.00
constant	13.4534	0.00	13.0212	0.00	13.4746	0.02	6.1132	0.22	11.3956	0.00	8.7541	0.00
R-squared	0.72		0.82		0.88		0.91		0.65		0.77	
N	66		66		66		66		66		66	
Hausman					28.15	0.01						
F-test for time dummies			12.87				7.26	0.00			28.76	
F-test for individual effect					5.18	0.00	4.83	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.9 Appendix 2.9 Results for equation (2) EKC : CO_2 in developing countries group

CO_2	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	1.7782	0.01	1.6818	0.01	2.3456	0.00	3.387	0.00	2.0012	0.00	2.3909	0.00
Per capita GDP^2	-0.3236	0.03	-0.3082	0.04	-0.3323	0.00	-0.4184	0.00	-0.2861	0.00	-0.2969	0.00
Per capita GDP^3	0.0227	0.02	0.0227	0.02	0.0171	0.00	0.0206	0.00	0.0154	0.00	0.0156	0.00
Year 1995 dummy			-0.3601	0.52			-0.6125	0.00			-0.503	0.00
Year 2000 dummy			-1.2733	0.03			-1.4139	0.00			-1.1984	0.00
Constant	-0.8252	0.31	-0.2623	0.77	-2.0403	0.07	-4.3603	0.00	-1.4293	0.11	-2.3695	0.01
R-squared	0.35		0.38		0.33		0.59		0.3		0.32	
N	123		123		123		123		123		123	
Hausman					11.13	0.00						
F-test for time dummies			2.59	0.08			24.82	0.00			37.64	0.00
F-test for individual effect					25.08	0.00	39.6	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.10 Appendix 2.10 Results for equation (2) EKC : NO_2 in developing countries group

NO_2	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0008	0.67	0.0014	0.46	0.0115	0.00	0.0127	0.00	0.0026	0.22	0.0033	0.11
Per capita GDP^2	0	0.84	0	0.81	-0.0006	0.03	-0.0007	0.01	0	0.84	-0.0002	0.38
Year 1995 dummy			-0.0021	0.56			-0.0052	0.04			-0.0026	0.26
Year 2000 dummy			0.0055	0.15			-0.0002	0.95			0.0046	0.08
Constant	0.0149	0.00	0.0134	0.00	-0.0163	0.08	-0.0171	0.09	0.0088	0.11	0.0083	0.12
R-squared	0.04		0.07		0.22		0.28		0.04		0.06	
N	123		123		123		123		123		123	
Hausman					11.42	0.00						
F-test for time dummies			2.15	0.12			3.41	0.04			8.72	0.01
F-test for individual effect					5.71	0.00	5.93					
Time Dummies	N		Y		N		Y		N		Y	

2.8.11 Appendix 2.11 Results for equation (2) EKC : PM in developing countries group

PM	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-14.0112	0.01	-15.2024	0.00	-4.5814	0.00	7.3554	0.10	-7.8638	0.06	-0.281	0.94
Per capita GDP^2	0.9522	0.05	1.1495	0.02			-0.342	0.27	0.2651	0.42	0.0961	0.73
Year 1995 dummy			-11.1057	0.26			-15.7414	0.00			-13.7309	0.00
Year 2000 dummy			-20.1594	0.05			-27.0567	0.00			-23.3859	0.00
Constant	105.3157	0.00	115.6095	0.00	89.2341	0.00	58.9506	0.00	96.6899	0.00	79.4093	0.00
R-squared	0.11		0.14		0.11		0.49		0.09		0.03	
N	123		123		123		123		123		123	
Hausman					0.04	0.95						
F-test for time dummies			1.94	0.15			28.75	0.00			47.1	0.00
F-test for individual effect					23.94	0.00	38.86	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.12 Appendix 2.12 Results for equation (2) EKC : CH_4 in developing countries group

CH_4	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.2068	0.06	0.1996	0.08	0.4472	0.03	0.5641	0.01	0.4367	0.01	0.4739	0.01
Per capita GDP^2	-0.0094	0.39	-0.0081	0.47	-0.067	0.05	-0.0748	0.03	-0.0639	0.03	-0.062	0.04
Per capita GDP^3							0.0036	0.04			0.003	0.06
Year 1995 dummy			-0.1432	0.52	0.4337	0.23	-0.1347	0.04	0.4314	0.18	-0.1286	0.04
Year 2000 dummy			-0.1644	0.48	0.0034	0.06	-0.1683	0.04	0.0032	0.05	-0.1544	0.04
Constant	0.5849	0.02	0.6829	0.02			0.1802	0.63			0.3426	0.29
R-squared	0.09		0.1		0.09		0.15		0.09		0.1	
N	123		123		123		123		123		123	
Hausman					0.61	0.89						
F-test for time dummies			0.31	0.73			2.77	0.07			5.57	0.07
F-test for individual effect					38.73	0.00	40.38	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.13 Appendix 2.13 Results for equation (2) EKC : change in forest area in developing countries group

Forest	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	5.0851	0.01	5.0202	0.01	1.3331	0.47	1.6548	0.40	3.0762	0.03	3.1413	0.03
Per capita GDP^2	-0.8742	0.03	-0.8616	0.03	-0.2972	0.33	-0.3211	0.30	-0.5386	0.03	-0.5218	0.04
Per capita GDP^3			0.0436	0.08			0.0169	0.30	-4.7904	0.05	0.0259	0.06
Year 1995 dummy	-7.9213	0.00	-0.3436	0.82	-1.5119	0.64	-0.2836	0.63			-0.4065	0.47
Year 2000 dummy	0.044	0.07	-0.6418	0.68	0.0161	0.31	-0.4505	0.55			-0.7137	0.28
Constant			-7.5735	0.00			-2.2184	0.52	0.0268	0.05	-4.9965	0.04
R-squared	0.09		0.1		0.09		0.15		0.09		0.1	
N	123		123		123		123		123		123	
Hausman					2.12	0.55						
F-test for time dummies			0.09	0.92			0.15	0.86			1.19	0.55
F-test for individual effect					20.19	0.00	19.75	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.14 Appendix 2.14 Results for equation (2) EKC : BOD in developing countries group

BOD	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.5755	0.00	0.537	0.00	0.269	0.28	0.746	0.00	0.533	0.00	0.6145	0.00
Per capita GDP^2	-0.0342	0.03	-0.0273	0.07	-0.0222	0.23	-0.0409	0.02	-0.0372	0.01	-0.0332	0.01
Year 1995 dummy			-0.611	0.05			-0.6557	0.00			-0.622	0.00
Year 2000 dummy			-0.7954	0.01			-0.8644	0.00			-0.804	0.00
Constant	0.3316	0.34	0.7839	0.04	1.3864	0.04	0.2539	0.69	0.6105	0.17	0.6036	0.15
R-squared	0.22		0.26		0.02		0.24		0.21		0.26	
N	123		123		123		123		123		123	
Hausman					3.4	0.18						
F-test for time dummies			3.56	0.03			11.63	0.00			26.82	0.00
F-test for individual effect					8.95	0.00	11.12	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.15 Appendix 2.15 Results for equation (2) EKC : CO2 in developed countries group

CO_2	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.3505	0.42	0.3532	0.43	0.1278	0.39	0.6921	0.01	0.1472	0.30	0.6341	0.00
Per capita GDP^2	-0.0043	0.67	-0.0028	0.79	-0.0021	0.51	-0.0093	0.02	-0.0024	0.44	-0.0085	0.02
Year 1995 dummy			-0.9325	0.44			-1.2121	0.01			-1.1266	0.00
Year 2000 dummy			-1.7672	0.22			-2.2214	0.02			-2.026	0.01
Constant	3.9964	0.37	4.1738	0.36	7.5178	0.00	0.4585	0.89	7.2612	0.00	1.1903	0.67
R-squared	0.07		0.1		0.04		0.2		0.07		0.09	
N	66		66		66		66		66		66	
Hausman					0.95	0.62						
F-test for time dummies			0.79	0.45			3.82	0.03			8.92	0.01
F-test for individual effect					61.3		68.1					
Time Dummies	N		Y		N		Y		N		Y	

2.8.16 Appendix 2.16 Results for equation (2) EKC : NO2 in developed countries group

NO_2	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0048	0.11	0.0053	0.08	0.0045	0.06	0.0093	0.03	0.0044	0.04	0.0056	0.03
Per capita GDP^2	-0.0001	0.20	-0.0001	0.15	-0.0001	0.14	-0.0001	0.03	-0.0001	0.10	-0.0001	0.04
Year 1995 dummy			-0.0063	0.44			-0.014	0.06			-0.008	0.10
Year 2000 dummy			0.0024	0.81			-0.0167	0.26			-0.0024	0.77
Constant	-0.0117	0.70	-0.0143	0.64	-0.0131	0.62	-0.0696	0.19	-0.0112	0.64	-0.0209	0.47
R-squared	0.08		0.1		0.15		0.25		0.08		0.09	
N	66		66		66		66		66		66	
Hausman					0.22	0.89						
F-test for time dummies			0.58	0.56			2.6	0.08			4.12	0.13
F-test for individual effect					9.41		10.45					
Time Dummies	N		Y		N		Y		N		Y	

2.8.17 Appendix 2.17 Results for equation (2) EKC : PM in developed countries group

PM	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-4.108	0.01	-3.9617	0.01	-4.0853	0.00	-0.8507	0.62	-4.1487	0.00	-3.2167	0.01
Per capita GDP^2	0.0683	0.06	0.0634	0.09	0.0726	0.00	0.0309	0.25	0.0733	0.00	0.0606	0.00
Year 1995 dummy			-1.3447	0.75			-7.0294	0.02			-3.2713	0.13
Year 2000 dummy			1.2378	0.81			-12.6831	0.04			-3.8634	0.32
Constant	84.6345	0.00	83.8843	0.00	82.2378	0.00	41.854	0.05	83.1873	0.00	72.3823	0.00
R-squared	0.27		0.28		0.41		0.48		0.27		0.25	
N	66		66		66		66		66		66	
Hausman					0.24	0.89						
F-test for time dummies			0.16	0.85			2.94	0.06			2.29	0.31
F-test for individual effect					16.39		18.08					
Time Dummies	N		Y		N		Y		N		Y	

2.8.18 Appendix 2.18 Results for equation (2) EKC : CH4 in developed countries group

CH4	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0014	0.97	0.0072	0.17	-0.0172	0.01	0.0061	0.75	-0.017	0.01	0.0061	0.74
Per capita GDP2												
Year 1995 dummy			-0.0684	0.12			-0.0684	0.90				
Year 2000 dummy			-0.2246	0.35			-0.2246	0.73				
Constant	1.7537	0.02	1.6758	2.07	2.0738	0.00	1.6758	0.04	2.0703	0.00	1.6939	0.00
R-squared	0.01		0.01		0.14		0.18		0.01		0.01	
N	66		66		66		66		66		66	
Hausman					0.03	0.86						
F-test for time dummies			0.06	0.97			0.89	0.42			1.92	0.38
F-test for individual effect					244.05	0.00	234.04					
Time Dummies	N		Y		N		Y		N		Y	

2.8.19 Appendix 2.19 Results for equation (2) EKC : change in forest area in developed countries group

forest	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0693	0.50	-0.0522	0.68	-0.0842	0.01	0.0787	0.34	-0.0838	0.00	0.0622	0.42
Per capita GDP2												
Year 1995 dummy			-0.2049	0.90			-0.6007	0.10			-0.5507	0.11
Year 2000 dummy			-0.4548	0.81			-1.5303	0.04			-1.3945	0.04
Constant	4.5771	0.04	4.4505	0.81	4.8802	0.00	2.2839	0.10	4.8722	0.00	2.5574	0.13
R-squared	0.01		0.01		0.16		0.24		0.01		0.01	
N	66		66		66		66		66		66	
Hausman					0.01	0.94						
F-test for time dummies			0.03	0.97			2.25	0.12			4.22	0.12
F-test for individual effect					99.67	0.00	105.59	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.20 Appendix 2.20 Results for equation (2) EKC : BOD in developed countries group

BOD	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0813	0.66	-0.066	0.72	-0.1753	0.03	0.289	0.01	-0.1568	0.05	0.2151	0.02
Per capita GDP2	0.0022	0.60	0.0029	0.51	0.0026	0.14	-0.0036	0.04	0.0023	0.17	-0.0026	0.08
Year 1995 dummy			-0.7908	0.11			-1.1224	0.00			-1.0121	0.00
Year 2000 dummy			-1.1543	0.05			-1.7513	0.00			-1.4979	0.00
Constant	5.2328	0.01	5.2918	0.01	6.9867	0.00	1.3016	0.34	6.7348	0.00	2.2373	0.06
R-squared	0.01		0.07		0.27		0.62		0.01		0.05	
N	66		66		66		66		66		66	
Hausman					1.14	0.56						
F-test for time dummies			2.22	0.12			19.16	0.00			39.29	0.00
F-test for individual effect					35.29		62.92					
Time Dummies	N		Y		N		Y		N		Y	

2.8.21 Appendix 2.21 Results for equation (3) prevention : Safe water in developing countries group

Safe water	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	15.6826	0.00	15.7983	0.00	8.607	0.00	5.6759	0.00	11.232	0.00	9.3517	0.00
Per capita GDP2	-2.0296	0.00	-2.0523	0.00	-1.0808	0.00	-0.845	0.00	-1.4327	0.00	-1.2963	0.00
Per capita GDP3	0.087	0.01	0.0878	0.01	0.0459	0.01	0.0368	0.01	0.0611	0.00	0.056	0.00
Year 1995 dummy			0.6233	0.77			1.9581	0.00			1.5211	0.00
Year 2000 dummy			1.1206	0.61			4.0135	0.00			3.0804	0.00
Constant	54.1913	0.00	53.5749	0.00	67.9111	0.00	74.4155	0.00	62.8262	0.00	67.0176	0.00
R-squared	0.61		0.61		0,32		0.57		0.61		0.59	
N	123		123		123		123		123		123	
Hausman					7.8	0.05						
F-test for time dummies			0.13	0.87			22.04	0.00			24.8	0.00
F-test for individual effect					40.81	0.00	63.49	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.22 Appendix 2.22 Results for equation (3) prevention : Safe sanitation in developing countries group

Sanitation	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	25.0752	0.00	24.9027	0.00	4.3914	0.00	2.4968	0.01	6.5745	0.00	5.135	0.00
Per capita GDP2	-3.1639	0.00	-3.1328	0.00	-0.2355	0.00	-0.1764	0.01	-0.3739	0.00	-0.3231	0.00
Per capita GDP3	0.1386	0.01	0.1379	0.01	57.8627	0.00						
Year 1995 dummy			-0.8016	0.79			1.6594	0.01			0.9339	0.17
Year 2000 dummy			-1.9448	0.54			3.9757	0.00			2.6141	0.00
Constant	18.4552	0.00	19.4143	0.00			62.9216	0.00	51.8412	0.00	55.7639	0.00
R-squared	0.68		0.69		0.32		0.51		0.66		0.63	
N	123		123		123		123		123		123	
Hausman					16.44	0.00						
F-test for time dummies			0.19	0.83			15	0.00			10.05	0.01
F-test for individual effect					73.94		100.1					
Time Dummies	N		Y		N		Y		N		Y	

2.8.23 Appendix 2.23 Results for equation (3) prevention: Safe water in developed countries group

Safe Water	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.4427	0.00	0.4492	0.00	1.2516	0.00	1.024	0.00	1.2515	0.00	1.2389	0.00
Per capita GDP2	-0.0086	0.00	-0.0086	0.00	-0.0507	0.00	-0.0483	0.00	-0.0501	0.00	-0.0505	0.00
Per capita GDP3					0.0007	0.00	0.0007	0.00	0.0006	0.00	0.0007	0.00
Year 1995 dummy			-0.1956	0.52			0.3555	0.15			-0.006	0.97
Year 2000 dummy			-0.2145	0.55			1.0121	0.05			0.17	0.56
Constant	94.3352	0.00	94.331	0.00	89.7719	0.00	92.8037	0.00	89.6535	0.00	89.9398	0.00
R-squared	0.31		0.32		0.41		0.48		0.33			
N	66		66		66		66		66		66	
Hausman					0.84	0.66						
F-test for time dummies			0.26	0.77			2.32	0.11			0.77	0.68
F-test for individual effect					11.43		12.32					
Time Dummies	N		Y		N		Y		N		Y	

2.8.24 Appendix 2.24 Results for equation (3) prevention: Safe sanitation in developed countries group

Sanitation	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.271	0.27	0.2672	0.29	0.3058	0.00	0.4491	0.02	0.3113	0.00	0.4445	0.00
Per capita GDP2	-0.0038	0.50	-0.0031	0.61	-0.0059	0.01	-0.0078	0.01	-0.0059	0.00	-0.0076	0.00
Year 1995 dummy			-0.3216	0.64			-0.3332	0.30			-0.3355	0.19
Year 2000 dummy			-0.7374	0.36			-0.5483	0.40			-0.5611	0.25
Constant	95.3722	0.00	95.4674	0.00	95.5917	0.00	93.8247	0.00	95.5042	0.00	93.8592	0.00
R-squared	0.1		0.11		0.21		0.23		0.09		0.1	
N	66		66		66		66		66		66	
Hausman					0.62	0.73						
F-test for time dummies			0.43	0.65			0.58	0.57			1.71	0.43
F-test for individual effect					42.55		41.13					
Time Dummies	N		Y		N		Y		N		Y	

2.8.25 Appendix 2.25 Results for equation (4) preston curve : life expectancy rate in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.1904	0.00	0.1909	0.00	0.0359	0.00	0.0307	0.00	0.0613	0.00	0.062	0.00
Per capita GDP2	-0.0273	0.00	-0.0274	0.00	-0.0018	0.01	-0.0017	0.01	-0.0036	0.00	-0.0036	0.00
Per capita GDP3	0.0012	0.00	0.0012	0.00								
Year 1995 dummy			0.0018	0.91			0.0036	0.55			-0.0038	0.56
Year 2000 dummy			0.0062	0.69			0.0113	0.14			-0.0012	0.88
Constant	3.8485	0.00	3.8458	0.00	4.0844	0.00	4.0987	0.00	4.0175	0.00	4.0173	0.00
R-squared	0.76		0.76		0.31		0.33		0.68		0.68	
N	123		123		123		123		123		123	
Hausman					24.95	0.00						
F-test for time dummies			0.08	0.92			1.15	0.32			0.39	0.82
F-test for individual effect					23.4		23.46					
Time Dummies	N		Y		N		Y		N		Y	

2.8.26 Appendix 2.26 Results for equation (4) preston curve : infant mortality rate in developing countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.418	0.00	-0.4275	0.00	-0.2573	0.00	-0.1461	0.00	-0.3107	0.00	-0.2437	0.00
Per capita GDP2	0.0238	0.00	0.0253	0.00	0.0112	0.00	0.0078	0.00	0.0148	0.00	0.0133	0.00
Year 1995 dummy			-0.0284	0.75			-0.0937	0.00			-0.0674	0.01
Year 2000 dummy			-0.1269	0.17			-0.2355	0.00			-0.1869	0.00
Constant	4.6716	0.00	4.7253	0.00	4.2959	0.00	3.9967	0.00	4.4372	0.00	4.2599	0.00
R-squared	0.66		0.67		0.54		0.74		0.66		0.65	
N	123		123		123		123		123		123	
Hausman					5.21	0.07						
F-test for time dummies			1.05	0.35			29.01	0.00			36.7	0.00
F-test for individual effect					24.22		41.86					
Time Dummies	N		Y		N		Y		N		Y	

2.8.27 Appendix 2.27 Results for equation (4) preston curve : child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.4991	0.00	-0.5086	0.00	-0.2882	0.00	-0.1591	0.00	-0.3632	0.00	-0.2794	0.00
Per capita GDP2	0.0291	0.00	0.0306	0.00	0.0132	0.00	0.0091	0.00	0.0182	0.00	0.0159	0.00
Year 1995 dummy			-0.0333	0.73			-0.116	0.00			-0.0835	0.00
Year 2000 dummy			-0.1295	0.20			-0.2692	0.00			-0.2089	0.00
Constant	5.1348	0.00	5.1907	0.00	4.6244	0.00	4.2814	0.00	4.8244	0.00	4.6061	0.00
R-squared	0.69		0.7		0.53		0.74		0.69		0.68	
N	123		123		123		123		123		123	
Hausman					9.19	0.01						
F-test for time dummies			0.91	0.41			32.94	0.00			37.53	0.00
F-test for individual effect					23.66		43.5					
Time Dummies	N		Y		N		Y		N		Y	

2.8.28 Appendix 2.28 Results for equation (4) preston curve : life expectancy rate in developed countries group

Lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0337	0.00	0.0358	0.00	0.0078	0.00	-0.0008	0.57	0.0082	0.00	0.0026	0.05
Per capita GDP2	-0.0012	0.01	-0.0014	0.00	-0.0001	0.00	0	0.97	-0.0001	0.00	0	0.04
Per capita GDP3	0	0.02	0	0.01			0.0154	0.00			0.0105	0.00
Year 1995 dummy			0.0035	0.57			0.0356	0.00			0.0242	0.00
Year 2000 dummy			0.013	0.08			4.339	0.00			4.2969	0.00
Constant	4.0532	0.00	4.039	0.00	4.2287	0.00			4.2256	0.00		
R-squared	0.58		0.6		0.84		0.93		0.5		0.35	
N	66		66		66		66		66		66	
Hausman					1.97	0.37						
F-test for time dummies			1.74	1.80			29.41	0.00			29.27	0.00
F-test for individual effect					29.91		70.42					
Time Dummies	N		Y		N		Y		N		Y	

2.8.29 Appendix 2.29 Results for equation (4) preston curve : infinant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.1324	0.00	-0.1298	0.00	-0.1603	0.00	-0.0255	0.44	-0.1383	0.00	-0.087	0.00
Per capita GDP2	0.0023	0.00	0.0025	0.00	0.0024	0.00	0.0007	0.19	0.0021	0.00	0.0015	0.00
Year 1995 dummy			-0.1932	0.00			-0.3022	0.00			-0.2151	0.00
Year 2000 dummy			-0.3117	0.00			-0.5232	0.00			-0.3272	0.00
Constant	3.4684	0.00	3.4907	0.00	3.9637	0.00	2.2889	0.00	3.6537	0.00	3.0559	0.00
R-squared	0.57		0.68		0.78		0.87		0.56		0.67	
N	66		66		66		66		66		66	
Hausman					11.09	0.00						
F-test for time dummies			10.09	0.00			14.9	0.00			35.5	0.00
F-test for individual effect					6.94		9.26	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.30 Appendix 2.30 Results for equation (4) preston curve : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.117	0.00	-0.1151	0.00	-0.1591	0.00	-0.021	0.48	-0.1323	0.00	-0.0769	0.00
Per capita GDP2	0.0019	0.00	0.0022	0.00	0.0024	0.00	0.0006	0.21	0.002	0.00	0.0014	0.00
Year 1995 dummy			-0.1948	0.00			-0.2988	0.00			-0.2178	0.00
Year 2000 dummy			-0.334	0.00			-0.5426	0.00			-0.3586	0.00
Constant	3.5098	0.00	3.5375	0.00	4.1649	0.00	2.4388	0.00	3.8013	0.00	3.1402	0.00
R-squared	0.56		0.69		0.81		0.9		0.55		0.67	
N	66		66		66		66		66		66	
Hausman					24.37	0.00						
F-test for time dummies			12.61				17.52	0.00			44.96	0.00
F-test for individual effect					7.58	0.00	10.2	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.31 Appendix 2.31 Results for equation (1) when co2 is environmental indicator : life expectancy rate in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0016	0.73	0.0016	0.75	0.0058	0.07	0.0115	0.01	0.0059	0.04	0.0101	0.01
co2	0.0032	0.26	0.0032	0.27	-0.0037	0.23	-0.0079	0.04	0.0001	0.98	-0.0024	0.43
Pop density	-4.04E-05	0.36	-4.03E-05	0.36	0.0005	0.00	0.0007	0.00	0.0001	0.20	0.0001	0.09
Urban Pop	0.0014	0.00	0.0014	0.01	0.0042	0.00	0.0045	0.00	0.0021	0.00	0.0021	0.00
Physician	-0.0067	0.54	-0.0067	0.54	0.0147	0.21	0.0137	0.24	0.0052	0.61	0.0042	0.68
Gov Effective	0.0243	0.11	0.0243	0.12	-0.0195	0.08	-0.0176	0.11	-0.005	0.64	-0.0074	0.49
Safe water	0.0044	0.00	0.0044	0.00	0.0004	0.76	0.0016	0.25	0.0025	0.01	0.0029	0.00
Sanitation	0.0008	0.08	0.0008	0.09	-0.0005	0.64	-0.0002	0.87	0.001	0.12	0.001	0.16
Temperature	-0.0024	0.09	-0.0024	0.10	0.0092	0.27	0.0063	0.45	-0.0014	0.55	-0.0012	0.59
rainm	0.0317	0.00	0.0317	0.00	-0.0011	0.97	-0.0021	0.95	0.0231	0.18	0.0171	0.33
Year 1995 dummy			-0.002	0.90			-0.0118	0.09			-0.0075	0.21
Year 2000 dummy			-0.0004	0.98			-0.0231	0.05			-0.0142	0.09
Constant	3.6921	0.00	3.6927	0.00	3.7069	0.00	3.6016	0.00	3.7513	0.00	3.7185	0.00
R-squared	0.75		0.76		0.5		0.53		0.7		0.7	
N	123		123		123		123		123		123	
Hausman					26.23	0.00						
F-test for time dummies			0.01	0.99			2.03	0.14			3.00	0.22
F-test for individual effect					24.77	0.00	25.57	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.32 Appendix 2.32 Results for equation (1) when no2 is environmental indicator : life expectancy rate in developing countries group

Lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0058	0.15	0.0059	0.17	0.005	0.09	0.0064	0.06	0.0072	0.01	0.0092	0.00
nopp	-0.747	0.08	-0.7664	0.08	-0.2766	0.29	-0.295	0.28	-0.3352	0.19	-0.3146	0.23
Pop density	- 0.0001	0.20	-0.0001	0.21	0.0005	0.00	0.0006	0.00	0.0001	0.23	0.0001	0.15
Urban Pop	0.0012	0.01	0.0012	0.01	0.0043	0.00	0.0044	0.00	0.0021	0.00	0.0022	0.00
Physician	0.0004	0.97	0.0003	0.98	0.0145	0.22	0.0127	0.29	0.0076	0.45	0.0049	0.63
Gov Effective	0.0219	0.15	0.0217	0.16	-0.0216	0.06	-0.021	0.07	-0.0082	0.45	-0.0097	0.38
Safe water	0.0041	0.00	0.0041	0.00	0.0004	0.79	0.0008	0.56	0.0024	0.01	0.0028	0.00
Sanitation	0.0007	0.13	0.0007	0.14	-0.0002	0.83	0	1.00	0.001	0.14	0.0009	0.17
Temperature	- 0.0021	0.13	-0.0021	0.14	0.0075	0.38	0.0063	0.47	-0.0014	0.52	-0.0014	0.53
rainm	0.031	0.00	0.031	0.00	0.0044	0.89	0.006	0.86	0.025	0.14	0.0219	0.20
Year 1995 dummy			-0.005	0.74			-0.0062	0.34			-0.0069	0.24
Year 2000 dummy			-0.0006	0.97			-0.0082	0.40			-0.0097	0.19
Constant	3.7234	0.00	3.7254	0.00	3.7122	0.00	3.6661	0.00	3.7585	0.00	3.7297	0.00
R-squared	0.76		0.76		0.5		0.51		0.71		0.71	
N	123		123		123		123		123		123	
Hausman					22.91	0.01						
F-test for time dummies			0.06	0.93			0.49	0.62			2.03	0.36
F-test for individual effect					24.24		23.89					
Time Dummies	N		Y		N		Y		N		Y	

2.8.33 Appendix 2.33 Results for equation (1) when PM is environmental indicator : life expectancy rate in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0043	0.29	0.0046	0.28	0.0042	0.14	0.0059	0.08	0.006	0.02	0.0087	0.00
pm	2.10E-05	0.89	1.27E-05	0.94	0.0001	0.79	-0.0001	0.72	4.15E-06	0.98	-0.0002	0.32
Pop density	-4.17E-05	0.36	-4.00E-05	0.39	0.0005	0.00	0.0006	0.00	0.0001	0.20	0.0001	0.09
Urban Pop	0.0012	0.01	0.0012	0.01	0.0042	0.00	0.0044	0.00	0.0021	0.00	0.0022	0.00
Physician	-0.0035	0.74	-0.0035	0.75	0.0115	0.32	0.0087	0.47	0.0053	0.60	0.0026	0.79
Gov Effective	0.0234	0.13	0.0229	0.15	-0.0189	0.09	-0.0176	0.13	-0.005	0.64	-0.0064	0.55
Safe water	0.0043	0.00	0.0043	0.00	0.0004	0.74	0.0011	0.46	0.0025	0.01	0.0031	0.00
Sanitation	0.0009	0.08	0.0009	0.09	-0.0001	0.92	-2.64E-05	0.98	0.001	0.13	0.0008	0.27
Temperature	-0.0023	0.11	-0.0023	0.12	0.0092	0.29	0.0089	0.30	-0.0014	0.55	-0.001	0.66
rainm	0.0301	0.01	0.0298	0.01	0.0011	0.97	0.0005	0.99	0.0231	0.18	0.016	0.36
Year 1995 dummy			-0.0035	0.83			-0.0068	0.38			-0.0089	0.16
Year 2000 dummy			-0.0044	0.79			-0.0116	0.34			-0.0158	0.07
Constant	3.7002	0.00	3.7025	0.00	3.6703	0.00	3.612	0.00	3.7511	0.00	3.7255	0.00
R-squared	0.75		0.75		0.5		0.5		0.7		0.71	
N	123		123		123		123		123		123	
Hausman					22.91	0.01						
F-test for time dummies			0.04	0.96			0.49	0.62			3.33	0.19
F-test for individual effect					24.57		24.22					
Time Dummies	N		Y		N		Y		N		Y	

2.8.34 Appendix 2.34 Results for equation (1) when CH4 is environmental indicator : life expectancy rate in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0049	0.22	0.0054	0.21	0.0039	0.18	0.0055	0.11	0.0607	0.18	0.0086	0.01
CH4	-0.009	0.26	-0.0093	0.25	0.0032	0.75	0.0018	0.86	-0.0024	0.75	-0.0047	0.59
Pop density	-4.81E-05	0.28	-4.70E-05	0.30	0.0005	0.00	0.0006	0.00	0.0009	0.00	0.0001	0.14
Urban Pop	0.0013	0.01	0.0013	0.01	0.0042	0.00	0.0044	0.00	0.0021	0.00	0.0022	0.00
Physician	0.0015	0.90	0.0014	0.90	0.0106	0.37	0.0091	0.45	0.0061	0.37	0.0041	0.69
Gov Effective	0.0218	0.15	0.0209	0.18	-0.018	0.12	-0.0175	0.14	-0.0055	0.12	-0.0078	0.47
Safe water	0.0043	0.00	0.0043	0.00	0.0004	0.75	0.0009	0.52	0.0025	0.75	0.0029	0.00
Sanitation	0.0008	0.11	0.0008	0.13	-0.0002	0.88	0.0001	0.95	0.001	0.88	0.0009	0.17
Temperature	-0.002	0.16	-0.002	0.17	0.0101	0.24	0.0089	0.32	-0.0014	0.24	-0.0013	0.57
rainm	0.03	0.01	0.0297	0.01	0.0002	1.00	0.001	0.98	0.0234	1.00	0.0199	0.25
Year 1995 dummy			-0.0047	0.76			-0.0051	0.44			-0.0067	0.25
Year 2000 dummy			-0.0063	0.70			-0.0089	0.37			-0.0117	0.11
Constant	3.7034	0.00	3.706	0.00	3.6575	0.00	3.6112	0.00	3.7536	0.00	3.7213	0.00
R-squared	0.76		0.76		0.5		0.5		0.7		0.71	
N	123		123		123		123		123		123	
Hausman					23.23	0.01						
F-test for time dummies			0.08	0.92			0.42	0.66			2.55	0.28
F-test for individual effect					24.29		23.88					
Time Dummies	N		Y		N		Y		N		Y	

2.8.35 Appendix 2.35 Results for equation (1) when forest is environmental indicator : life expectancy rate in developing countries group

Lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0074	0.06	0.0077	0.07	0.004	0.16	0.0056	0.09	0.0061	0.02	0.0084	0.01
Forest	0.0038	0.00	0.0038	0.00	-0.0005	0.67	-0.0006	0.59	-0.0024	0.77	0.0004	0.73
Population density	-0.0001	0.22	-0.0001	0.23	0.0005	0.00	0.0006	0.00	0.0001	0.22	0.0001	0.16
Urban Population	0.0011	0.02	0.0011	0.02	0.0042	0.00	0.0043	0.00	0.0021	0.00	0.0021	0.00
Physician	-0.0107	0.30	-0.0108	0.30	0.0104	0.38	0.0081	0.50	0.0061	0.56	0.0026	0.80
Gov Effective	0.0018	0.91	0.0014	0.93	-0.0189	0.09	-0.0179	0.12	-0.0055	0.61	-0.0065	0.55
Safe water	0.0039	0.00	0.0039	0.00	0.0004	0.77	0.0009	0.52	0.0025	0.01	0.003	0.00
Sanitation	0.0009	0.06	0.0009	0.07	-0.0001	0.90	0.0002	0.89	0.001	0.13	0.0009	0.16
Temperature	-0.0036	0.01	-0.0036	0.01	0.0101	0.24	0.0091	0.29	-0.0014	0.55	-0.0014	0.52
Rainfall	0.0455	0.00	0.0454	0.00	0.0001	1.00	0.0007	0.98	0.0234	0.17	0.0216	0.21
Year 1995 dummy			-0.0029	0.85			-0.0057	0.39			-0.0059	0.32
Year 2000 dummy			-0.0033	0.83	0.5		-0.0096	0.33			-0.0106	0.15
Constant	3.7414	0.00	3.7428	0.00	3.6652	0.00	3.6044	0.00	3.7536	0.00	3.7208	0.00
R-squared	0.77		0.77		0.5		0.5		0.71		0.72	
N	123		123		123		123		123		123	
Hausman					23.23	0.01						
F-test for time dummies			0.03	0.97			0.51	0.60			2.07	0.35
F-test for individual effect					22.31		22.02					
Time Dummies	N		Y		N		Y		N		Y	

2.8.36 Appendix 2.36 Results for equation (1) when BOD is environmental indicator : life expectancy rate in developing countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0042	0.29	0.0045	0.29	0.0041	0.15	0.0062	0.07	0.0063	0.02	0.0083	0.01
BOD	0.0006	0.92	0.0001	0.98	-0.0011	0.77	-0.0039	0.36	0.0006	0.57	0.0004	0.93
Population density	-4.05E-05	0.36	-3.91E-05	0.39	0.0005	0.00	0.0006	0.00	0.0001	0.24	0.0001	0.13
Urban Population	0.0012	0.01	0.0012	0.01	0.0042	0.00	0.0046	0.00	0.002	0.00	0.0022	0.00
Physician	-0.0036	0.75	-0.0034	0.77	0.0116	0.32	0.009	0.44	0.0052	0.60	0.0027	0.79
Gov Effective	0.0232	0.15	0.023	0.16	-0.019	0.09	-0.0179	0.12	-0.0048	0.65	-0.0069	0.52
Safe water	0.0043	0.00	0.0043	0.00	0.0003	0.80	0.0009	0.54	0.0026	0.01	0.0029	0.00
Sanitation	0.0009	0.08	0.0008	0.09	-0.0002	0.87	0.0003	0.79	0.001	0.13	0.001	0.16
Temperature	-0.0023	0.11	-0.0023	0.11	0.0102	0.24	0.0101	0.25	-0.0015	0.49	-0.0013	0.58
Rainfall	0.0297	0.01	0.0295	0.01	0.0005	0.99	0.0016	0.96	0.0257	0.13	0.0194	0.26
Year 1995 dummy			-0.0036	0.82			-0.0086	0.25			-0.0059	0.35
Year 2000 dummy			-0.0046	0.79			-0.0142	0.21	0.72		-0.0107	0.19
Constant	3.7008	0.00	3.7032	0.00	3.668	0.00	3.5645	0.00	3.7516	0.00	3.7188	0.00
R-squared	0.75		0.75		0.5		0.5		0.71		0.71	
N	123		123		123		123		123		123	
Hausman					35.53	0.00						
F-test for time dummies			0.04	0.96			0.84	0.44			1.73	0.42
F-test for individual effect					24.58		24.49					
Time Dummies	N		Y		N		Y		N		Y	

2.8.37 Appendix 2.37 Results for equation (1) when co2 is environmental indicator : infant mortality rate in developing countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0447	0.02	-0.0242	0.21	-0.0934	0.00	-0.0648	0.00	-0.0945	0.00	-0.059	0.00
co2	0.0156	0.17	0.0082	0.47	0.0638	0.00	0.0432	0.01	0.0473	0.00	0.0275	0.03
Population density	0.0004	0.05	0.0004	0.02	-0.0015	0.05	-0.0009	0.25	-3.60E-05	0.90	0.0002	0.58
Urban Population	0.0033	0.09	0.0028	0.15	-0.0079	0.21	-0.0061	0.33	0.0005	0.85	0.0001	0.96
Physician	-0.1295	0.00	-0.1252	0.00	-0.0472	0.39	-0.0498	0.35	-0.0507	0.26	-0.0557	0.19
Gov Effective	-0.3212	0.00	-0.3462	0.00	0.0095	0.85	0.0192	0.70	-0.0403	0.40	-0.0613	0.19
Safe water	-0.0094	0.00	-0.0094	0.00	-0.0086	0.15	-0.0027	0.68	-0.012	0.00	-0.0091	0.02
Sanitation	-0.0095	0.00	-0.0101	0.00	-0.0124	0.03	-0.0106	0.05	-0.0114	0.00	-0.0123	0.00
Temperature	0.0135	0.02	0.0137	0.01	-0.0027	0.95	-0.0159	0.68	0.0146	0.10	0.0156	0.07
Rainfall	-0.1534	0.00	-0.1665	0.00	0.074	0.62	0.0632	0.67	-0.056	0.41	-0.101	0.13
Year 1995 dummy			-0.0805	0.18			-0.046	0.16			-0.0497	0.06
Year 2000 dummy			-0.1808	0.01			-0.1129	0.04			-0.1215	0.00
Constant	4.954	0.00	5.0368	0.00	5.8868	0.00	5.3635	0.00	5.4142	0.00	5.2184	0.00
R-squared	0.85		0.86		0.75		0.76		0.8		0.82	
N	123		123		123		123		123		123	
Hausman					9.73	0.00						
F-test for time dummies			3.92	0.02			2.35	0.10			12.14	0.00
F-test for individual effect					17.95	0.00	17.38	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.38 Appendix 2.38 Results for equation (1) when no2 is environmental indicator : infant mortality rate in developing countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0315	0.06	-0.0176	0.29	-0.0674	0.00	-0.0361	0.02	-0.071	0.00	-0.0414	0.00
Nopp	-0.2796	0.87	0.4729	0.78	0.6312	0.64	1.3099	0.30	-0.0348	0.98	1.0617	0.37
Population density	0.0003	0.05	0.0004	0.02	-0.0011	0.17	-0.0003	0.71	0	0.92	0.0002	0.38
Urban Population	0.0023	0.21	0.0022	0.21	-0.0082	0.25	-0.0054	0.40	-0.0013	0.63	-0.001	0.71
Physician	-0.1112	0.01	-0.1188	0.01	0.0025	0.97	-0.0408	0.47	-0.0161	0.73	-0.0471	0.28
Gov Effective	-0.325	0.00	-0.3484	0.00	0.0054	0.93	0.0346	0.52	-0.0492	0.36	-0.0607	0.21
Safe water	-0.0099	0.00	-0.0095	0.00	-0.0091	0.18	0.0016	0.81	-0.0128	0.00	-0.0084	0.03
Sanitation	-0.0093	0.00	-0.0099	0.00	-0.0179	0.00	-0.0117	0.04	-0.0106	0.00	-0.0121	0.00
Temperature	0.014	0.01	0.0138	0.01	-0.0038	0.93	-0.0181	0.66	0.0152	0.09	0.0161	0.06
Rainfall	-0.1625	0.00	-0.1729	0.00	0.0366	0.83	0.0239	0.88	-0.0864	0.20	-0.131	0.05
Year 1995 dummy			-0.0837	0.17			-0.0775	0.00			-0.0617	0.02
Year 2000 dummy			-0.194	0.00			-0.1938	0.00			-0.1601	0.00
Constant	5.0069	0.00	5.0502	0.00	6.3555		5.0579	0.01	5.513		5.2014	0.00
R-squared	0.84		0.87		0.68		0.75		0.81		0.82	
N	123		123		123		123		123		123	
Hausman					39.16	0.00						
F-test for time dummies			4.66	0.01			9.33	0.00			24.71	0.00
F-test for individual effect					13.91		16.09					
Time Dummies	N		Y		N		Y		N		Y	

2.8.39 Appendix 2.39 Results for equation (1) when PM is environmental indicator : infant mortality rate in developing countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.024	0.12	-0.0125	0.43	-0.0626	0.00	-0.034	0.04	-0.0618	0.00	-0.0395	0.00
Pm	0.0021	0.00	0.0018	0.00	0.0023	0.02	0.0004	0.74	0.0023	0.00	0.0011	0.15
Population density	0.0002	0.27	0.0002	0.15	-0.0007	0.41	-0.0003	0.69	-4.19E-05	0.88	0.0002	0.54
Urban Population	0.0025	0.15	0.0024	0.15	-0.0074	0.28	-0.005	0.44	-0.0011	0.67	-0.0008	0.76
Physician	-0.1509	0.00	-0.1488	0.00	0.015	0.79	-0.0231	0.68	-0.0377	0.40	-0.0453	0.29
Gov Effective	-0.358	0.00	-0.3737	0.00	-0.0033	0.95	0.0193	0.72	-0.0717	0.15	-0.0818	0.09
Safe water	-0.0106	0.00	-0.0103	0.00	-0.0095	0.14	0.0004	0.95	-0.0136	0.00	-0.0101	0.01
Sanitation	-0.0077	0.00	-0.0085	0.00	-0.0136	0.03	-0.0117	0.04	-0.0087	0.00	-0.011	0.00
Temperature	0.0087	0.12	0.0094	0.09	-0.0274	0.52	-0.0297	0.46	0.0115	0.17	0.0144	0.08
Rainfall	-0.1288	0.00	-0.1409	0.00	0.0707	0.67	0.0481	0.76	-0.0597	0.36	-0.1086	0.10
Year 1995 dummy			-0.0643	0.27			-0.0754	0.04			-0.049	0.09
Year 2000 dummy			-0.1569	0.01			-0.1791	0.00			-0.1294	0.00
Constant	4.8819	0.00	4.9499	0.00	6.2326	0.00	5.297	0.00	5.2981	0.00	5.1916	0.00
R-squared	0.85		0.87		0.7		0.74		0.82		0.83	
N	123		123		123		123		123		123	
Hausman					32.29	0.00						
F-test for time dummies			3.27	0.04			5.45	0.00			12.67	0.00
F-test for individual effect					13.56		14.54					
Time Dummies	N		Y		N		Y		N		Y	

2.8.40 Appendix 2.40 Results for equation (1) when CH4 is environmental indicator : life expectancy rate in developing countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0394	0.01	-0.0246	0.13	-0.0673	0.00	-0.0333	0.04	-0.0735	0.00	-0.0413	0.00
CH4	0.0907	0.00	0.0833	0.01	0.0285	0.58	0.0075	0.88	0.0725	0.06	0.0474	0.19
Population density	0.0004	0.01	0.0005	0.01	-0.0011	0.16	-0.0003	0.66	0.0001	0.64	0.0003	0.30
Urban Population	0.0012	0.51	0.0012	0.49	-0.0074	0.30	-0.0048	0.47	-0.0021	0.43	-0.0014	0.59
Physician	-0.1588	0.00	-0.1587	0.00	0.0028	0.96	-0.0278	0.62	-0.0463	0.33	-0.0574	0.20
Gov Effective	-0.3051	0.00	-0.3297	0.00	0.0067	0.91	0.0228	0.67	-0.0393	0.45	-0.0654	0.18
Safe water	-0.0094	0.00	-0.0092	0.00	-0.0094	0.16	0.0009	0.89	-0.0124	0.00	-0.009	0.02
Sanitation	-0.0084	0.00	-0.0091	0.00	-0.0175	0.01	-0.0119	0.04	-0.0099	0.00	-0.0118	0.00
Temperature	0.0111	0.05	0.0113	0.04	-0.0036	0.94	-0.0265	0.52	0.0143	0.10	0.0156	0.06
Rainfall	-0.1655	0.00	-0.1737	0.00	0.0416	0.81	0.0436	0.78	-0.0965	0.14	-0.1309	0.04
Year 1995 dummy			-0.0745	0.20			-0.0807	0.01			-0.0589	0.03
Year 2000 dummy			-0.1771	0.01			-0.1889	0.00			-0.1497	0.00
Constant	4.9786	0.00	5.0395	0.00	6.2844	0.00	5.2284	0.00	5.4514	0.00	5.2208	0.00
R-squared	0.85		0.87		0.7		0.74		0.82		0.83	
N	123		123		123		123		123		123	
Hausman					25.9	0.00						
F-test for time dummies			4.22	0.02			8.62	0.00			21.64	0.00
F-test for individual effect					12.82	0.00	14.71	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.41 Appendix 2.41 Results for equation (1) when forest is environmental indicator : life expectancy rate in developing countries group

Lnimr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0302	0.07	-0.0152	0.36	-0.0639	0.00	-0.0324	0.04	-0.0699	0.00	-0.0385	0.00
Forest	0.0023	0.63	0.002	0.68	0.006	0.29	0.004	0.44	0.0026	0.59	-0.0001	0.99
Population density	0.0003	0.05	0.0004	0.02	-0.0011	0.18	-0.0003	0.68	0	0.93	0.0002	0.42
Urban Population	0.0022	0.23	0.0021	0.22	-0.0081	0.26	-0.0051	0.44	-0.0015	0.58	-0.0008	0.75
Physician	-0.1172	0.01	-0.1204	0.00	0.022	0.72	-0.0173	0.76	-0.0159	0.73	-0.0402	0.35
Gov Effective	-0.3377	0.00	-0.3604	0.00	-0.0002	1.00	0.0209	0.69	-0.053	0.31	-0.0715	0.14
Safe water	-0.01	0.00	-0.0098	0.00	-0.0087	0.20	0.0012	0.85	-0.013	0.00	-0.0088	0.03
Sanitation	-0.0093	0.00	-0.01	0.00	-0.0188	0.00	-0.0127	0.03	-0.0107	0.00	-0.0122	0.00
Temperature	0.0131	0.03	0.0132	0.02	-0.0153	0.73	-0.032	0.43	0.0148	0.10	0.0161	0.06
Rainfall	-0.1533	0.00	-0.1639	0.00	0.0522	0.76	0.049	0.75	-0.0773	0.27	-0.1261	0.06
Year 1995 dummy			-0.0842	0.16			-0.0793	0.01			-0.0642	0.02
Year 2000 dummy			-0.1908	0.00			-0.1862	0.00			-0.1558	0.00
Constant	5.0231	0.00	5.084	0.00	6.5637	0.00	5.3672	0.00	5.5342	0.00	5.237	0.00
R-squared	0.84		0.87		0.68		0.74		0.8		0.82	
N	123		123		123		123		123		123	
Hausman					23.84	0.00						
F-test for time dummies			4.6	0.01			8.47	0.00			23.19	0.00
F-test for individual effect					14.09	0.00	15.95	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.42 Appendix 2.42 Results for equation (1) when BOD is environmental indicator : infant mortality rate in developing countries group

Lnimr	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0335	0.03	-0.015	0.34	-0.0608	0.00	-0.0385	0.01	-0.0695	0.00	-0.0386	0.00
BOD	-0.0505	0.03	-0.0723	0.00	0.0641	0.00	0.0416	0.04	0.0315	0.07	0.0018	0.92
Population density	0.0004	0.02	0.0005	0.01	-0.0014	0.06	-0.0007	0.34	-2.24E-05	0.94	0.0002	0.42
Urban Population	0.0014	0.45	0.0009	0.58	-0.0106	0.11	-0.0077	0.23	-0.0013	0.62	-0.0008	0.76
Physician	-0.0721	0.11	-0.0601	0.16	-0.0017	0.98	-0.0217	0.69	-0.0293	0.53	-0.0413	0.34
Gov Effective	-0.2785	0.00	-0.2902	0.00	0.0068	0.90	0.0203	0.69	-0.0547	0.29	-0.0746	0.12
Safe water	-0.0097	0.00	-0.0093	0.00	-0.0035	0.59	0.0018	0.78	-0.0123	0.00	-0.009	0.02
Sanitation	-0.0085	0.00	-0.0091	0.00	-0.02	0.00	-0.015	0.01	-0.0116	0.00	-0.0122	0.00
Temperature	0.013	0.02	0.0125	0.02	-0.0444	0.28	-0.0447	0.26	0.0162	0.07	0.0162	0.06
Rainfall	-0.1576	0.00	-0.1666	0.00	0.0486	0.76	0.0416	0.78	-0.0877	0.20	-0.1269	0.05
Year 1995 dummy			-0.1205	0.04			-0.0473	0.16			-0.0632	0.03
Year 2000 dummy			-0.2397	0.00			-0.1361	0.01			-0.1543	0.00
Constant	5.0454	0.00	5.1506	0.00	6.8398	0.00	5.847	0.00	5.4728	0.00	5.2394	0.00
R-squared	0.85		0.87		0.73		0.75		0.79		0.82	
N	123		123		123		123		123		123	
Hausman					11.74	0.00						
F-test for time dummies			7.4	0.00			4.26	0.02			19.17	0.00
F-test for individual effect					16.08	0.00	15.43	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.43 Appendix 2.43 Results for equation (1) when CO2 is environmental indicator : child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0487	0.01	-0.0278	0.17	-0.088	0.00	-0.051	0.02	-0.0921	0.00	-0.0511	0.00
co2	0.0116	0.33	0.004	0.74	0.0611	0.00	0.0343	0.07	0.0422	0.00	0.0198	0.15
Population density	0.0003	0.09	0.0004	0.05	-0.0016	0.05	-0.0008	0.32	-0.0001	0.77	0.0001	0.68
Urban Population	0.0025	0.22	0.0019	0.34	-0.0123	0.08	-0.0098	0.15	-0.0008	0.78	-0.0012	0.65
Physician	-0.1262	0.01	-0.1221	0.01	-0.056	0.35	-0.061	0.30	-0.0481	0.32	-0.0548	0.23
Gov Effective	-0.3314	0.00	-0.3573	0.00	-0.0074	0.90	0.0049	0.93	-0.0578	0.27	-0.0826	0.10
Safe water	-0.0108	0.00	-0.0107	0.00	-0.0099	0.13	-0.0021	0.77	-0.0138	0.00	-0.0104	0.01
Sanitation	-0.0115	0.00	-0.0121	0.00	-0.014	0.02	-0.0118	0.05	-0.0135	0.00	-0.0146	0.00
Temperature	0.0187	0.00	0.0188	0.00	0.0115	0.79	-0.0067	0.87	0.0196	0.04	0.0205	0.02
Rainfall	-0.1823	0.00	-0.1957	0.00	0.069	0.68	0.0595	0.71	-0.0856	0.23	-0.1354	0.05
Year 1995 dummy			-0.0913	0.15			-0.0694	0.05			-0.0666	0.02
Year 2000 dummy			-0.1862	0.01			-0.1482	0.01			-0.1423	0.00
Constant	5.4709	0.00	5.5581	0.00	6.3077	0.00	5.6269	0.00	5.9678	0.00	5.7584	0.00
R-squared	0.87		0.88		0.74		0.76		0.83		0.85	
N	123		123		123		123		123		123	
Hausman					209.94	0.00						
F-test for time dummies			3.7	0.03			3.32	0.04			14.38	0.00
F-test for individual effect					16.04	0.00	16.02	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.44 Appendix 2.44 Results for equation (1) when NO2 is environmental indicator : child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.038	0.03	-0.0242	0.16	-0.0631	0.00	-0.0287	0.09	-0.0706	0.00	-0.0387	0.01
Nopp	-0.6503	0.72	0.0451	0.98	0.6235	0.67	1.2301	0.36	-0.2067	0.88	0.8495	0.50
Population density	0.0003	0.12	0.0004	0.06	-0.0013	0.14	-0.0003	0.67	-3.70E-05	0.90	0.0002	0.53
Urban Population	0.0017	0.36	0.0016	0.37	-0.0126	0.10	-0.0094	0.18	-0.0024	0.39	-0.0021	0.44
Physician	-0.1105	0.01	-0.1181	0.01	-0.0086	0.90	-0.056	0.35	-0.0153	0.76	-0.0486	0.29
Gov Effective	-0.3353	0.00	-0.3587	0.00	-0.0111	0.86	0.0191	0.74	-0.0663	0.24	-0.0806	0.12
Safe water	-0.0113	0.00	-0.0108	0.00	-0.0104	0.15	0.0014	0.84	-0.0145	0.00	-0.0099	0.02
Sanitation	-0.0115	0.00	-0.0121	0.00	-0.0193	0.00	-0.0126	0.04	-0.0128	0.00	-0.0144	0.00
Temperature	0.0191	0.00	0.0189	0.00	0.0105	0.83	-0.007	0.87	0.0201	0.03	0.0209	0.02
Rainfall	-0.1883	0.00	-0.1985	0.00	0.033	0.86	0.0252	0.88	-0.1117	0.12	-0.1568	0.02
Year 1995 dummy			-0.0932	0.14			-0.0939	0.01			-0.0749	0.01
Year 2000 dummy			-0.1917	0.01			-0.213	0.00			-0.1702	0.00
Constant	5.5232	0.00	5.57	0.00	6.7543	0.00	5.3544	0.00	6.0595	0.00	5.7447	0.00
R-squared	0.87		0.88		0.69		0.75		0.84		0.85	
N	123		123		123		123		123		123	
Hausman					28.97	0.00						
F-test for time dummies			4.16	0.02			9.72	0.00			24.62	0.00
F-test for individual effect					13.04	0.00	15.39	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.45 Appendix 2.45 Results for equation (1) when PM is environmental indicator : child mortality rate in developing countries group

Lncmr	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0314	0.05	-0.0199	0.23	-0.058	0.00	-0.0273	0.11	-0.0614	0.00	-0.038	0.01
Pm	0.002	0.00	0.0018	0.01	0.0027	0.01	0.0005	0.67	0.0025	0.00	0.0012	0.13
Population density	0.0001	0.42	0.0002	0.25	-0.0007	0.39	-0.0004	0.66	-0.0001	0.67	0.0001	0.72
Urban Population	0.0019	0.29	0.0018	0.30	-0.0117	0.11	-0.009	0.20	-0.0022	0.40	-0.0019	0.47
Physician	-0.1515	0.00	-0.1496	0.00	0.0046	0.94	-0.0381	0.52	-0.039	0.40	-0.0482	0.28
Gov Effective	-0.3669	0.00	-0.3828	0.00	-0.0201	0.73	0.0041	0.94	-0.0874	0.10	-0.0988	0.05
Safe water	-0.0119	0.00	-0.0116	0.00	-0.0108	0.12	0	1.00	-0.0153	0.00	-0.0116	0.01
Sanitation	-0.0097	0.00	-0.0106	0.00	-0.0144	0.03	-0.0124	0.04	-0.0108	0.00	-0.0132	0.00
Temperature	0.0138	0.02	0.0145	0.01	-0.0158	0.73	-0.0186	0.66	0.016	0.07	0.0189	0.03
Rainfall	-0.1557	0.00	-0.1678	0.00	0.0706	0.69	0.0494	0.76	-0.0817	0.23	-0.1329	0.05
Year 1995 dummy			-0.0733	0.23			-0.0893	0.02			-0.0599	0.05
Year 2000 dummy			-0.1573	0.02			-0.1946	0.00			-0.1371	0.00
Constant	5.3886	0.00	5.4591	0.00	6.6004	0.00	5.5925	0.00	5.83	0.00	5.7212	0.00
R-squared	0.88		0.89		0.71		0.75		0.85		0.86	
N	123		123		123		123		123		123	
Hausman					63.1	0.00						
F-test for time dummies			2.95	0.06			5.47	0.00				
F-test for individual effect					13.06	0.00	14.1	0.00			12.4	0.00
Time Dummies	N		Y		N		Y		N		Y	

2.8.46 Appendix 2.46 Results for equation (1) when CH4 is environmental indicator : child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0459	0.01	-0.031	0.07	-0.0628	0.00	-0.0253	0.14	-0.0737	0.00	-0.039	0.01
CH4	0.0806	0.02	0.073	0.03	0.0243	0.66	-0.0016	0.98	0.0669	0.10	0.0392	0.31
Population density	0.0004	0.04	0.0004	0.02	-0.0013	0.14	-0.0004	0.63	0.0001	0.85	0.0002	0.46
Urban Population	0.0007	0.71	0.0008	0.68	-0.0119	0.13	-0.0089	0.21	-0.0031	0.26	-0.0024	0.37
Physician	-0.1547	0.00	-0.1547	0.00	-0.0074	0.91	-0.042	0.48	-0.0438	0.39	-0.057	0.23
Gov Effective	-0.3166	0.00	-0.3416	0.00	-0.0109	0.86	0.0058	0.92	-0.0547	0.32	-0.0836	0.10
Safe water	-0.0107	0.00	-0.0105	0.00	-0.0107	0.14	0.0009	0.90	-0.0141	0.00	-0.0103	0.01
Sanitation	-0.0105	0.00	-0.0113	0.00	-0.019	0.00	-0.0129	0.03	-0.0122	0.00	-0.0142	0.00
Temperature	0.0164	0.01	0.0167	0.00	0.01	0.83	-0.0166	0.70	0.0192	0.03	0.0204	0.02
Rainfall	-0.1916	0.00	-0.1999	0.00	0.0384	0.83	0.0452	0.78	-0.1209	0.08	-0.1568	0.02
Year 1995 dummy			-0.0845	0.17			-0.0978	0.00			-0.0725	0.01
Year 2000 dummy			-0.1788	0.01			-0.2094	0.00			-0.1615	0.00
Constant	5.4862	0.00	5.55	0.00	6.7054	0.00	5.5556	0.00	6.0009	0.00	5.7594	0.00
R-squared	0.88		0.88		0.69		0.75		0.85		0.86	
N	123		123		123		123		123		123	
Hausman					69.75	0.00						
F-test for time dummies			3.83	0.02			9.19	0.00			22.12	0.00
F-test for individual effect					12.3	0.00	14.43	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.47 Appendix 2.47 Results for equation (1) when forest is environmental indicator : child mortality rate in developing countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.04	0.02	-0.0251	0.15	-0.0598	0.00	-0.0252	0.12	-0.0705	0.00	-0.0367	0.01
forest	-0.0007	0.89	-0.0011	0.82	0.0057	0.35	0.0034	0.54	0.0018	0.72	-0.0009	0.85
Population density	0.0003	0.09	0.0004	0.05	-0.0012	0.15	-0.0004	0.64	-3.76E-05	0.90	0.0002	0.57
Urban Population	0.0017	0.36	0.0017	0.36	-0.0124	0.10	-0.009	0.20	-0.0025	0.37	-0.0019	0.48
Physician	-0.1121	0.01	-0.1157	0.01	0.0101	0.88	-0.0347	0.56	-0.016	0.74	-0.0435	0.34
Gov Effective	-0.3295	0.00	-0.3524	0.00	-0.0167	0.79	0.0062	0.91	-0.0669	0.23	-0.0877	0.08
Safe water	-0.011	0.00	-0.0107	0.00	-0.01	0.17	0.001	0.88	-0.0146	0.00	-0.0102	0.01
Sanitation	-0.0114	0.00	-0.0121	0.00	-0.0202	0.00	-0.0135	0.03	-0.0129	0.00	-0.0145	0.00
Temperature	0.0192	0.00	0.0193	0.00	-0.0006	0.99	-0.0197	0.65	0.0197	0.03	0.021	0.02
Rainfall	-0.1924	0.00	-0.203	0.00	0.048	0.79	0.0485	0.77	-0.1052	0.15	-0.156	0.03
Year 1995 dummy			-0.0935	0.14			-0.0958	0.00			-0.0775	0.01
Year 2000 dummy			-0.1918	0.00			-0.2062	0.00	0.84		-0.1676	0.00
Constant	5.4963	0.00	5.5597	0.00	6.9545	0.00	5.635	0.00	6.0727	0.00	5.7639	0.00
R-squared	0.87		0.88		0.69		0.75				0.86	
N	123		123		123		123		123		123	
Hausman					40.8	0.00						
F-test for time dummies			4.24	0.02			9	0.00			23.81	0.00
F-test for individual effect					13.2	0.00	15.27	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.48 Appendix 2.48 Results for equation (1) when BOD is environmental indicator : child mortality rate in developing countries group

Lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0408	0.01	-0.0224	0.17	-0.0566	0.00	-0.0305	0.06	-0.0697	0.00	-0.0361	0.01
BOD	-0.0517	0.04	-0.0738	0.00	0.0642	0.00	0.0355	0.10	0.0306	0.10	-0.0028	0.88
Population density	0.0004	0.05	0.0004	0.02	-0.0015	0.06	-0.0007	0.37	-0.0001	0.79	0.0002	0.53
Urban Population	0.0008	0.68	0.0003	0.85	-0.015	0.04	-0.0113	0.11	-0.0024	0.39	-0.0018	0.48
Physician	-0.0722	0.13	-0.0602	0.18	-0.0129	0.83	-0.0384	0.50	-0.0298	0.54	-0.0432	0.34
Gov Effective	-0.2868	0.00	-0.2984	0.00	-0.0096	0.87	0.0057	0.92	-0.0712	0.19	-0.0931	0.07
Safe water	-0.011	0.00	-0.0106	0.00	-0.0047	0.49	0.0015	0.82	-0.014	0.00	-0.0104	0.01
Sanitation	-0.0106	0.00	-0.0111	0.00	-0.0214	0.00	-0.0154	0.01	-0.0137	0.00	-0.0144	0.00
Temperature	0.018	0.00	0.0175	0.00	-0.0301	0.50	-0.0306	0.47	0.0211	0.02	0.0208	0.02
Rainfall	-0.1839	0.00	-0.1929	0.00	0.0448	0.79	0.0421	0.79	-0.1141	0.11	-0.155	0.02
Year 1995 dummy			-0.1299	0.04			-0.0685	0.06			-0.0787	0.01
Year 2000 dummy			-0.2406	0.00			-0.1634	0.00			-0.1691	0.00
Constant	5.5518	0.00	5.66	0.00	7.2378	0.00	6.0456	0.00	6.0152	0.00	5.7761	0.00
R-squared	0.88		0.89		0.73		0.76		0.83		0.86	
N	123		123		123		123		123		123	
Hausman					163.9	0.00						
F-test for time dummies			6.82	0.00			4.75	0.00			20.06	0.00
F-test for individual effect					14.74	0.00	14.5	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.49 Appendix 2.49 Results for equation (1) when CO2 is environmental indicator : life expectancy rate in developed countries group

Lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0035	0.00	0.0031	0.00	0.0023	0.00	-0.0003	0.55	0.0022	0.00	-0.0003	0.46
co2	-0.0017	0.07	-0.0016	0.10	-0.0037	0.00	-0.0026	0.01	-0.0026	0.01	-0.0021	0.01
Population density	-0.0001	0.02	-0.0001	0.02	-0.0003	0.07	-0.0002	0.15	2.46E-06	0.97	5.93E-06	0.91
Urban Population	-0.0001	0.76	-0.0001	0.74	-0.0022	0.22	-0.0009	0.41	0.0003	0.59	0.0006	0.27
Physician	-0.0092	0.14	-0.01	0.12	0.0206	0.00	0.0051	0.22	0.0134	0.00	0.0025	0.54
Gov Effective	-0.0059	0.54	-0.0046	0.65	0.0169	0.00	0.0074	0.09	0.0124	0.02	0.0061	0.12
Safe water	0.0114	0.00	0.0117	0.00	-0.0015	0.48	-0.0036	0.02	0.0023	0.25	-0.0014	0.34
Sanitation	-0.0037	0.01	-0.0039	0.01	0.0097	0.00	0.006	0.00	0.0028	0.09	0.0025	0.06
Temperature	0.0015	0.00	0.0014	0.01	-0.0017	0.38	-0.0019	0.24	0.0012	0.18	2.20E-05	0.98
Rainfall	0.0182	0.07	0.0196	0.05	-0.0135	0.62	-0.0259	0.18	0.0012	0.93	-0.0012	0.93
Year 1995 dummy			0.0061	0.34			0.0114	0.00			0.0121	0.00
Year 2000 dummy			0.0068	0.44			0.0313	0.00			0.0299	0.00
Constant	3.5442	0.00	3.5326	0.00	3.6469	0.00	4.2174	0.00	3.726	0.00	4.1847	0.00
R-squared	0.63		0.64		0.91		0.96		0.34		0.13	
N	66		66		66		66		66		66	
Hausman					21.46	0.02						
F-test for time dummies			0.5	0.60			24.41	0.00			38.12	0.00
F-test for individual effect					34.3	0.00	82.27	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.50 Appendix 2.50 Results for equation (1) when NO2 is environmental indicator : life expectancy rate in developed countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0026	0.00	0.0022	0.01	0.0027	0.00	-0.0003	0.57	0.0021	0.00	-0.0005	0.29
NO2	0.1089	0.44	0.099	0.49	-0.0782	0.27	-0.0612	0.19	-0.0408	0.57	-0.0386	0.45
Population density	-0.0001	0.09	-0.0001	0.08	-0.0005	0.01	-0.0002	0.04	-1.75E-05	0.76	-1.80E-05	0.74
Urban Population	-0.0003	0.36	-0.0003	0.37	-0.0042	0.03	-0.0022	0.08	2.77E-05	0.96	0.0003	0.53
Physician	-0.0001	0.99	-0.0019	0.76	0.0212	0.00	0.0034	0.45	0.0148	0.00	0.0018	0.69
Gov Effective	0.0007	0.94	0.002	0.84	0.0196	0.00	0.0066	0.17	0.0137	0.01	0.0061	0.14
Safe water	0.0118	0.00	0.0122	0.00	-0.0012	0.59	-0.0038	0.02	0.0028	0.18	-0.0012	0.46
Sanitation	-0.0038	0.02	-0.0041	0.01	0.0102	0.00	0.0059	0.01	0.0015	0.38	0.0014	0.29
Temperature	0.0014	0.02	0.0013	0.02	-0.0025	0.25	-0.0016	0.38	0.0013	0.16	0.0002	0.83
Rainfall	0.0299	0.00	0.0305	0.00	-0.0055	0.86	-0.0155	0.46	0.0126	0.36	0.0092	0.48
Year 1995 dummy			0.007	0.28			0.0139	0.00			0.0137	0.00
Year 2000 dummy			0.0087	0.34			0.0348	0.00			0.0324	0.00
Constant	3.4691	0.00	3.4619	0.00	3.7061	0.00	4.3239	0.00	3.7893	0.00	4.2675	0.00
R-squared	0.61		0.62		0.89		0.95		0.42		0.16	
N	66		66		66		66		66		66	
Hausman					30.36	0.00						
F-test for time dummies			0.69	0.50			24.63	0.00			42.26	0.00
F-test for individual effect					29.1	0.00	70.03	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.51 Appendix 2.51 Results for equation (1) when PM is environmental indicator : life expectancy rate in developed countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0028	0.00	0.0022	0.01	0.0028	0.00	-0.0001	0.92	0.0021	0.00	-0.0005	0.32
PM	0.0003	0.29	0.0004	0.16	-0.0005	0.01	-0.0003	0.03	-0.0003	0.13	-0.0001	0.32
Population density	-0.0001	0.03	-0.0001	0.03	-0.0005	0.00	-0.0003	0.01	-1.45E-05	0.80	-1.91E-05	0.73
Urban Population	-0.0001	0.62	-0.0001	0.69	-0.0045	0.01	-0.0025	0.04	-4.99E-05	0.92	0.0003	0.62
Physician	-0.0014	0.78	-0.0033	0.53	0.0141	0.01	0.0001	0.98	0.0118	0.02	0.0001	0.99
Gov Effective	0.0034	0.73	0.0073	0.48	0.0149	0.02	0.0049	0.30	0.0108	0.06	0.0047	0.27
Safe water	0.0111	0.00	0.0113	0.00	-0.003	0.20	-0.0046	0.01	0.0019	0.37	-0.0016	0.33
Sanitation	-0.0032	0.05	-0.0033	0.04	0.0102	0.00	0.0061	0.00	0.0012	0.48	0.0013	0.34
Temperature	0.0014	0.01	0.0012	0.03	-0.0017	0.41	-0.0012	0.48	0.0014	0.12	0.0003	0.73
Rainfall	0.0278	0.00	0.0291	0.00	-0.0209	0.46	-0.0248	0.22	0.0092	0.51	0.007	0.60
Year 1995 dummy			0.0087	0.19			0.013	0.00			0.0136	0.00
Year 2000 dummy			0.0129	0.16			0.0325	0.00	0.39		0.0319	0.00
Constant	3.4734	0.00	3.4598	0.00	3.9491	0.00	4.43	0.00	3.9355	0.00	4.3368	0.00
R-squared	0.61		0.63		0.9		0.96				0.14	
N	66		66		66		66		66		66	
Hausman					8.21	0.00						
F-test for time dummies			1.22	0.31			22.64	0.00			40.36	0.00
F-test for individual effect					33.83	0.00	75.5	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.52 Appendix 2.52 Results for equation (1) when CH4 is environmental indicator : life expectancy rate in developed countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0028	0.00	0.0023	0.01	0.0024	0.00	-0.0005	0.39	0.002	0.00	-0.0006	0.19
CH4	-0.0003	0.90	-0.0007	0.76	-0.0088	0.07	-0.0058	0.07	-0.0043	0.20	-0.0051	0.06
Population density	-0.0001	0.06	-0.0001	0.04	-0.0004	0.01	-0.0002	0.07	-4.69E-05	0.46	-4.72E-05	0.40
Urban Population	-0.0002	0.55	-0.0002	0.62	-0.0032	0.09	-0.0015	0.21	0.0003	0.59	0.0006	0.25
Physician	-0.0025	0.65	-0.0046	0.43	0.0194	0.00	0.0023	0.60	0.0147	0.00	0.0016	0.71
Gov Effective	0.0001	0.99	0.002	0.84	0.02	0.00	0.0067	0.16	0.0147	0.01	0.0069	0.09
Safe water	0.0118	0.00	0.012	0.00	-0.0007	0.76	-0.0034	0.03	0.0024	0.24	-0.0014	0.37
Sanitation	-0.0039	0.01	-0.0042	0.01	0.0089	0.00	0.0051	0.01	0.0017	0.32	0.0016	0.23
Temperature	0.0015	0.01	0.0015	0.01	-0.0021	0.32	-0.001	0.58	0.0016	0.10	0.0006	0.52
Rainfall	0.0279	0.00	0.0292	0.00	-0.0111	0.70	-0.0166	0.41	0.0163	0.25	0.0127	0.33
Year 1995 dummy			0.0072	0.28			0.0142	0.00			0.014	0.00
Year 2000 dummy			0.01	0.27			0.034	0.00			0.0319	0.00
Constant	3.4945	0.00	3.5034	0.00	3.7181	0.00	4.3205	0.00	3.7917	0.00	4.255	0.00
R-squared	0.61		0.62		0.89		0.96		0.39		0.17	
N	66		66		66		66		66		66	
Hausman					119.78	0.00						
F-test for time dummies			0.78	0.46			24.1	0.00			44.22	0.00
F-test for individual effect					31.4	0.00	74.13	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.53 Appendix 2.53 Results for equation (1) when forest is environmental indicator : life expectancy rate in developed countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.0029	0.00	0.0024	0.01	0.0026	0.00	-0.0005	0.33	0.002	0.00	-0.0006	0.24
forest	0.0003	0.63	0.0003	0.59	-0.0004	0.74	0.0012	0.14	-0.0008	0.30	0.0002	0.81
Population density	-0.0001	0.04	-0.0001	0.03	-0.0004	0.02	-0.0003	0.02	-1.53E-05	0.79	-1.49E-05	0.79
Urban Population	-0.0003	0.38	-0.0003	0.38	-0.004	0.04	-0.002	0.11	0.0001	0.89	0.0003	0.55
Physician	-0.003	0.58	-0.0048	0.39	0.0195	0.00	0.0036	0.42	0.0143	0.00	0.0012	0.78
Gov Effective	-0.0002	0.98	0.0016	0.87	0.0201	0.00	0.0066	0.17	0.0145	0.01	0.0059	0.17
Safe water	0.0119	0.00	0.0123	0.00	-0.0006	0.80	-0.0044	0.01	0.003	0.15	-0.0012	0.46
Sanitation	-0.0038	0.01	-0.0041	0.01	0.0093	0.01	0.0062	0.01	0.0011	0.52	0.0013	0.33
Temperature	0.0015	0.01	0.0014	0.01	-0.0028	0.21	-0.0022	0.23	0.0012	0.17	0.0001	0.90
Rainfall	0.0269	0.00	0.0277	0.00	-0.0088	0.77	-0.0153	0.46	0.0131	0.33	0.0094	0.48
Year 1995 dummy			0.0071	0.28			0.0149	0.00			0.0142	0.00
Year 2000 dummy			0.0098	0.27			0.0373	0.00	0.43		0.0331	0.00
Constant	3.4795	0.00	3.4708	0.00	3.718	0.00	4.3496	0.00	3.8059	0.00	4.28	0.00
R-squared	0.61		0.62		0.88		0.96				0.16	
N	66		66		66		66		66		66	
Hausman					22.49	0.01						
F-test for time dummies			0.77	0.47			26.51	0.00			40.96	0.00
F-test for individual effect					28.33	0.00	71.23	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.54 Appendix 2.54 Results for equation (1) when BOD is environmental indicator : life expectancy rate in developed countries group

lnlexp	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	0.002	0.00	0.0016	0.04	0.0025	0.00	-0.0004	0.48	0.0019	0.00	-0.0003	0.54
BOD	-0.0072	0.00	-0.0071	0.00	-0.0031	0.25	0.0003	0.88	-0.0052	0.01	-0.0017	0.38
Population density	-0.0001	0.02	-0.0001	0.02	-0.0004	0.02	-0.0002	0.05	-1.02E-05	0.84	-6.25E-06	0.90
Urban Population	0	0.94	0	0.92	-0.0035	0.07	-0.0021	0.11	0.0003	0.57	0.0004	0.39
Physician	0.0029	0.54	0.0017	0.73	0.0185	0.00	0.0024	0.60	0.012	0.01	0.0017	0.70
Gov Effective	0.0053	0.52	0.0075	0.39	0.0159	0.03	0.007	0.18	0.0096	0.08	0.0062	0.16
Safe water	0.0123	0.00	0.0125	0.00	-0.0018	0.46	-0.0035	0.04	0.002	0.34	-0.0007	0.67
Sanitation	-0.0038	0.01	-0.004	0.00	0.0093	0.00	0.0055	0.01	0.0014	0.39	0.0012	0.40
Temperature	0.0007	0.18	0.0006	0.24	-0.0017	0.47	-0.0018	0.34	0.0008	0.30	0.0001	0.92
Rainfall	0.0379	0.00	0.0381	0.00	-0.0068	0.82	-0.0163	0.45	0.0194	0.11	0.012	0.34
Year 1995 dummy			0.0022	0.71			0.0145	0.00			0.0119	0.00
Year 2000 dummy			0.0073	0.36			0.0355	0.00			0.029	0.00
Constant	3.4481	0.00	3.4458	0.00	3.8091	0.00	4.331	0.00	3.9014	0.00	4.2428	0.00
R-squared	0.7		0.7		0.89		0.95		0.56		0.28	
N	66		66		66		66		66		66	
Hausman					22.12	0.00						
F-test for time dummies			0.44	0.64			22.32	0.00			26.78	0.00
F-test for individual effect					22.29	0.00	51.49	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.55 Appendix 2.55 Results for equation (1) when CO2 is environmental indicator : infant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0294	0.00	-0.0068	0.43	-0.0315	0.01	0.006	0.70	-0.0327	0.00	-0.0038	0.65
co2	0.0185	0.08	0.0113	0.20	0.0564	0.05	0.0296	0.27	0.0202	0.15	0.0114	0.34
Population density	0.0003	0.43	0.0004	0.31	0.0042	0.23	0.0019	0.55	-0.0002	0.73	-0.0001	0.92
Urban Population	0.0027	0.39	0.0034	0.21	0.0221	0.58	0.0093	0.80	0.0025	0.62	0.0005	0.91
Physician	-0.0458	0.51	-0.0099	0.87	-0.4041	0.00	-0.1445	0.26	-0.1915	0.02	-0.046	0.52
Gov Effective	-0.0173	0.87	-0.1212	0.21	-0.3366	0.01	-0.1264	0.35	-0.1498	0.14	-0.1194	0.15
Safe water	-0.1159	0.00	-0.1349	0.00	-0.0342	0.47	0.0033	0.94	-0.0818	0.02	-0.0725	0.01
Sanitation	-0.0022	0.89	0.0097	0.49	-0.1309	0.04	-0.0737	0.20	-0.026	0.28	-0.0094	0.64
Temperature	-0.0009	0.87	0.0029	0.55	0.1083	0.02	0.0675	0.18	-0.0019	0.84	0.0075	0.36
Rainfall	-0.1122	0.31	-0.1832	0.05	0.4259	0.49	0.2695	0.65	-0.0197	0.90	-0.1117	0.41
Year 1995 dummy			-0.2479	0.00			-0.2378	0.01			-0.2505	0.00
Year 2000 dummy			-0.3808	0.00			-0.4722	0.00			-0.3996	0.00
Constant	13.9954	0.00	14.5535	0.00	16.4184	0.00	7.4356	0.12	13.6157	0.00	10.4433	0.00
R-squared	0.63		0.75		0.85		0.88		0.58		0.71	
N	66		66		66		66		66		66	
Hausman					67.22	0.00						
F-test for time dummies			12.56	0.00			5.4	0.00			33.32	0.00
F-test for individual effect					7.22	0.00	6.02	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.56 Appendix 2.56 Results for equation (1) when NO2 is environmental indicator : infant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0214	0.01	-0.0016	0.83	-0.0371	0.00	0.0058	0.71	-0.0301	0.00	-0.0017	0.83
NO2	-0.2998	0.85	0.397	0.76	1.3766	0.36	0.9772	0.46	0.6653	0.63	0.4806	0.66
Population density	0.0003	0.59	0.0004	0.33	0.0068	0.06	0.0029	0.35	-0.0001	0.89	2.95E-05	0.96
Urban Population	0.0043	0.18	0.0041	0.12	0.0531	0.18	0.024	0.49	0.0037	0.45	1.03E-03	0.81
Physician	-0.1273	0.05	-0.0447	0.43	-0.4145	0.00	-0.1293	0.31	-0.231	0.00	-0.0631	0.37
Gov Effective	-0.0841	0.42	-0.1669	0.07	-0.3749	0.01	-0.1164	0.39	-0.1707	0.09	-0.131	0.11
Safe water	-0.1211	0.00	-0.1391	0.00	-0.0367	0.46	0.0075	0.87	-0.083	0.02	-0.0722	0.01
Sanitation	-0.0008	0.96	0.0117	0.41	-0.1389	0.04	-0.075	0.20	-0.0205	0.39	-0.0062	0.76
Temperature	-0.0005	0.94	0.0027	0.60	0.1197	0.01	0.0626	0.22	-0.0027	0.77	0.0074	0.38
Rainfall	-0.219	0.04	-0.2371	0.01	0.2987	0.64	0.1458	0.81	-0.1114	0.44	-0.1599	0.20
Year 1995 dummy			-0.2535	0.00			-0.2648	0.00			-0.255	0.00
Year 2000 dummy			-0.4048	0.00			-0.51	0.00			-0.4123	0.00
Constant	14.7032	0.00	14.925	0.00	15.5338	0.00	6.2787	0.17	13.4142	0.00	10.1954	0.00
R-squared	0.61		0.74		0.83		0.88		0.57		0.7	
N	66		66		66		66		66		66	
Hausman					12.15	0.27						
F-test for time dummies			13.65	0.00			6.97	0.00			34.89	0.00
F-test for individual effect					6.91	0.00	6.09	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.57 Appendix 2.57 Results for equation (1) when PM is environmental indicator : infant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0207	0.00	-0.0018	0.81	-0.0398	0.00	-0.0013	0.93	-0.0286	0.00	-0.0033	0.69
Pm	0.0057	0.04	0.0028	0.25	0.0102	0.01	0.0073	0.05	0.0075	0.01	0.0035	0.18
Population density	0.0003	0.43	0.0003	0.33	0.0082	0.02	0.0044	0.16	-0.0003	0.62	-0.0001	0.86
Urban Population	0.0058	0.07	0.005	0.06	0.0609	0.10	0.033	0.32	0.0056	0.25	0.0021	0.62
Physician	-0.1036	0.07	-0.0484	0.32	-0.27	0.03	-0.0575	0.64	-0.1798	0.02	-0.0493	0.48
Gov Effective	-0.0108	0.92	-0.1264	0.19	-0.2756	0.04	-0.0711	0.59	-0.0968	0.34	-0.0951	0.26
Safe water	-0.1384	0.00	-0.1462	0.00	0.001	0.98	0.0296	0.50	-0.0737	0.03	-0.0669	0.02
Sanitation	0.0136	0.44	0.0175	0.25	-0.1414	0.02	-0.0841	0.13	-0.0042	0.86	0.0002	0.99
Temperature	-0.0034	0.56	0.0017	0.74	0.1006	0.03	0.0527	0.28	-0.005	0.58	0.0055	0.51
Rainfall	-0.2061	0.03	-0.2406	0.00	0.6128	0.31	0.3679	0.52	-0.0593	0.67	-0.1341	0.29
Year 1995 dummy			-0.2408	0.00			-0.2377	0.00			-0.2394	0.00
Year 2000 dummy			-0.3762	0.00			-0.4493	0.00			-0.3795	0.00
Constant	14.4861	0.00	14.8677	0.00	10.4672	0.02	3.7305	0.41	10.2415	0.00	8.7858	0.00
R-squared	0.64		0.75		0.85		0.89		0.59		0.7	
N	66		66		66		66		66		66	
Hausman					80.56	0.00						
F-test for time dummies			11.58	0.00			5.82	0.00			28.55	0.00
F-test for individual effect						7.64	6.75					
Time Dummies	N		Y		N		Y		N		Y	

2.8.58 Appendix 2.58 Results for equation (1) when CH4 is environmental indicator : infant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0219	0.00	-0.0009	0.91	-0.0345	0.00	0.0073	0.64	-0.0292	0.00	-0.0006	0.94
CH4	-0.0027	0.92	0.0142	0.53	0.0557	0.60	0.0275	0.77	-0.009	0.82	0.0253	0.46
Population density	0.0003	0.60	0.0005	0.26	0.0064	0.08	0.0027	0.40	-0.0003	0.73	0.0002	0.70
Urban Population	0.0043	0.24	0.0032	0.29	0.0447	0.28	0.0192	0.59	0.0046	0.41	-0.0005	0.92
Physician	-0.1234	0.05	-0.0411	0.43	-0.3935	0.00	-0.1134	0.37	-0.2383	0.00	-0.0554	0.43
Gov Effective	-0.0824	0.43	-0.1693	0.07	-0.3857	0.01	-0.1187	0.39	-0.1725	0.09	-0.1325	0.10
Safe water	-0.1222	0.00	-0.134	0.00	-0.0445	0.37	0.0027	0.95	-0.0842	0.02	-0.0693	0.02
Sanitation	-0.0008	0.96	0.0126	0.38	-0.125	0.06	-0.066	0.26	-0.0197	0.41	-0.0051	0.80
Temperature	-0.0006	0.93	0.0018	0.73	0.1215	0.01	0.0616	0.24	-0.0009	0.93	0.0053	0.55
Rainfall	-0.2097	0.04	-0.2614	0.00	0.3613	0.57	0.1633	0.78	-0.1118	0.46	-0.2017	0.12
Year 1995 dummy			-0.2581	0.00			-0.2698	0.00			-0.2619	0.00
Year 2000 dummy			-0.4081	0.00			-0.5111	0.00			-0.4174	0.00
Constant	14.7761	0.00	14.3972	0.00	15.4079	0.00	6.1651	0.18	13.4438	0.00	9.8875	0.00
R-squared	0.61		0.74		0.83		0.88		0.57		0.7	
N	66		66		66		66		66		66	
Hausman					14.62	0.15						
F-test for time dummies			13.91	0.00			7	0.00			36.04	0.00
F-test for individual effect					6.78	0.00	5.93	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.59 Appendix 2.59 Results for equation (1) when forest is environmental indicator : infant mortality rate in developed countries group

lnimr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.024	0.00	-0.0032	0.66	-0.0361	0.00	0.0096	0.54	-0.0296	0.00	-0.0021	0.80
forest	-0.0082	0.19	-0.0093	0.07	0	1.00	-0.0206	0.37	-0.0022	0.81	-0.0059	0.47
Population density	0.0002	0.62	0.0002	0.49	0.0067	0.08	0.0036	0.27	-0.0002	0.79	-0.0001	0.91
Urban Population	0.0052	0.11	0.0054	0.04	0.0501	0.21	0.0206	0.55	0.0043	0.38	0.002	0.63
Physician	-0.0998	0.09	-0.0277	0.58	-0.3992	0.00	-0.135	0.29	-0.2252	0.00	-0.0551	0.43
Gov Effective	-0.0734	0.48	-0.158	0.08	-0.3871	0.01	-0.1163	0.39	-0.1653	0.11	-0.1287	0.12
Safe water	-0.1211	0.00	-0.1391	0.00	-0.0435	0.40	0.0177	0.70	-0.0844	0.02	-0.0752	0.01
Sanitation	-0.0022	0.89	0.0096	0.49	-0.1297	0.06	-0.0793	0.18	-0.0191	0.42	-0.006	0.76
Temperature	-0.0015	0.80	0.0025	0.60	0.1266	0.01	0.0733	0.16	-0.0021	0.81	0.0074	0.36
Rainfall	-0.1922	0.05	-0.223	0.01	0.3412	0.60	0.1413	0.81	-0.1237	0.38	-0.1618	0.18
Year 1995 dummy			-0.2577	0.00			-0.2814	0.00			-0.259	0.00
Year 2000 dummy			-0.4059	0.00			-0.552	0.00			-0.4143	0.00
Constant	14.741	0.00	15.0591	0.00	15.4561	0.00	5.8516	0.20	13.3935	0.00	10.4316	0.00
R-squared	0.62				0.83		0.88		0.58		0.72	
N	66		66		66		66		66		66	
Hausman					13.59	0.19						
F-test for time dummies			14.85	0.00			7.72	0.00			35.99	0.00
F-test for individual effect					6.45	0.00	5.69	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.60 Appendix 2.60 Results for equation (1) when BOD is environmental indicator : infant mortality rate in developed countries group

	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0204	0.01	-0.0011	0.89	-0.0331	0.01	0.0073	0.64	-0.0258	0.00	-0.0013	0.87
BOD	0.0138	0.54	0.0003	0.99	0.0559	0.32	-0.0186	0.73	0.052	0.07	-0.0041	0.88
Population density	0.0003	0.50	0.0003	0.35	0.0057	0.12	0.003	0.36	-0.0002	0.76	-1.71E-05	0.97
Urban Population	0.0038	0.24	0.0042	0.11	0.0409	0.31	0.0237	0.50	0.0018	0.71	0.0014	0.74
Physician	-0.1312	0.03	-0.0532	0.30	-0.367	0.00	-0.1139	0.37	-0.2434	0.00	-0.0638	0.37
Gov Effective	-0.0925	0.38	-0.1676	0.07	-0.309	0.05	-0.132	0.35	-0.1591	0.11	-0.1326	0.11
Safe water	-0.1219	0.00	-0.1389	0.00	-0.0264	0.61	-0.0003	1.00	-0.0749	0.04	-0.0733	0.01
Sanitation	-0.0007	0.97	0.0113	0.43	-0.124	0.06	-0.0675	0.25	-0.0215	0.35	-0.0051	0.80
Temperature	0.0007	0.91	0.0032	0.55	0.1049	0.04	0.0676	0.20	0.0046	0.63	0.0074	0.40
Rainfall	-0.2323	0.03	-0.2459	0.01	0.3224	0.61	0.144	0.81	-0.1857	0.20	-0.1649	0.19
Year 1995 dummy			-0.2536	0.00			-0.2831	0.00			-0.2597	0.00
Year 2000 dummy			-0.4008	0.00			-0.5336	0.00			-0.4137	0.00
Constant	14.7328	0.00	14.9729	0.00	13.6733	0.01	6.3707	0.18	12.58	0.00	10.2117	0.00
R-squared	0.61		0.74		0.83		0.88		0.56		0.71	
N	66		66		66		66		66		66	
Hausman					3.27	0.97						
F-test for time dummies			13.33	0.00			6.55	0.00			29.48	0.00
F-test for individual effect					6.9	0.00	5.99	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.61 Appendix 2.61 Results for equation (1) when CO2 is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0311	0.00	-0.0068	0.36	-0.036	0.00	-0.0003	0.98	-0.0342	0.00	-0.0036	0.62
co2	0.0247	0.01	0.017	0.03	0.0525	0.05	0.0248	0.31	0.0243	0.06	0.0157	0.12
Population density	0.0002	0.67	0.0002	0.57	0.0045	0.18	0.0022	0.45	-0.0002	0.73	-0.0001	0.91
Urban Population	0.0011	0.70	0.0018	0.42	0.0368	0.32	0.0254	0.44	0.0024	0.59	0.0006	0.87
Physician	-0.0381	0.55	-0.0018	0.97	-0.3826	0.00	-0.1273	0.28	-0.1837	0.01	-0.0422	0.50
Gov Effective	0.0133	0.89	-0.1037	0.22	-0.3285	0.01	-0.1131	0.36	-0.1281	0.17	-0.1216	0.09
Safe water	-0.095	0.00	-0.1148	0.00	-0.0517	0.24	-0.0145	0.72	-0.0818	0.01	-0.076	0.00
Sanitation	-0.0103	0.50	0.0023	0.85	-0.1234	0.03	-0.068	0.20	-0.025	0.25	-0.0072	0.68
Temperature	0.004	0.44	0.0081	0.06	0.0892	0.04	0.0416	0.37	0.0009	0.91	0.0107	0.13
Rainfall	0.0186	0.85	-0.0551	0.50	0.3584	0.53	0.143	0.79	0.0584	0.68	-0.0292	0.80
Year 1995 dummy			-0.2388	0.00			-0.2418	0.00			-0.2398	0.00
Year 2000 dummy			-0.4017	0.00			-0.4557	0.00			-0.4151	0.00
Constant	12.7932	0.00	13.3603	0.00	16.7924	0.00	8.0525	0.07	13.575	0.00	10.612	0.00
R-squared			0.79		0.87		0.9		0.63		0.78	
N	66		66		66		66		66		66	
Hausman					66.38	0.00						
F-test for time dummies			17.48	0.00			6.41	0.00			42.2	0.00
F-test for individual effect					6.99	0.00	5.25	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.62 Appendix 2.62 Results for equation (1) when NO2 is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0213	0.00	0.0007	0.92	-0.0416	0.00	-0.0011	0.94	-0.0309	0.00	-0.0005	0.94
NO2	0.0638	0.97	0.9147	0.44	1.7182	0.22	1.3136	0.27	0.8577	0.51	0.8114	0.41
Population density	0.0001	0.79	0.0003	0.47	0.0069	0.04	0.0032	0.27	-0.0001	0.93	0.0001	0.89
Urban Population	0.003	0.32	0.0028	0.23	0.0667	0.07	0.0391	0.22	0.0038	0.41	0.0012	0.76
Physician	-0.1377	0.03	-0.0473	0.35	-0.3971	0.00	-0.1224	0.29	-0.24	0.00	-0.0673	0.28
Gov Effective	-0.0734	0.46	-0.172	0.04	-0.3603	0.01	-0.1033	0.40	-0.1608	0.09	-0.1368	0.06
Safe water	-0.102	0.00	-0.1213	0.00	-0.0519	0.26	-0.0089	0.82	-0.0824	0.02	-0.0739	0.00
Sanitation	-0.0081	0.62	0.0057	0.66	-0.1337	0.03	-0.0728	0.17	-0.0197	0.37	-0.0034	0.85
Temperature	0.004	0.49	0.0074	0.11	0.0977	0.03	0.0362	0.43	0	1.00	0.0105	0.16
Rainfall	-0.114	0.24	-0.1293	0.09	0.2266	0.70	0.0307	0.95	-0.0476	0.72	-0.093	0.40
Year 1995 dummy			-0.247	0.00			-0.2615	0.00			-0.2459	0.00
Year 2000 dummy			-0.4408	0.00			-0.4839	0.00			-0.4346	0.00
Constant	13.6839	0.00	13.8802	0.00	15.9934	0.00	7.1761	0.09	13.4064	0.00	10.1674	0.00
R-squared	0.62		0.77		0.85		0.9		0.59		0.76	
N	66		66		66		66		66		66	
Hausman					15.55	0.11						
F-test for time dummies			19.22	0.00			8	0.00			43.96	0.00
F-test for individual effect					7.39	0.00	5.85	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.63 Appendix 2.63 Results for equation (1) when PM is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0202	0.00	0.0016	0.81	-0.0433	0.00	-0.0055	0.70	-0.0292	0.00	-0.001	0.90
pm	0.0043	0.11	0.0011	0.62	0.0082	0.04	0.0053	0.12	0.0062	0.03	0.002	0.40
Population density	0.0001	0.73	0.0001	0.65	0.008	0.01	0.0041	0.16	-0.0003	0.64	-0.0001	0.90
Urban Population	0.0043	0.16	0.0035	0.15	0.0716	0.05	0.0441	0.16	0.0055	0.22	0.0021	0.60
Physician	-0.1256	0.02	-0.0648	0.15	-0.274	0.02	-0.0606	0.59	-0.2015	0.00	-0.0627	0.32
Gov Effective	-0.0198	0.85	-0.1572	0.08	-0.2857	0.02	-0.072	0.56	-0.103	0.28	-0.1169	0.12
Safe water	-0.1149	0.00	-0.1237	0.00	-0.0246	0.60	0.0047	0.91	-0.0758	0.02	-0.0708	0.01
Sanitation	0.0026	0.88	0.0071	0.60	-0.1317	0.02	-0.0748	0.15	-0.0055	0.81	0.001	0.95
Temperature	0.0022	0.69	0.0079	0.09	0.0853	0.05	0.0305	0.50	-0.0016	0.85	0.0101	0.18
Rainfall	-0.1106	0.22	-0.1468	0.05	0.4983	0.39	0.2031	0.70	-0.0122	0.93	-0.0881	0.43
Year 1995 dummy			-0.2427	0.00			-0.2453	0.00			-0.2391	0.00
Year 2000 dummy			-0.4223	0.00			-0.4438	0.00			-0.4141	0.00
Constant	13.5545	0.00	13.9481	0.00	11.879	0.01	5.2065	0.22	10.8257	0.00	9.2959	0.00
R-squared	0.64		0.78		0.87		0.91		0.6		0.76	
N	66		66		66		66		66		66	
Hausman					42.96	0.00						
F-test for time dummies			16.79	0.00			6.83	0.00			37	0.00
F-test for individual effect					7.76		6.19					
Time Dummies	N		Y		N		Y		N		Y	

2.8.64 Appendix 2.64 Results for equation (1) when CH4 is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0213	0.00	0.0023	0.72	-0.0384	0.00	0.001	0.94	-0.0295	0.00	0.0012	0.87
CH4	0.0128	0.62	0.0308	0.12	0.065	0.51	0.0418	0.62	0.0046	0.90	0.0385	0.19
Population density	0.0002	0.61	0.0005	0.23	0.0064	0.06	0.0028	0.34	-0.0001	0.87	0.0004	0.49
Urban Population	0.0021	0.54	0.001	0.71	0.0566	0.14	0.0321	0.33	0.0038	0.46	-0.0011	0.80
Physician	-0.1294	0.03	-0.0408	0.38	-0.3714	0.00	-0.1008	0.38	-0.2419	0.00	-0.0554	0.37
Gov Effective	-0.0739	0.46	-0.1771	0.03	-0.3739	0.00	-0.1063	0.40	-0.1612	0.09	-0.1397	0.05
Safe water	-0.0974	0.01	-0.1103	0.00	-0.0616	0.19	-0.0154	0.70	-0.0813	0.02	-0.0699	0.01
Sanitation	-0.0072	0.66	0.0074	0.56	-0.1168	0.06	-0.0603	0.26	-0.0185	0.40	-0.0016	0.93
Temperature	0.0028	0.64	0.0056	0.23	0.1003	0.03	0.0343	0.47	0.0007	0.94	0.0075	0.33
Rainfall	-0.129	0.18	-0.1829	0.02	0.3031	0.00	0.0543	0.92	-0.0689	0.62	-0.1578	0.16
Year 1995 dummy			-0.2569	0.00			-0.2682	0.00			-0.2567	0.00
Year 2000 dummy			-0.4475	0.00			-0.4844	0.00			-0.442	0.00
Constant	13.1719	0.00	12.7449	0.00	15.8402	0.61	7.0357	0.10	13.2153	0.00	9.7252	0.00
R-squared	0.62		0.78		0.85		0.9		0.6		0.77	
N	66		66		66		66		66		66	
Hausman					19.58	0.03						
F-test for time dummies			20.59	0.00			8.01	0.00			47.14	0.00
F-test for individual effect					7.07	0.00	5.38					
Time Dummies	N		Y		N		Y		N		Y	

2.8.65 Appendix 2.65 Results for equation (1) when forest is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.023	0.00	-0.0005	1.00	-0.0405	0.00	0.0038	0.79	-0.03	0.00	-0.0005	0.94
forest	-0.0073	0.22	-0.0084	0.07	-0.0059	0.81	-0.0254	0.23	-0.0028	0.74	-0.0069	0.34
Population density	0	0.92	0.0001	0.86	0.0071	0.05	0.004	0.18	-0.0002	0.75	-0.0001	0.87
Urban Population	0.0039	0.19	0.0042	0.07	0.0632	0.09	0.0345	0.27	0.0044	0.33	0.0023	0.54
Physician	-0.1199	0.04	-0.0438	0.33	-0.3888	0.00	-0.1277	0.27	-0.2357	0.00	-0.06	0.33
Gov Effective	-0.0657	0.50	-0.1645	0.04	-0.3775	0.00	-0.1035	0.40	-0.1549	0.10	-0.1332	0.07
Safe water	-0.102	0.00	-0.121	0.00	-0.0571	0.24	0.0032	0.94	-0.0825	0.02	-0.0757	0.00
Sanitation	-0.0096	0.55	0.0032	0.80	-0.1268	0.05	-0.0773	0.15	-0.0191	0.38	-0.0035	0.84
Temperature	0.0035	0.52	0.0079	0.07	0.1082	0.02	0.0496	0.29	0.001	0.90	0.0111	0.12
Rainfall	-0.0974	0.29	-0.1284	0.07	0.2662	0.66	0.0271	0.96	-0.0591	0.65	-0.0973	0.36
Year 1995 dummy			-0.2512	0.00			-0.2827	0.00			-0.2522	0.00
Year 2000 dummy			-0.4364	0.00			-0.5365	0.00			-0.438	0.00
Constant	13.7559	0.00	14.0669	0.00	16.0026	0.00	6.6291	0.11	13.3321	0.00	10.3212	0.00
R-squared	0.63		0.79		0.85		0.9		0.6		0.77	
N	66		66		66		66		66		66	
Hausman					15.08	0.12						
F-test for time dummies			20.35	0.00			9.23	0.00			45.75	0.00
F-test for individual effect					6.78	0.00	5.53	0.00				
Time Dummies	N		Y		N		Y		N		Y	

2.8.66 Appendix 2.66 Results for equation (1) when BOD is environmental indicator : child mortality rate in developed countries group

lncmr	Pooled OLS				Fixed Effects				Random Effects			
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z
Per capita GDP	-0.0191	0.01	0.0024	0.72	-0.0386	0.00	0.0013	0.92	-0.0265	0.00	0.0001	0.98
BOD	0.018	0.40	0.0055	0.75	0.0328	0.54	-0.0485	0.33	0.0467	0.08	-0.0079	0.75
Population density	0.0001	0.80	0.0001	0.68	0.0062	0.07	0.0034	0.24	-0.0002	0.76	-1.18E-05	0.98
Urban Population	0.0025	0.40	0.003	0.20	0.0575	0.13	0.0414	0.20	0.0022	0.63	0.0019	0.63
Physician	-0.1518	0.01	-0.0709	0.13	-0.3592	0.00	-0.1016	0.37	-0.2525	0.00	-0.0681	0.28
Gov Effective	-0.0868	0.38	-0.1774	0.03	-0.3298	0.03	-0.1403	0.28	-0.1511	0.10	-0.1391	0.06
Safe water	-0.103	0.00	-0.121	0.00	-0.0504	0.30	-0.024	0.56	-0.0755	0.02	-0.0754	0.00
Sanitation	-0.0083	0.61	0.0046	0.72	-0.1189	0.05	-0.0624	0.23	-0.0202	0.35	-0.0016	0.93
Temperature	0.0061	0.31	0.0091	0.06	0.0935	0.06	0.046	0.33	0.0069	0.43	0.0106	0.18
Rainfall	-0.1411	0.15	-0.1562	0.04	0.2685	0.65	0.0044	0.99	-0.12	0.36	-0.0998	0.37
Year 1995 dummy			-0.244	0.00			-0.3022	0.00			-0.255	0.00
Year 2000 dummy			-0.43	0.00			-0.5369	0.00			-0.4386	0.00
Constant	13.7757	0.00	14.0097	0.00	14.8514	0.00	7.6463	0.07	12.6467	0.00	10.1679	0.00
R-squared	0.63		0.78		0.85		0.9		0.59		0.76	
N	66		66		66		66		66		66	
Hausman					2.25	0.99						
F-test for time dummies			18.2	0.00			8.6	0.00			38.24	0.00
F-test for individual effect					6.98	0.00	5.86	0.00				
Time Dummies	N		Y		N		Y		N		Y	

Chapter 3 Environmental Health in Thailand

3.1. Introduction

The Thai people consider rivers to be the foundation of life. But Thailand's rivers are becoming increasingly polluted. Almost a third of the country's total available surface water is unsuitable for human consumption (Pollution Control Department , 2000). The decline in water quality has been contemporaneous with economic development and population growth. Between 1990 and 1996, Thailand's GDP grew at 8.5% per year. The government's national development plans have aimed to develop the economy mostly through industrialization, as well as agricultural production. As result, many of Thailand's rivers have become polluted by industrial wastes. Farming also causes pollution through its discharge of animal wastes, agricultural chemicals, and sediment into rivers. As economic growth has proceeded, Thailand's population has also grown at a rapid rate (1.96% annual population growths in the 1990s). In the year 2000, municipal urban areas had a population accounting for 31.1 % compared with 18.7% in 1990. In urbanizing areas, rivers have become polluted due to the discharge of untreated wastewater from households. As a result of growing domestic, agriculture and industrial wastewater, water quality in most of Thailand's rivers is poor.

This study focuses on the consequences for waterborne diseases of water contamination by biological agents. Pollution by chemical agents is also a concern in particular regions of Thailand, but biological agents are a concern throughout the entire country. Perhaps the most direct impact of this contamination on the welfare of the Thai people is the resulting burden of waterborne diseases, including diarrhea, dysentery, cholera, and typhoid. Waterborne diseases account for 25 to 35% of all hospital cases in Thailand (Ministry of Public Health , 2000). According to the Department of Public Health of Thailand, the top ten leading causes of morbidity in the country include diarrhea and dysentery. Specifically, diarrhea has been the leading causes of morbidity for the past decade.

This chapter investigates the interrelationships between economic growth, water pollution, and the health status of the Thai population. These relationships are commonly examined in the framework of the environmental Kuznet's curve (EKC) relating income and environmental quality, the Preston curve relating income and health, and environmental health models of health outcomes as a function of environmental quality. While there is a substantial literature on these relationships, none have been empirically estimated for Thailand. Hence, the empirical results here provide an important first quantitative description and assessment of the relationships between water quality, economic growth, and public health at the provincial level for all of Thailand for the past couple decades (1994 - 2003). This complements the more typical cross-country analyses of these relationships and can help raise the awareness of Thai policy makers regarding the importance of water quality and the challenges of steering the country on a sustainable development path.

This paper is structured as follows. The next section introduces Thailand, with a focus on rivers, water quality, and water borne diseases. Section two discusses prior literature and the conceptual framework. Section three describes the empirical approach. Section four presents and discusses the data, focusing on measures of water quality. Section five presents the empirical results. Section six concludes and discusses.

3.2. Thailand

Thailand is a tropical developing country in South East Asia, with an area of 513,115 square kilometers and population of approximately 63 million people in 2002. The urban population is about 12 million with high density in the national and provincial capitals. Thailand is divided into 76 provinces in five regions: North, Central, Northeast, East and South.

The North region is mountainous with four upstream rivers (Nan, Ping, Wang, and Yom) flowing southward to form the Chao Phrya River in the Central region. The Northeast region, which is dominated by a large plateau, covers one third of Thailand’s land area. However, poor soils, seasonal drought and seasonal heavy flooding in this region lead to low soil fertility, low agricultural productivity and consequently low incomes for populations in this area.

In sharp contrast to the Northeast, the Central region is the most fertile area for agriculture. The region is dominated by the Chao Phraya river and its tributaries, which provide an ample water supply for agricultural irrigation. Bangkok, which is the capital of and largest urban area in Thailand, is also situated on the southern edge of the region with population of approximately 7 million people.

The East region consists of a series of low mountain ranges and small basins from short rivers, which drain into the Gulf of Thailand. The Bangpakong river is the most important watershed in this region. The Eastern Seaboard industrial development, which has been promoted by the central Thai government, has attracted both domestic and foreign investment to this region. Finally, the South region is a narrow peninsula with steep coast on the west side, and river plains on the east side. The landscape includes agriculture, forest, mountains, beaches, and many islands. The largest and longest river of the South region is Tapi, which has a major tributary called Phum Duang.

3.2.1. Water Quality in Thailand

Water pollution in Thailand originates from the domestic, industrial and agricultural sectors. In agricultural areas, the plentiful surface water is used and recycled back to the rivers. Raising livestock, poultry farming, aquaculture and crop cultivation all generate waste water with organic and inorganic pollutants. In 2006, the agricultural sector generated 14 million cubic meters of wastewater per day, resulting in 890 ton BOD/day (Pollution Control Department, 2006). Agricultural sources of BOD are highest in the northeastern and central regions, which account for more than 29 percent of the country's organic wastewater pollution (Pollution Control Department, 2006). The dominant source of organic pollution, however, is domestic wastewater, which contributes 54 percent of the country's organic wastewater pollution. "Domestic" wastewater originates from both homes and commercial establishments. In 2006, the Bangkok Metropolitan Region (BMR) generated approximately 9 million cubic meters of wastewater per year, or 2,600 ton BOD/day in total, which accounted for 81 percent of total BOD pollution generated in the Central region.

In addition to domestic and agricultural activities, Thailand was ranked 14th worst in the world in 2000 in terms of industrial organic water pollution (World Bank, 2003). In 2006, approximately 120,000 factories throughout the country generated 6.8 million cubic meters of wastewater daily, totally resulting in 2,700 ton BOD/day. The bulk of the industrial wastewater is generated in the Central and East regions, where there are industrial development zones promoted by the government. The top three industrial sectors in terms of percentage of BOD are pulp and paper (32%), industrial chemical (15%) and sugar factories (10%) respectively (Pollution Control Department, 2006).

3.2.2. Waterborne disease in Thailand

The health impacts of water degradation can be measured in terms of the burden of waterborne diseases, including diarrhea, dysentery, cholera, and typhoid. While mortality from these diseases clearly also depends on the quality and accessibility of health care, morbidity is tightly linked to consumption and use of contaminated water, often compounded by poor hygiene (WHO, 2000). In this section, I draw on data from Annual Public Health Statistic by Bureau of Policy and Strategy, Ministry of Public Health (MOPH), Annual Surveillance Report by Bureau of Epidemiology, MOPH, Thai Health Profile by Bureau of Policy and Strategy, MOPH, and Thailand Health Report by Institute of Population and Social Researches, Thai Health Foundation. I focus on the year 2003, which is the most recent year included in the panel dataset that I use for model estimation. All hospitals and health care services in Thailand are required to collect epidemiologic data on waterborne diseases. “Notifiable disease reports” are forwarded to the provincial health office, or to the

Bangkok Metropolitan Administration. At all 76 provincial health offices, the data are analyzed to monitor the local situation, and then sent to Bureau of Epidemiology, MOPH. The national statistics and details of prevalence of each disease in each province are published in an Annual Surveillance Report. In 2003, acute diarrhea[3] represented the greatest number of cases, and thus the highest morbidity rate, of any disease in Thailand, with 966,760 cases or 1,536 occurrences per 100,000 population. In the same year, dysentery[4] was ranked 10th in terms of total morbidity with 23,110 total or 37 cases per 100,000 population. The morbidity rates for cholera and typhoid (enteric fever) were 1.59 and 15.72 per 100,000 respectively. Morbidity and mortality for all diseases under surveillance in Thailand in 2003 are reported in Table 3.1.

As in other parts of the world, diarrhea is a major public health problem in Thailand. There have been substantial improvements over the past decade. For example, the mortality rate of diarrhea has declined from 1.11 per 100,000 population in 1994 to 0.15 per 100,000 population in 2003. However, the morbidity rate has remained relatively stable over the time at 1,488.82 and 1,536.08 per 100,000 population in 1994 and 2003, respectively. The

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[3] Acute diarrhea is defined as a disorder in which people develop loose stools and increased frequency of stools. Acute diarrhea lasts less than 14 days.

[4] Dysentery is defined as a group of gastrointestinal disorders characterized by inflammation of the intestines, particularly the colon. Characteristic features include abdominal pain and cramps, straining at stool (tenesmus), and frequent passage of watery diarrhea or stools containing blood and mucus.

mortality rate for dysentery has decreased from 0.03 in 1994 to less than 0.001 per 100,000 population in 2003. Unlike that of diarrhea, the morbidity rate of dysentery has also decreased more than three-fold from 135.95 per 100,000 population in 1994 to 36.72 per 100,000 population in 2003. Dysentery incidence remains high among the population under five years of age, over 65 years of age, and 55-64 years of age. In 2003, the morbidity rates of dysentery for those age groups were 176.88, 38.19 and 29.99 per 100,000 population respectively. Although children under five years of age were only 8% of population, they accounted for 40.3% of dysentery cases. The incidence of dysentery is lowest in middle-aged members of the population and increases again for those over 55 years of age.

The incidences of both typhoid and cholera are reported to have fallen to very low levels in Thailand. In the case of typhoid (enteric) fever, this is largely due to the wide availability of oral and parenteral vaccine. The morbidity rate was 28.77 per 100,000 population in 1994 compared to 15.72 per 100,000 population in 2003. In 2003, 9,893 cases and three deaths from typhoid fever were reported. The incidence of cholera has also decreased largely due to improvements in sanitary standards for food and the availability of treated water. Only small cluster outbreaks in slums and river estuaries have been reported in recent years. In 2003, the reported cases and deaths from cholera were 1,002 and 7 respectively. Thus, the morbidity rate of cholera was 1.59 per 100,000. One concern with the public data on typhoid and cholera is that there may be incentives to underreport (or in some

Table 3.1 Ranking of Morbidity Rate of Diseases under Surveillance, Thailand, 2003 (BE.2546)

Rank	Diseases	Cases	Deaths	Morbidity Rate (Per 100,000 Pop.)
1	Acute diarrhea	966760	124	1536.08
2	Pyrexia of Unknown Origin	188743	27	299.89
3	Haemorrhagic Conjunctivitis	135618	0	215.48
4	Food Poisoning	131561	14	209.04
5	Pneumonia	129417	1042	205.63
6	Dengue Haemorrhagic Fever –Total	63657	75	101.14
7	Chickenpox	42530	1	67.58
8	Tuberculosis –Total	34643	219	55.04
9	Influenza	29918	0	47.54
10	Dysentery –Total	23110	1	36.72
11	Malaria	19910	31	31.63
12	Sexually transmitted diseases - Total	16204	0	25.75
13	Mumps	11069	0	17.59
14	Enteric fever –Total	9893	3	15.72
15	Snake bite	8018	6	12.74
16	Hepatitis –Total	7152	14	11.36
17	Herpes Zoster	6009	1	9.55
18	Suicide	5028	170	7.99
19	Leptospirosis	4962	82	7.88

years, simply not report) these diseases in order to protect the tourism industry. This is less likely to be the case with diarrhea and dysentery because these are not such high profile diseases and less likely to result in negative news coverage or travel warnings[5].

3.3. Prior literature and conceptual framework

3.3.1. Income & health

The rule of thumb for this relationship is that "wealthier countries are healthier countries." Many previous studies have found a relationship between per capita income and public health mostly in cross-country comparisons such as Leu (1986); Parkin, McGuire, & Yule (1987); Hitiris & Posnett (1992); Benzeval & Webb (1995); Pritichett & Summers (1996). A similar relationship has been found between per capita income and health within countries (at the regional level), such as (Sorlie, Backlund & Keller, 1995; Ecob & Smith, 1999). Increasing income is associated with better health but at a diminishing rate at higher levels of income (Ecob & Smith, 1999).

Most of the literature on distribution and evolution of income and health within countries has focused on developed countries (e.g., Sorlie, Backlund & Keller, 1995; Ecob &Smith, 1999; Martikainen, Makela, Koskinen & Valkonen, 2001). There are few studies in middle-income and low-income countries (Buve, Bishikwabo-Nsarhaza & Mutangadura, 2002; Mahkuz 2008), and apparently none in Thailand.

[5] (Zuckerman, Rombo, & Fisch, 2007) stated that with increasing tourism to areas, the official figures of cholera problem are likely to continue to under-report

3.3.2. Environmental Kuznets Curve (EKC)

The Environmental Kuznets Curve (EKC) hypothesis posits an inverted-U shape relationship between per capita GDP and environmental degradation. This is based on the observation that environmental degradation and pollution generally increase in the early stages of economic growth. However, beyond some level of per capita income (the turning point), environmental degradation and pollution rates slow down or even reverse. One explanation that has been offered for the proposed shape of the EKC is the natural progression of economic development from clean agricultural economy to polluting industrial economy to clean service economy. Another explanation offered for the turning point is that environmental quality is a luxury good. In any case, the empirical evidence on the EKC hypothesis for water is mixed, with results depending on the set of countries included in the sample.

The EKC literature began with Grossman & Krueger (1994) and Grossman (1995), who examined the empirical relationship between per capita income and water quality indicators by using data from the Global Environment Monitoring System (GEM)/Waters project. They found evidence of inverted-U shaped curve for BOD, chemical oxygen demand (COD) and fecal coliform, N-shaped curve for total coliform and monotonically increasing curve for DO. Shafik (1994) used a similar empirical approach to examine per capita income and DO as well as fecal coliform using cross-country data from 1960 to 1990. He found that DO has a negative linear relationship with economic growth, while fecal coliform shows N-shaped curve relationship with economic growth. Sample biases from the most polluted rivers are a possible explanation for the increase in fecal coliform at high income level. Another possible reason is that improvements in water supply systems lead people to use less water from the river and thus be less concerned about river water quality. Torras & Boyce (1998) used the same GEM/Water data set as Grossman & Kruger (1994) to reassess the EKC hypothesis. They concluded that DO is increasing with economic growth. Fecal coliform shows inverted-U shaped curve relationship with economic growth. When income inequality is included as a covariate, DO has N-shaped relationship with income and the income effect recedes into statistical insignificance for fecal coliform. (Hettige, Muthukumara, & Wheeler, 2000) investigated the relationship between industrial water pollution and economic development using data from environmental protection agencies in twelve countries. Their findings do not support the EKC hypothesis but rather suggest that industrial water emissions rise until countries attain middle income status, and then remain approximately constant as they grow richer. Recently, Yang, Zhang, Wang & Xia (2006) investigated the EKC for industrial water use and income in the OECD countries. Their result supports the EKC hypothesis that industrial water use has experienced an increase, level-off and then decrease with increasing income in most OECD countries.

In sum, previous research has reached widely varying conclusions on the EKC for water quality, by examining different sets of countries and time periods, controlling for different sets of covariates, and employing different measures of water quality. These include a) the concentration of pathogens in the water (indirectly measured by fecal or total coliforms), b) amount of toxic chemicals discharged in the water by human activities (lead, cadmium, mercury, and arsenic), and c) measures of deterioration of the water oxygen regime (dissolved oxygen, biological and/or chemical oxygen demand).

This wide variation in findings also characterizes the broader literature on the EKC. There is no single relationship that is consistent across all studies. Stern, Common & Barbier (1996) suggested that analyses of EKC for individual countries is preferred to cross-country analyses, because more could be learnt from examining the experiences of individual countries at varying levels of development as they develop over time. Vincent (1997) agreed that the cross-country version of EKC is likely just a statistical artifact. He found that pollution-income relationships from cross-countries studies fail to predict accurately trends in air and water pollution in Malaysia. He used a panel data set of six pollution indicators from Malaysian states to estimate pollution-income relationship and did not find any evidence for the EKC hypothesis. In the same year, Carson, Jeon & McCubbin (1997) used data from the 50 US states, and found that per capita emissions of air toxics decrease as per capita income increases. Thus, there are inconclusive results for the relationship between environment and economic growth even in the single-country studies.

There are very few empirical EKC studies specifically on water in a single country or the sub-national level. Vincent (1997) presented the first analysis of water pollution and income in a developing country, Malaysia. He measured water quality as BOD, COD, ammoniacal nitrogen, pH and suspended solids. Empirical results show that income is not significantly associated with BOD, COD, or suspended solids. Ammoniacal nitrogen and pH have positive relationship with income, which means that increasing income is associated with worse water pollution. Paudel, Zapata & Susanto (2005) used data from 53 Louisiana parishes over a 14-yeacr period to investigate the EKC hypothesis. They found that per capita income and the level of nitrogen (N), phosphorus (P), and DO follows EKC curve relationship. Song, Zheng & Tong (2008) used Chinese provincial data from 1985 to 2005 to examine the existence of the EKC relationship between per capita GDP and per capita waste water. They found that inverted N-shaped relationship for wastewater. Most recently, Anamika & Hubacek (2008) examined the relationship between economic growth and water pollution for 16 states of India. Their results suggest an inverted U-shaped curve for 4 states, U-shaped curves for 2 states and N-shaped curves for 6 states.

3.3.3. Environmental Health

The literature on environmental health recognizes that the impact of the environment on health is mediated by behavior - including social factors such as health infrastructure, demographic factors such as urbanization, and individual knowledge and decisions, for example, regarding sanitation. Pruss-Ustun & Corvalan (2006) report that approximately one-quarter of global disease burden, and one-third of the burden among children is due to environmental quality. Pruss, Kay, Fewtrell & Bartram (2002) used intervention studies to estimate the disability-adjusted life year (DALY) impacts of water, sanitation and hygiene. They found that lack of clean water, sanitation and hygiene are responsible for 4.0% of all deaths and 5.7% of the total disease burden globally. Heller, Colosimo & Figueiredo. (2003) studied the impact of environmental sanitation on the incidence of diarrhea among children under five years of age. They found that both behaviors and environmental conditions, such as washing fruit and vegetable, presence of wastewater in the street, domestic water reservoir condition, feces disposal from swaddle and presence of vectors in the house, are significantly associated with the incidence of diarrhea. Clasen, Haller, Walker, Bartram & Cairncross (2007) studied the effectiveness of improved water supplies and sanitation in preventing diarrhea. Their study was consistent with the results from Esrey, Potash, Roberts & Shiff (1991) that better water quality reduced the incidence of ascariasis, diarrhea, schistosomiasis, and trachoma, but its role in diarrhea disease control was less important than that of sanitation and hygiene.

Access to water supply and sanitation are basic human needs and rights that directly impact on improved health. In addition, water supply and sanitation are two of the most main keys in development (Bendahmane, 1993). In term of public investment in health infrastructure, Word Bank (2002) showed that spending on health infrastructure in developing countries, especially in sub-Saharan Africa, remains considerably lower than in developed countries. In 2000, one-sixth of the global population did not have access to improved water supply and two-fifths of global population did not have access to improved sanitation. The absence of public health infrastructure in low income countries significantly undermines overall country's health status. Basically, water supply and sanitation project is associated with country's growth or country's income since water supply and sanitation project mainly depends on fiscal constraint.

3.3.4. Conceptual framework

Following the literature described above, the incidence of waterborne diseases can be considered a function of income, water quality, and preventive measures such as investments in sanitation. While the rule of thumb that "wealthier countries are healthier countries" may apply, the relationship between income and health is mediated by environmental quality and public health investments. In turn, environmental quality and these investments in health infrastructure are also functions of the level of development, or income. In all of these relationships, there are likely to be feed-back loops over time if not simultaneity. Thus, I turn next to my empirical approach, which employs panel methods to assess the underlying drivers of waterborne disease incidence in Thailand.

3.4. Empirical approach/methods

$$H_{it} = f\,(X_{it}, E_{it}, Y_{it,,} S_{it}\ ; \tau, \rho) \tag{1}$$

$$E_{it} = f\,(X_{it}\ ; \tau, \rho) \tag{2}$$

$$Y_{it} = f\,(X_{it}\ ; \tau, \rho) \tag{3}$$

$$H_{it} = f\,(X_{it}; \tau, \rho) \tag{4}$$

The primary model relates morbidity rates (H_{it}) to income (X_i) and environmental quality (E_{it}) controlling for some key socioeconomics (S_{it}), prevention factors (Y_{it}). This model is estimated both with the full set of water quality variables and with each individual water quality variable in a separate model. Second, the environmental Kuznet curve model relates a province's environment quality (E_{it}) to its income level (X_{it}) as in equation (2). Equation 3 relates a province's prevention level (Y_{it}) to its income level (X_{it}). Finally, the Preston model suggests that a province's health status (H_{it}) depends on its income level (X_{it}) as in equation (4).

In each case, we cannot observe all of the possible confounding factors, represented as τ and ρ. To address this, we employ panel estimation techniques that allow for possibility of time specific (τ) and province specific (ρ) effects where i = 1,…., n province and t = 1,…., T years. For each model (1 – 4), we first estimate a pooled model, then compare fixed and random, and finally consider year dummies or a time trend.

When statistical tests suggest that fixed effects with time dummies is the best model, this may create an interpretation problem if time-invariant or rarely changing variables are of policy interest (Beck, 2001; Baltagi 2001). Thus, I also employ Plumper and Troeger technique for decomposing the unit effects. Specifically, Plumper & Troeger (2007) combine a quasi-OLS estimate of time-invariant and slowly changing variables with quasi-fixed-effects estimate of the time varying variables.

3.5. Data Sources

3.5.1. Health Variables (H)

The data on health outcomes used in this study are collected from Annual Epidemiological Surveillance Reports from 1994 to 2003 published by Department of Disease Control, Ministry of Public Health, Thailand. The list of 76 provinces in Thailand is shown in Table A3.1. Specifically, I examine morbidity rates for diarrhea and dysentery, which quantify the number of cases per 100 people in one year.

3.5.2. Environment Variables (E)

For water quality, I use data from the Pollution Control Department, Ministry of Natural Resource and Environment. There are 366 water quality monitoring stations across Thailand. Water quality samples are taken 3 to 4 times a year during wet and dry seasons. This study compiles the data from water quality monitoring stations by year and by province, to represent the water quality in each province of Thailand in each year from 1994 to 2003. Specifically, I compiled data on Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), and Total Coliform Bacteria (TCB) in water from each river monitored by the Pollution Control Department, Ministry of Natural Resource and Environment. Because each province contains portions of several rivers, a weighted arithmetic mean was used to measure the level of water pollutant for each province in each year. The specific indicators are as follows.

a) Biochemical Oxygen Demand (BOD)

BOD is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. Wastewater from domestic, industry and agriculture can contain a wide range of potential contaminations which increase oxygen demand. Standards for BOD levels are set by WHO as well as the Pollution Control Department. If BOD levels are less than 1.5 mg/l, the water quality is considered good. If BOD levels are between 1.5 mg/l and 2 mg/l, water is considered as fair. If BOD level are between 2.0 mg/l and 4.0 mg/l, water is considered as poor. If BOD level are higher than 4.0 mg/l, water is considered as very poor.

b) Dissolved Oxygen (DO)

DO is oxygen that is dissolved in water. The main factor contributing to changes in DO levels is the build-up of organic wastes. In order to breathe, organisms in the water have to access the oxygen in the water. The number of organisms using oxygen can influence the amount of DO present. If more oxygen is used than is being put in, DO levels decrease. Thus, low DO levels indicate water pollution. If DO levels are more than 6 mg/l, water quality is considered good. If DO levels are between 4 mg/l and 6 mg/l, water is considered as fair. If DO level are between 2 mg/l and 4 mg/l, water is considered as poor. If DO level are lower than 2 mg/l, water is considered as very poor.

c) Total Coliform Bacteria (TCB)

TCB is bacteria that come from the intestinal tracks of warm blooded animals. Not all coliforms are harmful in themselves, but they do indicate the possible presence of pathogenic bacteria. That is why it is the most common indicator of water quality. If TCB levels are less than 5000 mpn/ml, water is considered as good. If TCB levels are 5000 - 20,000 mpn/ml, water is considered as fair.

In sum, poor water quality is represented by (a) higher BOD, (b) lower DO, and (c) higher TCB.[6]

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[6] I also used principal component analysis, which is a method that reduces data dimensionality by performing a covariance analysis between factors, to define a single water quality indicator. The first principal component, which is negatively correlated with

3.5.3. Income Variable (X)

Data on Gross Provincial Product (GPP) come from National Economics and Social Development Board (NESDB)'s Yearly National Income of Thailand. GPP is available for all 76 provinces from 1994 to 2003. I use GPP in constant 1988 prices expressed in Thai Baht currency and divide by provincial population (reported by Department of Provincial Administration, Ministry of Interior) to obtain per capita GPP.

3.5.4. Socio-Economic and Prevention Variables (S, Y)

Population density (number of individuals per square kilometer) is calculated using the provincial area and provincial population from Ministry of Interior's statistical yearbooks. To represent availability of healthcare services, I collected data on the number of hospitals in each province (lagged by two years) from the statistical yearbooks of Ministry of Public Health (1992 to 2001).[7]

Data on the percentage of households with safe drinking water and sanitation are from the 1990 and 2000 Population and Housing Census reported by National Statistical Office, Ministry of Information and Communication. Households with sanitation are defined as households with a sanitary type of toilet include flush latrine or molded bucket latrine. Households with bottled drinking water, tap water, rain water or private well are considered

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BOD/TCB and positively correlated with DO, represents good water quality. However, specification testing did not suggest any advantage to using this aggregate measure of water quality, so it is not reported further.

[7] I also gathered data on education, but the enrollment rates of both primary and secondary school seemed unrealistically high and I therefore did not use these data.

to have safe drinking water. Lack of safe drinking water or sanitation is a major cause of waterborne diseases, because of exposure to infectious agents, chemical pollutants, and poor hygiene. Thus, these variables reflect public investments in preventive measures against waterborne diseases. The growth rate of sanitation and safe drinking water in each province represents the percentage change over the decade of the 1990s, because these variables are only available from the Census conducted every ten years. Thus, these are examples of the rarely changing variables that motivate the Plumper & Troeger (2007) approach.

In sum, I test the relationships between water quality, waterborne diseases, and economic growth using a panel data set for Thailand's 76 provinces from 1994 to 2003. The data that I use in the analysis are summarized in Table 3.2, with the correlation matrix presented in Table 3.3. Note that I have scaled the data such that all independent variables have a mean between 1 and 1000. This table does not include other variables that I collected, tested, but then excluded from the analysis for several reasons. First, some variables – such as typhoid and cholera – are not available for every year and seem to underreport. Second, some variables – such as percent primary school enrollment – show very little variation. Third, some variables – such as hospital beds - are highly correlated with variables included in the analysis.

3.6. Results

3.6.1. Environmental Health

My first set of models examine the relationship between health outcomes (diarrhea and dysentery rates) and the full set of explanatory variables, including income, demographics, health infrastructure, water quality. After controlling for socioeconomic factors, I expect both diarrhea and dysentery to be positively related to poor water quality – as indicated by TCB and BOD - and negatively related to good water quality, as indicated by DO. The steps in this empirical analysis are as follows:

1. OLS models of the diarrhea and dysentery rates with pooled data from all provinces and years, i.e., no dummies for provinces. The estimation results for the log-log functional form are presented in Tables A3.2 and A3.3. For the incidence rate of diarrhea, all estimated coefficients are statistically significant when time dummies are not included. With time dummies, most estimated coefficients except TCB are still significant. For the incidence rate of dysentery, all estimated coefficient but DO are statistically significant both without and with time dummies. The pooled-OLS approach completely disregards information about the time and cross-sectional dimensions of the panel data. In addition, the classical regression assumption of homoskedasticity is violated. Thus, the pooled-OLS estimators may be both biased and inconsistent (Gujarati, 2003; Wooldridge, 2002).

Table 3.2 Descriptive Statistics for Thailand

Variable	Definition	N	Mean	Std. Dev.	Min	Max
GPP	Per capita gross provincial product shown in 10, 000 baht	760	7.06	7.92	1.48	69.21
Diarrhea	Diarrhea cases per 100 people	760	1897.30	691.68	411.02	5229.98
Dysentery	Dysentery cases per 100 people	760	91.18	103.21	2.38	998.32
BOD	Biochemical oxygen demand (mg/l) * 100	760	148.48	85.79	20.00	1100.00
DO	Dissolved oxygen (mg/l) * 100	760	560.41	147.38	20.00	1050.00
TCB	Total coliform bacteria (mpn/100ml)	760	272.47	963.30	0.10	16000.00
Hospital	Number of hospitals lagged by two years	760	16.24	15.32	3.00	164.00
Year	Buddhist year (year 0 = year 543 BC)	760	2541.50	2.87	2537.00	2546.00
Pop Density	Population density (100 people per sq.km)	760	162.56	7.44	147.96	177.17
Sanitation90	Percent of households with sanitation in 1990	76	85.34	12.41	45.90	99.70
Sanitation00	Percent of households with sanitation in 2000	76	97.15	3.72	79.30	99.90
Water90	Percent of households with safe drinking water in 1990	76	79.50	15.32	43.50	99.30
Water00	Percent of households with safe drinking water in 2000	76	92.18	6.68	65.30	99.20
Growthsanit	[(Sanit_00-sanit_90)*100]/sanit_90	76	16.34	18.42	0.10	99.35
Growthwater	[(Water_00-water_90)*100/water_90	76	19.98	22.59	-2.27	76.18
GPP90	Per capita gross provincial product year 1990 shown in 10, 000 baht	76	3.06	2.84	1.11	15.55
GPP00	Per capita gross provincial product year 2000, shown in 10, 000 baht	76	6.87	8.12	1.53	47.84
GrowthGPP	(Gdp1000_00-gdp1000_90)*100/gdp1000_90	76	112.94	108.08	1.79	784.10

Table 3.3 Correlation Matrix between Independent Variables

	GPP	BOD	DO	TCB	Hospital	Pop Density	Sanitation90	Sanitation00	Water90	Water00
GPP	1.00									
BOD	0.26	1.00								
DO	-0.41	-0.28	1.00							
TCB	0.18	0.17	-0.25	1.00						
Hospital	0.24	0.23	-0.28	0.18	1.00					
Pop Density	0.37	0.15	-0.34	0.16	-0.08	1.00				
Sanitation90	0.33	0.09	-0.18	0.17	0.11	0.32	1.00			
Sanitation00	0.20	0.06	-0.16	0.09	0.13	0.26	0.63	1.00		
Water90	0.41	0.15	-0.26	0.14	0.14	0.26	0.40	0.23	1.00	
Water00	0.31	0.13	-0.29	0.10	0.12	0.26	0.44	0.54	0.70	1.00

2. Fixed-effects and random-effects are the logical estimation approaches for panel data. The fixed-effects approach is better suited to cases of unobservable province-effects and unobservable time-effects. On the other hand, if the unobserved individual heterogeneity is uncorrelated with the explanatory variable, the random-effects model is a better choice (Greene, 2003). For diarrhea rate, the F-tests for individual province effect without and with time dummies are 20.45 and 21.42 respectively (Column (c) and (d) of Table A3.2). For rate of dysentery, the F-tests for individual province effects without and with time dummies are 28.29 and 38.49 respectively (Column (c) and (d) of Table A3.3). Comparing with the critical value, the statistics suggest that there are province-specific effects. Not controlling for these province fixed effects creates an omitted variable bias and results in inconsistent estimates of the coefficients. In order to choose between fixed and random effects, I used the Hausman test is used to check the more efficient random effects model against a less efficient but consistent fixed effects model. For both diarrhea and dysentery, the significant p-values of the Hausman tests show that fixed effects model is preferred. The next important question is whether time dummies should be included in the fixed effects model. For both diarrhea and dysentery, tests of the null hypothesis that the time dummies are not jointly significant result in p-values smaller than 0.05. Hence, the fixed effect model should include the time dummies. The last question is whether the random effect is consistent when the time dummies are included. The Breusch–Pagan tests under the null hypothesis of no conditional heteroscedasticity or random effects indicate that province-specific fixed effects model is still the most

appropriate for both diarrhea and dysentery. Because adding dummy variables for each year significantly increases the number of explanatory variables and soaks up much of the explanatory power of the other variables, I also estimate a model that replaces this with a simple time trend.

3. Although the fixed effects approach can estimate coefficients for rarely changing variables, the fixed effects tend to soak up the explanatory power of these variables and make them statistically insignificant (Beck, 2001). The Plumper and Troeger (2007) technique combines a quasi-OLS estimate of time-invariant and slowly changing variables with a quasi-fixed-effects estimate of the time varying variables (Plumper & Troeger, 2007). The results are shown in Column (h) of Table A3.2 and Table A3.3.

The results from the most appropriate specification for the incidence of diarrhea and dysentery are selected and presented in Table 3.4. For this model, I present results from xtfeved procedure for two main reasons. First, the time dummies may be absorbing the explanatory power of other variables, making it difficult to interpret the estimation results of the fixed effects model. Second, the xtfeved procedure decomposes the unit effects to provide estimates of the effects of key prevention variables: percentage of households with safe drinking water and sanitation, and also the growth rate of safe drinking water and sanitation. The results from the fixed, random effects, xtfved specification, all with and without time dummies, as well as with a time trend variable instead of time dummies are shown in the appendix, Table A3.2 and Table A3.3.

Table 3.4 Results from the best model for equation (1) : environmental health in Thailand when all environmental indicators are included

	Ln(diarrhea rate)		Ln (dysentery rate)	
	Fevd		Fevd	
	Coef.	P>t	Coef.	P>t
Ln(GPP)	-0.0913	0.00	-1.6815	0.00
Ln(BOD)	-0.0505	0.00	-0.0963	0.01
Ln(DO)	-0.0426	0.04	-0.0546	0.23
Ln(TCB)	-0.0072	0.04	0.0403	0.00
Ln(hospital)	-0.0129	0.36	-0.8099	0.00
Ln(Pop Density)	-0.8071	0.00	-1.9154	0.00
Ln(Water90)	-0.3510	0.00	0.6189	0.03
Ln(Sanit90)	5.1224	0.00	19.8394	0.00
Growthwater	-0.0069	0.00	-0.0042	0.10
Growthsanit	0.0302	0.00	0.1289	0.00
Constant	-5.8304	0.00	-63.7146	0.00
R-squared	0.78		0.70	
N	760		760	

As expected, per capita GDP has a statistically significant and negative effect on morbidity rates (incidence) of diarrhea and dysentery. A 1% increase in per capita GDP reduces diarrhea and dysentery incidence by 0.09% and 1.68%, respectively. This is consistent with the Preston Curve. In terms of water quality indicators, higher BOD is associated with less of these water-borne diseases, perhaps because BOD is associated with poor taste and appearance of water thus discouraging consumption as drinking water. Higher DO, which represents better water quality, is associated with lower morbidity rate of diarrhea but has no effect on the morbidity rate of dysentery. TCB is the water quality indicator most directly related to these illnesses. The estimated coefficient on TCB has an unexpected negative relationship with incidence of diarrhea; however, it has the expected positive relationship with the incidence of dysentery. As indicated by the estimated coefficients for the percentage and the growth rate of households with safe drinking water, higher levels of household with safe drinking water clearly reduce the morbidity rate of diarrhea but unexpectedly increase the morbidity rate of dysentery. Contrary to expectation, the percentage and the growth rate of household with sanitation have a positive significant effect on the morbidity rate of both diarrhea and dysentery.

3.6.2. Environmental Kuznets Curve

The model of health outcomes presented above does not consider the complex causal relationships and potential multicollinearity between the environmental and income variables. This relationship between environment and income has been widely studied in the conceptual framework of the Environmental Kuznet Curve (EKC), which suggests that environmental quality first falls and then rises with income growth. I turn next to estimation of the EKC for water quality in Thailand.

1. I estimate the EKC by modeling the water quality indicators as a function of GDP and its square, following the same steps as above except xtfevd method since the time-invariant variable is not included: (1) pooled OLS with no time dummies, (2) test random vs. fixed with no time dummies, fixed with and without time dummies, and random vs. fixed with time dummies. For (1), as reported in Column (a) and (b)

of Tables A3.4 –A3.6, the pooled OLS confirms the EKC relationship for all three indicators of water quality, with turning points varying from 309,813 baht to 538,445 baht. For (2), all tests show that the province-specific fixed effects model with time dummies is most appropriate for these models. This difference in the signs of coefficients between fixed effects and pooled OLS has been observed in other studies as well (Alesina &Perotti, 1994; Berry & Waldfogel, 1997; Smith & Granberg-Rademacker, 1999; Forbes, 2000; Acemoglu, Johnson, Robison, & Yared, 2005).

In interpreting the results, the results from the most appropriate specification for the morbidity rate of diarrhea and dysentery are selected and presented in Table 3.5. These results collectively suggest that (a) there is no single EKC relationship that fits all water pollutants after controlling for province-specific effects, (b) there is no EKC relationship for BOD and DO, (c) there is the opposite of the EKC relationship between income and TCB. In term of TCB, the coefficients for per capita GDP and its quadratic term are statistically significant with negative and positive signs, respectively. Using the quadratic specification, we obtain the turning points of 572,153 Baht for TCB.

3.6.3. Prevention and Income

Since the relationship between prevention and per capita income is expected to be positive. Higher income should lead to higher prevention in each province. The following tables show the results from the estimations under the assumption that per capita GDP affects the access to the safe water and the access to the sanitation. Since the data of the access to the safe water and sanitation in Thailand is from the census, this data is only from year 1990 and 2000. The results from the growth rates of safe water and sanitation access are given in Table 3.6. The results show that the growth rates of sanitation and safe water access have positive relationships with per capita GDP and growth rate of GDP. Meanwhile, the provinces with high percentages of safe water and sanitation access as a base in year 1990 have slower growth rate in themselves. From Table 3.7, the estimated coefficients of GDP are not statistically significant with both access to safe water and sanitation in year 2000. The better access to safe water and sanitation in year 1990 significantly leads to better access to safe water and sanitation in year 2000.

Table 3.5 Results from the best model for equation (2) EKC in Thailand

	TCB		BOD		DO	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
GPP	-18046.4	0.00	-0.6477	0.64	6.4829	0.14
GPP^2	157.706	0.00			-0.0815	0.14
Constant	160744	0.00	137.9297	0.00	514.3826	0.00
R-squared	0.12		0.03		0.03	
N	760		760		760	
T-point	57.22				39.76	

*the fixed effects specification with time dummies is used for TCB, BOD and DO

Table 3.6 Result from prevention equation (3) when growth rate of sanitation/safe water are prevention level variables

	growthsanit		Growthwater	
	Coef.	P>t	Coef.	P>t
GPP90	0.2574	0.33	0.3217	0.34
Sanit90/Water90	-1.438	0.00	-1.4191	0.00
GrowthGPP	0.0062	0.34	0.0052	0.60
Constant	137.5867	0.00	131.2242	0.00
R-squared	0.90		0.89	

Table 3.7 Result from prevention equation (3) when sanitation/safe water in year 2000 are prevention level variables

	Sanit00		Water00	
	Coef.	P>t	Coef.	P>t
GPP90	-0.0743	0.58	0.0174	0.93
Sanit90/Water90	0.1924	0.00	0.2966	0.00
GrowthGPP	0.0016	0.64	0.0046	0.38
Constant	80.7706	0.00	68.0192	0.00
R-squared	0.40		0.49	

3.6.4. Health and Income Relationship

Many past studies show the evidence on the relationship between income and health based on cross-countries analysis. The following tables are focusing on the relationship between per capita GDP and the incidence of water borne disease in one country, Thailand. The models are estimated using quadratic or cubic form. All specifications are estimated and tested with pooled, fixed effects and random effects approaches without and with time dummies. Fixed effect with time trend is also included in this study.

In Table A3.7 – A3.8, the Hausman test confirms that the fixed effect should be used instead of the random effect model. The overall test shows that the fixed effects model with time dummies is appropriate for the health-income relationship study. However, the time dummies are absorbed the effects of GPP. That is why the fixed effects with time trend specification are used. Although the fixed effect with time trend specification shows better p-value compared to the fixed effects with time dummies, none of their GPP variables is significant. Hence, the fixed effect with no time dummies will be used to explain whether per capita GPP has an influence on health status.

In interpreting the results, the results from the most appropriate specification for the morbidity rate of diarrhea and dysentery are selected and presented in Table 3.8. When the morbidity rate of diarrhea is dependent variable, both per capita GPP in levels and its squared term have quite strong significance with the expected negative and positive sign, respectively. In other words, we observe that the morbidity rare of diarrhea decreases with an increase in per capita GPP at relatively low levels of income. Beyond per capita GPP at 444,900 Baht, the morbidity rate decreases with an increase in per capita GDP. In term of the morbidity rate of dysentery, the estimated coefficients of per capita GPP, its squared term and its cubic term exhibit an inverted N shaped relationship with the morbidity rate of dysentery as shown in Table 3.8. This inverted N shaped indicates that the morbidity rate decreases as a province develops, increase once the threshold GPP is reached, and then begins decreasing as GPP continue to increase.

3.6.5. Environmental health re-visited (OLS/fixed/random with individual water quality indicators)

To address concerns about multicollinearity among the different environment indicators, I estimate separate models for each indicator. As with previous models, I maintain the log-log functional form, and all specifications are estimated and tested with pooled, fixed effects and random effects approaches without and with time dummies as well as with a time trend variable instead of time dummies. The xtfevd method is also included.

Table 3.8 Result from the best models for equation (4) Preston Curve in Thailand

	diarrhea rate		dysentery_rate	
	Coef	P>t	Coef	P>t
GPP	-44.5671	0.01	-25.4525	0.00
GPP^2	0.5009	0.02	0.6041	0.00
GPP^3			-0.0045	0.00
Constant	2155.77	0.00	217.94	0.00
R-squared	0.01		0.07	
N	760.00		760.00	
T-point	44.49			

*the fixed effects specification without time dummies is used for diarrhea rate and dysentery rate

1. The morbidity rate of diarrhea[8]

The results from the full model with each environmental indicator are show in Table A3.9-A3.14. Table A3.9 to A3.11 report the result from equation (1) by using pooled, fixed effects, random effects and xtfevd techniques when the morbidity rate of diarrhea is used as health indicator. Estimates vary significantly, based on which technique is utilized, so it is necessary to test the validity of the assumptions underlying each method. First, a Hausman specification test comparing the fixed effects estimates of column (c) with the random effects estimates of column (f) rejects the assumption required for random effects. Since the fixed effected method is preferred, other important question is whether the time dummies are included in the fixed effected model. The F-test assuming the time dummies are not significant is rejected. Another question is whether the random effect with time dummies is applicable. The Breuch Pagen test with the null hypothesis of random effect is again rejected. Hence, the fixed effect with time dummies is preferred method based on the econometrics test. The column (d) presents results from the fixed effect with time dummies. The main difference when the time dummies are included is that the per capita GPP is no longer statistically significant. The time dummies also capture effects of other aggregate factors common to these provinces. Hence, I reestimate the panel regression with the fixed effect with time trend in the column (e). The fixed effect with time trend does not show any improvement in the significance of coefficients or the adjusted R^2 compared to the fixed effect with time dummies. As the earlier discussion, I try to remedy the problems of

[8] This study focuses on acute diarrhea, which is basically infectious disease associated with water. Most diarrhea is acute in onset and usually persists for less than three weeks.

estimating time-invariant and rarely changing variables in fixed effect models by using Plumper and Troeger technique. The results for this method are presented in column (h). Comparing with other estimations, the Plumper and Troeger technique perform better than pooled OLS, regular fixed effect, and random effect if the prevention variables are included.

In interpreting the results, the result from the most appropriate specification for the morbidity rate of diarrhea is selected and presented in Table 3.9. The estimated coefficient of per capita GPP is negative and statistically significant as expected. In other word, increasing in per capita GPP can lower the morbidity of diarrhea in all environmental indicators. The coefficient on TCB is unexpectedly negative and statistically significant, indicating that a one percent increase in TCB leads to 0.01 percent decreases in the morbidity rate of diarrhea, all else being equal. The population density effect is negative, implying that the higher population density, the lower the morbidity rate of diarrhea. This result shows that if the higher population which tends to be defined as the urban or metropolitan area, the lower the morbidity rate of diarrhea. This result supports the Preston curve hypothesis that most of health gains have been due to improvements in health at each higher level of income, which is likely to include better standard of living, rapid urbanization and population density. The percentage of households with safe drinking water in 1990 and its growth rate over ten years are negative, as expected. This implies that both the availability and the improvement of access to safe water lead to lower the morbidity rate of diarrhea, all else being equal. On the other hand, the percentage of household with sanitation in 1990 and its growth rate over ten years are positive, which are unexpected relationships.

Table 3.9 Results from the best models for equation (1) environmental health in Thailand when each environmental indicator is included: the morbidity rate of diarrhea

Lndiarate						
	TCB		BOD		DO	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
lnGPP	-0.1018	0.00	-0.0869	0.00	-0.0953	0.00
lnEnvironmental Indicator	-0.0064	0.06	-0.0509	0.00	-0.0460	0.02
lnHospital	-0.0175	0.21	0.0108	0.45	0.0024	0.87
lnPopden	-0.8357	0.00	-0.7816	0.00	-0.8140	0.00
lnWater90	-0.2949	0.02	-0.2980	0.01	-0.3279	0.01
lnSanit90	5.3909	0.00	4.8378	0.00	5.0789	0.00
Growthwater	-0.0065	0.00	-0.0063	0.00	-0.0064	0.00
Growthsanit	0.0319	0.00	0.0283	0.00	0.0299	0.00
Constant	-7.5274	0.00	-5.4089	0.00	-5.9949	0.00
R-squared	0.74		0.75		0.74	
N	760.00		760.00		760.00	

* the Plumper and Troeger technique is used for all cases

When BOD is use as water quality indicator, high BOD is associated with a decrease in the morbidity of diarrhea, implying province with water supply that contains high organic waste has lower morbidity rate of diarrhea. The possible explanation is that people obviously notice the heavy polluted water, and avoid to be exposed the contaminated water sources. Similar to previous table, the coefficient on population density is negative and statistically significant, indicating that one percent increase in population density leads to 0.78 percent decrease in the morbidity of diarrhea, all else being equal. Higher population density signifies more urban areas which offer better health care and healthier living conditions. The percentage of households with safe drinking water in 1990 and its growth rate over ten years are negative, and these support the statement that the household with lack adequate safe water is more likely to vulnerable to poor health condition. However, the percentage of households with sanitation in 1990 and its growth rate over ten years are unexpectedly positive.

When DO is used as water quality indicator, the estimated coefficient of DO is negative and statistically significant, as expected. Higher DO which represents good water quality leads to lower the morbidity rate of diarrhea. Like earlier studies, the negative coefficient on population density which represents the urban setting confirms that province with higher income will have lower the morbidity rate of diarrhea. In addition, each unit increase in the percentage of household with safe drinking water in 1990 and its growth rate are associated with roughly 33 percent fewer morbidity rate of diarrhea. However, the percentage of household with sanitation in 1990 and its growth rate have unexpected positive effect on the morbidity rate of diarrhea

2. The morbidity rate of dysentery[9]

The results from the full model by using pooled, fixed effects, random effects and xtfevd techniques when the morbidity rate of dysentery is used as health indicator are shown in Table A3.12-A3.14. I follow the same test steps as the previous section; Hausman test, time dummies test, and Breuch Pagen test. The fixed effect with time dummies as shown in column (d) is preferred method based on the econometrics test. However, the time dummies absorb the significance of per capita GPP. Hence, the fixed effects specification with time

[9] Dysentery in this study has two main types; bacillary dysentery (Shigellosis) and amoebic dysentery. Symptoms include severe bloody diarrhea, crampy abdominal pain, and fever. Watery diarrhea without blood can be found in the early stage. The bloody stool will be found in the following 3-5 days later.

trend is estimated and shown in column (e). As we can see from the table, the fixed effect with time trend does not show any improvement in the significance of coefficient or the adjusted R^2. That is why Plumper and Troeger technique is introduced to remedy the problem from rarely changing variables in fixed effect models. Besides, this study is the first empirical attempt to utilize different specifications including the new estimation technique for time-invariant variable in panel data model.

In interpreting the results, the result from the most appropriate specification for the morbidity rate of dysentery is selected and presented in Table 3.10.

Compared to the result from the morbidity rate of diarrhea, per capita GPP has a strongly negative effect on the morbidity rate of dysentery. The province with higher per capita GPP is more likely to have lower morbidity rate of dysentery in all environmental indicators studies. This result could reflect the fact that higher income province has better access to health care service. The estimated coefficients on the number of hospitals and population density are negative and statistically significant, as supporting to the previous result. In addition, the environmental variable which represents by TCB is associated with an increase in the morbidity rate of dysentery, as expected. High TCB level which represents bad water condition can significantly cause an increase in the morbidity rate of dysentery. However, the time invariant variables, which include the percentage of household with safe drinking water and sanitation in 1990 as well as their growth rates, are associated with higher morbidity rate of dysentery. These results are counter-intuitive.

Table 3.10 Results from the best models for equation (1) when each environmental indicator is included: the morbidity rate of dysentery

Lndyrate						
	TCB		BOD		DO	
	Coef.	P>z	Coef.	P>t	Coef.	P>z
lnGPP	-1.7008	0.00	-1.7132	0.00	-1.7307	0.00
lnEnvironmental Indicator	0.0417	0.00	-0.1054	0.00	-0.0912	0.03
lnHospital	-0.8197	0.00	-0.9371	0.00	-0.9544	0.00
lnPopden	-2.9709	0.00	-3.0490	0.00	-3.1162	0.00
lnWater90	1.3070	0.00	1.2059	0.00	1.1480	0.00
lnSanit90	25.0082	0.00	26.2554	0.00	26.7582	0.00
Growthwater	0.0017	0.52	-0.0008	0.76	-0.0010	0.69
Growthsanit	0.1520	0.00	0.1602	0.00	0.1635	0.00
Constant	-82.9766	0.00	-86.2546	0.00	-87.5277	0.00
R-squared	0.80		0.80		0.79	
N	760.00		760.00		760.00	

* the Plumper and Troeger technique is used for all cases

When BOD is used as environmental indicator, the significantly negative coefficients of both the number of hospitals and population density support the earlier statement. An interesting result to note is that the sign of coefficient on BOD which is negative and statistically significant in all models. This would indicate that higher level of BOD is associated with lower level of the morbidity rate of dysentery. When BOD is high, there is too much microorganism and low level of oxygen which causes water pollution that is commonly associated with health problem. However, the reasonable explanation to explain the negative sign is that people may use alternative sources of water when they spot too much signs of water contamination. Speaking of the prevention variables, the percentage of household with safe drinking water and sanitation in 1990 and the growth rate of sanitation are unreasonably associated with an increase in the morbidity rate of dysentery.

When DO is used as environmental indicator, the estimated coefficient of DO is negative and statistically significant, indicating that as a province has higher DO or better water quality, the morbidity of dysentery decreases. The estimated coefficients on both population density and the number of hospitals are negative and statistically significant, representing that the urban area with better health care infrastructure has better chance to lower the morbidity rate of dysentery. Attempting to include prevention variables in the fixed effect model, the results are somewhat similar to the results when BOD is used as environment indicator. Surprisingly, the percentage of household with safe drinking water and sanitation in 1990 and the growth rate of sanitation are associated with an increase in the morbidity rate of dysentery.

3.7. Discussion and Conclusions

The estimation results for diarrhea and dysentery show that in Thailand, growth in per capita GPP has been accompanied by decreasing morbidity from both waterborne diseases. For water quality indicators, the results are mixed. BOD, or biochemical oxygen demand, actually reduces morbidity from diarrhea and dysentery. This finding is consistent across specifications, as shown in section 3.6.5 and the appendix. The most likely explanation is that BOD is associated with poor appearance and taste that also discourage consumption of water. Dissolved oxygen –reflecting higher water quality – has the expected negative sign (although only significant when it is the sole environmental indicator in the case of dysentery). TCB is associated with higher rates of dysentery, but unexpectedly, not with higher rates of diarrhea.

Population density also plays a role. While population density might be expected to increase disease transmission, in the case of these waterborne diseases, it appears to proxy for economic development, urbanization, and access to more and higher quality options for drinking water. This is consistent with the number of hospital (lagged by two years), which reflects the availability of health care and is negative and statistically significant in the dysentery model.

The percentage of household with safe drinking water in 1990 and its growth rate exhibit a negative effect with respect to the morbidity rates of diarrhea; however, they surprisingly exhibit a positive effect with respect to the morbidity rate of dysentery. Meanwhile, percentage of household with sanitation in 1990 and its growth rate surprisingly exhibit a positive effect with respect to the morbidity rates of both diarrhea and dysentery.

These results suggest yet again that the way to attain better health status is through economic development and increasing income. However, there are closely links between water pollution and rapid economic development, such as industrial growth, urbanization and population. The impact of water pollution directly causes higher incidence rates of waterborne diseases. These findings have shown many implications that policy makers need to consider in order to formulate policies. Water pollutant indicators should be concerned or used as policy instruments, such as water pollution abatement, regulation on domestic sewage and industrial effluent. With effective policy enforcement and implementation, the country can cable of bring a balance between environment, health, and development.

3.8. References

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3.9 Appendix

3.9.1 Appendix 3.1 Provinces in Thailand

Amnat Charoen*
Angthong
Bangkok
Buri Ram
Chachoengsao
Chai Nat
Chaiyaphum
Chanthaburi
Chiang Mai
Chiang Rai
Chon Buri
Chumphon
Kalasin
Kamphaeng Phet
Kanchanaburi
Khon Kaen
Krabi
Lampang
Lamphun
Loei
Lop Buri
Mae Hong Son
Maha Sarakhagt
Mukdahan
Nakhon Nayok

Nakhon Pathom
Nakhon Phanom
Nakhon Ratchasima
Nakhon Sawan
Nakhon Si Thammarat
Nan
Narathiwat
Nong Bua Lam Phu*
Nonthaburi
Noog Khai
P.Nakhon S.Ayutthaya
Pathum Thani
Pattani
Phangnga
Phatthalung
Phayao
Phetchabun
Phetchaburi
Phichit
Phitsanulok
Phrae
Phuket
Prachin Buri
Prachuap Khiri Khan
Ranong

Ratchaburi
Rayong
Roi Et
Sakaew *
Sakon Nakhon
Samut Prakan
Samut Sakhon
Samut Songkhram
Saraburi
Satun
Si Sa Ket
Sing Buri
Songkhia
Sukhothai
Suphan Buri
Surat Thani
Surin
Tak
Trang
Trat
Ubon Ratchathani
Udon Thani
Uthai Thani
Uttaradit
Yala
Yasothon

*Amnat Charoen has been separated from Ubon Ratchathani since 1993)
*Nong Bua Lam Phu (has been separated from Uthaithani since 1993)
*Sakaew (has been separeted from Prachiburin since 1993)

3.92 Appendix 3.2 Results for equation (1) when all environmental indicators are included: the morbidity rate of diarrhea

Ln(diarrhea rate)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				Fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(g)		(h)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.		Coef.	P>t	Coef.	P>t
LnGPP	0.13	0.00	0.14	0.00	-0.09	0.08	-0.02	0.78	-0.08	0.26	0.01	0.71	0.08	0.03	-0.09	0.00
LnBOD	-0.08	0.00	-0.08	0.00	-0.05	0.00	-0.05	0.00	-0.05	0.00	-0.06	0.00	-0.06	0.00	-0.05	0.00
LnDO	0.15	0.00	0.16	0.00	-0.04	0.22	-0.04	0.27	-0.04	0.22	-0.01	0.82	0	0.93	-0.04	0.04
LnTCB	-0.01	0.06	-0.01	0.14	-0.01	0.09	-0.01	0.79	-0.01	0.08	-0.01	0.12	-0.01	0.53	-0.01	0.04
LnHospital	-0.23	0.00	-0.23	0.00	-0.01	0.82	-0.07	0.26	-0.01	0.94	-0.19	0.00	-0.19	0.00	-0.01	0.36
LnPop density	0.02	0.03	0.02	0.02	-0.81	0.00	-0.73	0.00	-0.77	0.00	0.02	0.55	0.02	0.52	-0.81	0.00
LnWater90	-1.38	0.00	-1.38	0.00							-1.29	0.00	-1.39	0.00	-0.35	0.00
LnSanit90	-1.36	0.00	-1.37	0.00							-1.38	0.08	-1.49	0.06	5.12	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.02	0.00	-0.02	0.00	-0.001	0.00
Growthsanit	-0.01	0.00	-0.01	0.00							-0.01	0.09	-0.01	0.08	0.03	0.00
year									-0.01	0.68						
Constants	18.38	0.00			15.71	0.00	14.89	0.00	19.51	0.04	20.44	0.00	21.13	0.00	-5.86	0.00
R-squared	0.41		0.44		0.07				0.07		0.19		0.4		0.78	
N	760		760		760		760		760		760		760		760	
Hausman							57.57	0.00								
F-test for time dummies			4.05	0.00			6.66	0.00								
F-test for individual effect					20.45	0.00	21.42	0.00	20.38	0.00					211.11	0.00
Breusch-Pagan Test													1057.53			
Time Dummies	N		Y		N		Y				N		Y			

3.93 Appendix 3.3 Results for equation (1) when all environmental indicators are included: the morbidity rate of dysentery

ln(dysentery)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				Fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(g)		(h)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
LnGPP	-0.37	0.00	-0.26	0.00	-1.68	0.00	0.01	0.95	-0.4	0.00	-0.99	0.00	-0.19	0.05	-1.68	0.00
LnBOD	-0.11	0.07	-0.03	0.58	-0.1	0.02	-0.08	0.03	-0.08	0.03	-0.13	0.00	-0.08	0.03	-0.1	0.01
LnDO	0.11	0.19	0.14	0.06	-0.05	0.50	-0.04	0.51	-0.01	0.83	-0.1	0.21	-0.02	0.76	-0.05	0.23
LnTCB100	0.08	0.00	0.02	0.25	0.04	0.00	0	0.70	-0.01	0.11	-0.06	0.00	-0.001	0.76	0.04	0.00
LnHospital	-0.25	0.00	-0.2	0.00	-0.81	0.00	-0.22	0.07	-0.13	0.27	-0.8	0.00	-0.21	0.02	-0.81	0.00
LnPop density	0.05	0.07	0.08	0.01	-2.92	0.00	0.53	0.15	0.18	0.63	-0.1	0.20	0.09	0.25	-2.92	0.00
LnWater90	-2.84	0.00	-3.27	0.00							-2.21	0.10	-3.62	0.00	1.23	0.00
LnSanit90	-3.75	0.00	-3.98	0.00							-0.13	0.96	-4.15	0.05	24.51	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.02	0.06	-0.02	0.05	0.001	0.67
Growthsanit	-0.04	0.00	-0.04	0.00							-0.01	0.58	-0.04	0.03	0.15	0.00
year									-0.13	0.00						
Constants	37.47	0.00	10.91		36.39	0.00	0.96	0.78	334.24	0.00	20.34	0.03	40.5	0.00	-79.9	0.00
R-squared	0.36		0.5		0.43		0.62		0.58		0.27		0.49		0.70	
N	760		760		760		760		760		760		760		760	
Hausman					177.01	0.00										
F-test for time dummies			21.41	0.00			38.18	0.00								
F-test for individual effect					28.29	0.00	38.49	0.00	35.67						0.82	
Breusch-Pagan Test													1844.39	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.94 Appendix 3.4 Result from EKC equation (2) when TCB is environmental quality

TCB	Pooled				Fixed effects				Random effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.		Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z	Coef.	P>z
GPP	6237.40	0.00	6106.88	0.00	-16780 .29	0.00	-18046.40	0.00	5776.74	0.00	5598.42	0.00
GPP2	-100.66	0.00	-93.69	0.00	137.36	0.01	157.71	0.00	-96.70	0.00	-87.54	0.00
R-squared	0.05		0.12		0.04		0.12		0.05		0.12	
N	760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					38.73	0.00						
F-test for time dummies			6.53	0.00			6.40	0.00				
F-test for individiual effect					2.19	0.00	2.24	0.00				
Breusch-Pagan Test											15.27	0.00
T-point	30.98		32.59		61.08		57.22		29.87		31.98	
Time dummies	N		Y		N		Y		N		Y	

3.9.5 Appendix 3.5 Result from EKC equation (2) when BOD is environmental quality

BOD	Pooled				Fixed effects				Random effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.		Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z	Coef.	P>z
GPP	4.43	0.00	4.48	0.00	0.40	0.75	-0.64	0.41	2.39	0.00	2.24	0.00
GPP2	-0.04	0.06	-0.04	0.05								
R-squared	0.07		0.09		0.01		0.03		0.01		0.09	
N	760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					3.12	0.07						
F-test for time dummies			1.67	0.09			2.43	0.01				
F-test for individiual effect					4.06	0.00	4.17	0.00				
Breusch-Pagan Test											184.60	0.00
T-point	53.84		51.67									
Time dummies	N		Y		N		Y		N		Y	

3.9.6 Appendix 3.6 Result from EKC equation (2) when DO is environmental quality

DO	Pooled				Fixed effects				Random effects			
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coef.		Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>z	Coef.	P>z
GPP	-14.71	0.00	-14.63	0.00	3.36	0.39	6.48	0.14	-8.43	0.00	-8.36	0.00
GPP2	0.18	0.00	0.17	0.00	-0.05	0.36	-0.08	0.14	0.08	0.04	0.08	0.05
R-squared	0.20		0.21		0.01		0.03		0.19		0.20	
N	760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					14.91	0.00						
F-test for time dummies			0.98	0.45			2.46	0.00				
F-test for individiual effect					13.82	0.00	14.11	0.00				
Breusch-Pagan Test											1046.12	0.00
T-point	41.36		41.91						51.56		54.60	
Time dummies	N		Y		N		Y		N		Y	

3.9.7 Appendix 3.7 Result from equation (4) when diarrhea rate is health indicator

	Diarrhea rate													
	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect			
	(a)		(b)		(c)		(d)		(e)		(f)		(h)	
	Coef	P>t	Coef	P>t	Coef	P>t	Coef	P>t	Coef	P>t	Coef	P>t	Coef	P>t
GPP	81.35	0.00	85.27	0.00	-44.57	0.01	-13.19	0.46	-22.70	0.18	-13.30	0.25	1.77	0.88
GPP2	-3.74	0.00	-3.91	0.00	0.50	0.02	0.22	0.32	0.30	0.16	0.18	0.31	0.07	0.70
GPP3	0.05	0.00	0.05	0.00										
year									-17.95	0.00				
R-squared	0.04		0.07		0.01		0.01		0.03		0.01		0.03	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman											8.24	0.02		
F-test for time dummies			2.52	0.01			6.76	0.00					67.99	0.00
F-test for individiual effect					27.48	0.00	29.37	0.00	27.82	0.00				
LM test													1868.07	0.00
T-point					44.49		30.23		37.32					
Time dummies	N		Y		N		Y				N		Y	

3.9.8 Appendix 3.8 Result from equation (4) when dysentery rate is health indicator

	Dysentery rate													
	Pooled				Fixed Effect				Fixed effect with time trend		Random Effect			
	(a)		(b)		(c)		(d)		(e)		(f)		(h)	
	Coef.	P>t	Coef.	P>t	Coef.		Coef.	P>t	Coef	P>t	Coef.	P>t	Coef.	P>t
GPP	-17.40	0.00	-16.71	0.00	-25.45	0.00	0.32	0.94	-1.94	0.60	-17.53	0.00	-6.97	0.02
GPP2	0.62	0.00	0.59	0.00	0.60	0.00	0.04	0.77	0.10	0.41	0.46	0.00	0.23	0.04
GPP3	-0.01	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.82	-0.01	0.50	-0.01	0.00	-0.01	0.10
Year									-11.26	0.00				
R-squared	0.10		0.20		0.07		0.42		0.38		0.09		0.17	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman											13.96	0.00		
F-test for time dummies			9.76	0.00			45.42	0.00						
F-test for individiual effect					25.56	0.00	40.23	0.00	38.25	0.00				
Breusch-Pagan Test													2145.40	0.00
Time dummies	N		Y		N		Y		N		N		Y	

3.9.9 Appendix 3.9 Result from equation (1) when TCB is environmental indicator: the morbidity rate of diarrhea

Ln(diarrhea rate)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				xtfevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(h)		(g)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
LnGPP	0.09	0.00	0.10	0.00	-0.10	0.05	-0.03	0.69	-0.08	0.23	0.00	0.97	0.08	0.05	-0.10	0.00
LnTCB	-0.02	0.00	-0.02	0.00	-0.01	0.13	-0.01	0.81	-0.01	0.11	-0.01	0.18	0.00	0.50	-0.01	0.06
LnHospital	-0.25	0.00	-0.25	0.00	-0.02	0.75	-0.07	0.25	-0.01	0.92	-0.20	0.00	-0.20	0.00	-0.02	0.21
LnPop density	0.03	0.02	0.03	0.01	-0.84	0.00	-0.74	0.00	-0.78	0.00	0.01	0.60	0.02	0.54	-0.84	0.00
LnWater90	-1.53	0.00	-1.56	0.00							-1.29	0.01	-1.41	0.00	-0.29	0.02
LnSanit90	-1.40	0.00	-1.42	0.00							-1.37	0.10	-1.51	0.07	5.39	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.02	0.00	-0.02	0.00	-0.01	0.00
Growthsanit	-0.01	0.00	-0.01	0.00							-0.01	0.11	-0.01	0.09	0.03	0.00
year									-0.01	0.58						
Constants	21.27	0.00	21.47	0.00	15.49	0.00	14.59	0.00	20.66	0.03	20.09	0.00	21.08	0.00	-7.56	0.00
R-squared	0.36		0.39		0.05		0.13		0.05		0.34		0.38		0.74	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					34.17	0.00										
F-test for time dummies			3.63	0.00			6.54	0.00								
F-test for individual effect					23.01	0.00	24.32		22.91						253.74	
Breusch-Pagan Test													1214.46	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.9.10 Appendix 3.10 Result from equation (1) when BOD is environmental indicator: the morbidity rate of diarrhea

Ln(diarrhea rate)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				fevd	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
LnGPP	0.09	0.00	0.10	0.00	-0.09	0.10	-0.03	0.73	-0.09	0.15	0.01	0.04	0.08	0.04	-0.09	0.00
LnBOD	-0.11	0.00	-0.11	0.00	-0.05	0.00	-0.05	0.00	-0.05	0.00	-0.06	0.02	-0.06	0.00	-0.05	0.00
LnHospital	-0.24	0.00	-0.24	0.00	0.01	0.84	-0.07	0.28	0.01	0.92	-0.18	0.03	-0.19	0.00	0.01	0.45
LnPop density	0.02	0.04	0.02	0.04	-0.78	0.00	-0.73	0.00	-0.80	0.00	0.02	0.03	0.02	0.57	-0.78	0.00
LnWater90	-1.39	0.00	-1.41	0.00							-1.24	0.47	-1.37	0.00	-0.30	0.01
LnSanit90	-1.41	0.00	-1.40	0.00							-1.45	0.82	-1.49	0.07	4.84	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.02	0.00	-0.02	0.00	-0.01	0.00
Growthsanit	-0.01	0.00	-0.01	0.00							-0.01	0.01	-0.01	0.09	0.03	0.00
year									0.00	0.84						
Constants	21.10	0.00	21.11	0.00	15.08	0.00	14.67	0.00	13.30	0.13	20.38	3.22	21.07	0.00	-5.41	0.00
R-squared	0.38		0.41		0.06		0.14		0.06		0.35		0.40		0.75	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					28.07	0.00										
F-test for time dummies			3.80	0.00			7.04									
F-test for individual effect					22.11		23.49		22.07						256.71	
Breusch-Pagan Test													1209.70	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.9.11 Appendix 3.11 Result from equation (1) when DO is environmental indicator: the morbidity rate of diarrhea

Ln(diarrhea rate)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(h)		(g)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
LnGPP	0.13	0.00	0.14	0.00	-0.10	0.07	-0.02	0.75	-0.10	0.12	0.01	0.88	0.08	0.04	-0.10	0.00
LnDO	0.19	0.00	0.20	0.00	-0.05	0.18	-0.05	0.18	-0.05	0.18	0.00	0.89	0.00	0.96	-0.05	0.02
LnHospital	-0.22	0.00	-0.22	0.00	0.00	0.97	-0.08	0.21	0.00	0.98	-0.19	0.00	-0.20	0.00	0.00	0.87
LnPop density	0.03	0.02	0.03	0.02	-0.81	0.00	-0.75	0.00	-0.83	0.00	0.02	0.50	0.02	0.51	-0.81	0.00
LnWater90	-1.32	0.00	-1.34	0.00							-1.28	0.00	-1.40	0.00	-0.33	0.01
LnSanit90	-1.42	0.00	-1.43	0.00							-1.45	0.06	-1.51	0.05	5.08	0.00
Growthwater	-0.01	0.00	-0.01	0.00							-0.02	0.00	-0.02	0.00	-0.01	0.00
Growthsanit	-0.01	0.00	-0.01	0.00							-0.01	0.08	-0.01	0.07	0.03	0.00
year									0.00	0.88						
Constants	18.97	0.00	18.99	0.00	15.46	0.00	14.89	0.00	14.16	0.11	20.33	0.00	21.00	0.00	-5.99	0.00
R-squared	0.39		0.42		0.05		0.13		0.05		0.34		0.38		0.74	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman					60.26	0.00										
F-test for time dummies			4.20	0.00			6.81	0.00								
F-test for individual effect							21.67	0.00	20.42	0.00					253.50	
Breusch-Pagan Test													1034.18	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.9.12 Appendix 3.12 Result from equation (1) when TCB is environmental indicator: the morbidity rate of dysentery

ln(dysentery)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(h)		(g)	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
LnGPP	-0.41	0.00	-0.29	0.00	-1.70	0.00	0.00	0.98	-0.41	0.00	-1.01	0.00	-0.19	0.04	-1.70	0.00
LnTCB	0.07	0.00	0.01	0.52	0.04	0.00	0.00	0.70	-0.01	0.13	0.07	0.00	0.00	0.75	0.04	0.00
LnHospital	-0.27	0.00	-0.22	0.00	-0.82	0.00	-0.22	0.07	-0.14	0.25	-0.80	0.00	-0.22	0.01	-0.82	0.00
LnPop density	0.06	0.06	0.08	0.00	-2.97	0.00	0.51	0.18	0.16	0.68	-0.10	0.21	0.09	0.24	-2.97	0.00
LnWater90	-2.96	0.00	-3.41	0.00							-2.17	0.11	-3.64	0.00	1.31	0.00
LnSanit90	-3.81	0.00	-4.01	0.00							-0.11	0.96	-4.16	0.05	25.01	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.02	0.07	-0.02	0.04	0.00	0.52
Growthsanit	-0.04	0.00	-0.04	0.00							-0.01	0.58	-0.04	0.03	0.15	0.00
year									-0.13	0.00						
Constants	35.12	0.00	38.55	0.00					335.83	0.00	18.76	0.04	40.16	0.00	-82.78	0.00
R-squared					0.42		0.62		0.58		0.27		0.49		0.80	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00			
Hausman					195.81	0.00										
F-test for time dummies			21.74	0.00			38.37	0.00								
F-test for individual effect					28.61	0.00	38.90	0.00	36.02						343.29	
Breusch-Pagan Test													1863.38	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.9.13 Appendix 3.13 Result from equation (1) when BOD is environmental indicator: the morbidity rate of dysentery

ln(dysentery)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(h)		(g)	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>t	Coef.	P>z	Coef.	P>z	Coef.	P>t
LnGPP	-0.34	0.00	-0.28	0.00	-1.71	0.00	0.00	0.99	-0.44	0.00	-0.97	0.00	-0.19	0.05	-1.71	0.00
LnBOD		0.04	-0.05	0.32	-0.11	0.01	-0.08	0.02	-0.08	0.03	-0.15	0.00	-0.08	0.02	-0.11	0.00
LnHospital	-0.29	0.00	-0.22	0.00	-0.94	0.00	-0.22	0.07	-0.12	0.32	-0.93	0.00	-0.21	0.02	-0.94	0.00
LnPop density	0.06	0.05	0.08	0.00	-3.05	0.00	0.53	0.16	0.11	0.77	-0.12	0.14	0.09	0.25	-3.05	0.00
LnWater90	-3.34	0.00	-3.44	0.00							-2.49	0.07	-3.59	0.00	1.21	0.00
LnSanit90	-3.47	0.00	-3.95	0.00							0.74	0.76	-4.14	0.05	26.26	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.03	0.03	-0.02	0.05	0.00	0.76
Growthsanit	-0.04	0.00	-0.04	0.00							-0.01	0.78	-0.04	0.03	0.16	0.00
year									-0.13	0.00						
Constants	36.41	0.00	38.79	0.00					322.39	0.00	18.12	0.06	40.20	0.00	-86.25	0.00
R-squared	0.34		0.49		0.41		0.62		0.58		0.25		0.49		0.80	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman																
F-test for time dummies			25.00	0.00			41.17	0.00								
F-test for individual effect					29.37	0.00	39.38	0.00	36.16						336.31	
Breusch-Pagan Test													1875.37	0.00		
Time Dummies	N		Y		N		Y				N		Y			

3.9.14 Appendix 3.14 Result from equation (1) when DO is environmental indicator: the morbidity rate of dysentery

ln(dysentery)	Pooled OLS				Fixed Effect				Fixed effect with time trend		Random Effect				fevd	
	(a)		(b)		(c)		(d)		(e)		(f)		(h)		(g)	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
LnGPP	-0.34	0.00	-0.26	0.00	-1.73	0.00	0.01	0.94	-0.45	0.00	-1.01	0.00	-0.19	0.04	-1.73	0.00
LnDO	0.04	0.58	0.13	0.06	-0.09	0.26	0.00	0.15	-0.02	0.77	-0.17	0.05	-0.03	0.68	-0.09	0.03
LnHospital	-0.30	0.00	-0.20	0.00	-0.95	0.00	-0.23	0.05	-0.12	0.29	-0.96	0.00	-0.22	0.01	-0.95	0.00
LnPop density	0.06	0.04	0.08	0.00	-3.12	0.00	0.50	0.18	0.08	0.84	-0.12	0.15	0.08	0.25	-3.12	0.00
LnWater90	-3.36	0.00	-3.39	0.00							-2.67	0.05	-3.65	0.00	1.15	0.00
LnSanit90	-3.52	0.00	-3.96	0.00							0.64	0.79	-4.16	0.05	26.76	0.00
Growthwater	-0.02	0.00	-0.02	0.00							-0.03	0.02	-0.02	0.04	0.00	0.69
Growthsanit	-0.04	0.00	-0.04	0.00							-0.01	0.75	-0.04	0.03	0.16	0.00
year									-0.13	0.00						
Constants	35.84	0.00	37.45	0.00			0.74	0.83	324.15	0.00	19.85	0.04	40.37	0.00	-87.53	0.00
R-squared	33.60		0.49		0.41		0.62		0.58				0.49		0.79	
N	760.00		760.00		760.00		760.00		760.00		760.00		760.00		760.00	
Hausman																
F-test for time dummies			25.92	0.00			41.28	0.00								
F-test for individual effect					29.34	0.00	29.39	0.00	35.65						333.16	0.00
Breusch-Pagan Test													1850.09	0.00		
Time Dummies	N		Y		N		Y		N		N		Y			

Chapter 4 Occupational and Environmental Health Impacts from Mining in Orissa, India

4.1 Introduction

This chapter models incidence of illness among individuals living near iron ore mines in rural Orissa, India. At the individual scale, occupational health effects can be identified separately from environmental health effects. Occupational health problems occur at work or because of the kind of work. These problems can include injury, accident, hearing problem caused by exposure to noise, vision problem, and illness caused by breathing, touching or ingesting unsafe substances.

Mine workers are exposed to a variety of health and safety hazards every day. In modern mining, occupation health hazards are especially associated with chemicals. Chemicals posing a physical or health hazard can enter the body via contact, ingestion and inhalation (Patnaik, 1999). NIOSH (2000) stated that concentrations of gases in mines such as methane and other airborne contaminants underground can poison mine workers. Moreover, crystalline silica has long been a serious hazard in mining by creating the risk of silico-tuberculosis. Holman, Psaila-Savona, Roberts, & McNulty (1987) and Cowie & Mabena (1991) show that the risk of silicosis increased with cumulate exposure. Prolonged exposure to silica can also lead to chronic obstructive pulmonary symptom. Arsenic pollution is also a consequence of arsenic, tin and copper mining and smelting with accompanying risk of lung cancer (Enterline, Day, & Marsh, 1995). Apart from chemical hazards, high temperatures and humidity may cause heat-related illnesses, especially heat stroke which can result in death. Long-term exposure of mine workers to heat stress is unhealthy and unproductive (MSHA, 2007). In addition, physical hazard such as whole body vibration is commonly experienced among mine workers. This is associated with an increased risk of spinal disorder.

In addition to the occupational health effects of working in mines, people who live close to mining areas may suffer the environmental health effects of degradation associated with land use change from mining and infrastructure development; top soil removal; overburden dumping; acid mine drainage; the degradation of surface and ground water quality; and increases in temperature and air pollution. Moreover, people who live close to mining areas are likely to consume drinking water from surface and groundwater sources contaminated by chemical wastes and debris from mining activities (Winkel, Berg, Amini, Hug, & Johnson, 2008). Other major pollutants from mining activities are particulate matter, dust and noise. People who live close to mining areas commonly suffer respiratory illnesses and hearing problems (IDRC, 2006; Ghose, 2008).

Another major environmental concern around mines is disturbance of ecosystems, with impacts ranging from degraded landscape aesthetics to habitat fragmentation (Giulio, Holderegger, & Tobias, 2009). According to (Patz, et al., 2004), "land use change activities eg. agricultural encroachment, deforestation, road construction, dam building, irrigation, wetland modification, mining, the concentration or expansion of urban environments, coastal zone degradation, and other activities lead to the infectious disease outbreaks and emergence events and modify the transmission of endemic infections". Specifically, changes in ecosystems are often associated with an increase in vector-borne parasitic disease. Pattanayak & Yasaoka (2008) stated that deforestation for mine development not only creates breeding sites, but also increases human contacts with vectors. For example, Yapabandara & Curtis (2004) concluded that changes in the environment due to gem mining may have caused the emergence of *Anopheles Subpictus* and *Anopheles Varuna* mosquito as significant malaria vectors in Sri Lanka.

On the other hand, mining can have beneficial local impacts in terms of economic expansion and decreasing poverty. It creates employment and attracts investment. Mining jobs and the additional employment from increased infrastructure benefit local and regional communities. Especially where there is significant under-employment, new jobs in the mining sector increase income, which in turn improves qualities of life. Income is well known to be correlated with health status. This is logical because income affects every aspect of living, from where people live to what people eat. People with higher income tend to enjoy better standards of living, health and access to better health care.

Thus, opening or expanding mines can impact the health of local communities through multiple pathways. Occupational health hazards and environmental degradation are both major factors. In addition, there could also be reduction in quality of life due to degradation of natural resources and livelihoods. This chapter analyzes the impact of mining on health by testing for evidence of local environmental health and occupational health effects on individuals working in and living near mines in Orissa, using several indicators of mine exposure and health. This draws and builds on previous work reported in Pattanayak & Yasaoka (2008). Similar issues were examined in Saha (2008). Saha (2008) found that villagers living closer to mines reported higher incidences of acute respiratory and workdays lost due to malaria. However, in order to assess environmental and health impacts, I put more emphasis on identifying the determinants of mine employment at the individual level and accounting for its endogeneity in evaluating the impacts of mines on health.

This chapter is structured as follows. The next section introduces Orissa, with a focus on mining activities. Section three presents a conceptual framework for occupational health and environmental health. Section four presents the empirical methods of this study. Section five describes the data. Section six presents the empirical results, with conclusions and discussion in the last section.

4.2 Orissa

Orissa is a state located on the east coast of India (See Figure A4.1). Of 28 states, Orissa is the ninth largest state by area, and the eleventh largest by population. There are 30 districts in Orissa. Geologically, Orissa is divided into five major regions: (1) the coastal plain in the east, (2) the middle mountainous and highlands region, 3) the central plateaus, (4) the western rolling uplands and (5) the major flood plains. Most of the population is located in the coastal plain, including the Mahanadi River delta. The total population of Orissa is 36,706,920 with 51% of male and 49% of female. The population density is 236 per km^2 with

85% of the people living in rural areas and 15% living in urban areas according to the 2001 census of India.

Orissa is known as one of the most mineral-rich states of India (see Figure A4.2). It has iron ore (32.90 per cent of Indian reserves), bauxite (59.95 per cent), chromite (98.4 per cent), coal (24.8 per cent) and manganese (67.6 per cent). The iron ore deposits of Orissa are found in five distinct geographic zones; (1) Bonai-Keonjhar,(2) Gandhamardhan, (3) Tomka-Daitari, (4) Gorumahiasani-Badampahar (5) Hirapur. The Keonjhar district itself contains 75% of the iron ore reserves of Orissa (Indian Bureau of Mines, 2005). Keonjhar is a land locked district in northern Orissa with an area of 8,249 sq.km. The forest area is 2,525.08 sq.km., or about 30 per cent of the total area. Based on the 2001 census, the total population of Keonjhar is 1,561,990. The population density is 188 persons per sq.km, and the population growth rate is 16.83 per cent per year. The Scheduled Tribes of the district represent about 44.5% of the total population, and another 11.6% of the population are Scheduled Castes. Most of the Scheduled Tribes work in agricultural jobs or in mining, quarrying and other services.

The underlying geology of Keonjhar includes some of the oldest rocks in the world at approximately 38,000 million years (see Figure A4.3). Iron ore deposits are found in most parts of the district from the Bihar border in the north of the Jajpur border in the south. Manganese ore deposits are found in Thakurani and Joda East hills of Barbil (Nayak, 2006).Chromite ore deposits are found in Boula area near village Nuasahi of Anandapur subdivision (Kishan, 2010). Industry in the district is also based on mining, including the Kalinga Iron Works Barbil and the Ferro-Manganese Plant, Joda.

4.2.1 Mine Development in Keonjhar

Mining activities first began in the 1950s in Joda, because of its very high grade iron ore. In 1984, 72 of 92 mining leases were operational. There were about 40 proposals for setting up steel plants in Orissa during 2003-1005. These included 44 million tonne capacity build-up project at a huge investment of around Rs.108,000 crore (US$2,372 million). According to the Indian Bureau of Mines (2005), the number of total mines has increased over 50 per cent from 76 in 2001 to 119 in 2005. During the past decade, the total value of iron ore mined in Keonjhar was valued at over Rs. 50,000 crores ($US 110 billion), or 21% of India's total production (Firoz, 2008). Mines in Orissa now cover 333.33 sq.km and has lead to loss of forest cover in Joda about 65.42 sq.km. Moreover, the issue of illegal mining in Keonjhar has also recently become a public concern. Illegal mining of iron and manganese ores in Keonjhar started in 2000 (Chakkabarty, 2009), in response to the growing demand for steel in the international market. Most of iron ore bearing hillocked of Keonjhar now show the sign of destruction due to cutting out of the ore without rehabilitation.

4.2.2 Issues in Keonjhar

Although more than hundred billion tonnes of iron ore has been produced from Keonjhar, 62% of Keonjhar's population still lives below the poverty line. Based on HDR 2004, Keonjhar ranked 24th out of 30 districts of Orissa in terms of the Human Development

Index. Per capita income of Keonjhar in 2001 was only Rs5,286 (US$116.41); whereas per capita income of Orissa was Rs6,487 (US$142.85), as compared to the Indian average of Rs11,779 (US$259.39). Generally, Orissa is considered a low income state. In addition, Keonjhar ranked 22nd in terms of HDI in the health sector (United Nation Development Programme, 2004). Thus, Keonjhar faces many problems, including poverty, poor healthcare and environmental degradation.

While poverty and economic development are key concerns, the issues of health and environmental degradation from mining also matters to the people of Keonjhar. Keonjhar residents have suffered from various health issues regarding to environmental degradation. Mining-related deforestation may have indirectly led to spread of malaria. Barnett, Nair, Tripathy, Borghi, Rath, & Costelllo (2008) show evidence that Keonjah has high morbidity and mortality rates of malaria and Tuberculosis (TB). Moreover, prolonged inhalation of dust from mining operations is another concern, due to potential lung damage and respiratory disease (Coggon & Taylor, 1998). Hence, all of these concerns are challenging and required urgent attention.

4.3 Conceptual Framework

Economic development through mining is challenging for government and policymakers. Mining activities can provide the foundation of an economy in terms of creating value added, boosting employment, and generating personal income. While mining is beneficial to the economy, both in terms of its own economic impact and the value to other industries of its product, it almost always has adverse environmental impacts and eventually health impacts. The chapter focuses specifically on the local health impacts of iron ore mining in Orissa.

Figure A4.4 presents a conceptual framework to analyze the impact of mining. The multiple dimensions of this impact include environmental conditions, economic conditions related to employment in mine, and health conditions as mediated by both environment and employment condition. Thus, to assess the impacts of mining activities on a local area, I consider the following steps.

a) Environmental Health

Mining activities obviously threaten local environment by causing pollutions and ecological changes. For example, Dutta, Sreedhar, & Basu, (2003) studied on effects of an abandoned chrysotile asbestos mine on villagers in the Chaibasa region of the West Singhbhum district of Jharkhand, India. The results found relationships between asbestos mining and several adverse health outcomes in this population, including low back pain, dyspnea. hemoptysis, and blindness due to the disposal of toxic asbestos and chromite waste by the mining company (McCulloch, 2003). studied on mines of Southern Africa produced all three commercial varieties of asebestos, namely chrysotile, crocidolite and amosite. The dust problem posed by asbestos mining extended far beyond the workplace to those who lived in adjacent communities. Counter, Bachanan, & Fernando (2005) investigated mercury levels in urine and hair of Andean children of indigenous Saraguro and Metizo gold miners in the Nambija, Ecuador gold mining settlement. The study found that mercury levels tended to be higher for children aged 6–14 years of the study area, and these might place them at risk for neuro-developmental and learning disorders. Hurtado, Gonzales, & Steenland (2006) studied on mercury exposures from working in or living near informal gold mining in southern Peru. Since mercury can be readily transferred between air, water, and soils and can be transported long distances in the atmosphere, the study found that smelters in these area were seriously contaminated.

b) Local Employment Opportunity

People who live close to mines may have better employment opportunity, not only from mine sectors but also other related-industries, such as transport or processing of minerals, or services for mine workers and companies. Mining can reduce poverty through the creation of jobs which generate income for workers and their family. Increases in family income are always associated with better well-being and living conditions.

c) Occupational Health

Working in mine faces too many health risks, such as dust-related diseases, waterborne disease, skin diseases, and mine accidents. For example, Meeran (2003) studied on the asbestos mining operation of Cape Plc. South African. Asbestos-related disease occurred on a significant scale among miners and people living near mining. Sabbioni, Wesp, Lewalter, & Rumler, (2007) studied on the respiratory effects of diphenylmethane diisocyanate (MDI)-based resins and ureaformol- and formophenolic-based resins, used in coal mining. The results showed that coal miners had respiratory symptoms and chronic bronchitis.

d) Impact of mining on health when both environmental health and occupational health are included

Mines as development projects can create employment and provide a significant source of local household income, which is beneficial outcome for local community. In general, the low income family is most vulnerable to poor health due to restricted health care, poor housing condition and sanitation. However, as mine development is likely to have costs or tradeoffs with pollution in the workplace and irreversible damage to environment, both positive and negative impacts on local people health through environment and occupation are accounted for this study.

e) Impacts of Other Factors on Health

Education and health usually are positively related. The National Health Interview Survey in 2001 showed that the better educated a person was, the more likely that person was to report being in excellent or very good health. Among adults age 25 and above, 78 percent of those with a bachelor’s degree or higher reported being in excellent or very good health, compared 39 percent of those with less than a high school education. Age is also related to health. As age increases, the mid-age adult tend to have better health compared to the children, and the elderly. Besides, health service and health are also directly related. Persons with better access to health service tend to have better health.

4.4 An Empirical Model of Impacts of Mine on Human Health in Individual Level

The empirical model for this individual level study is based on the definition of environmental and occupational health as well as the conceptual framework above. In the first step, the individual-level dataset is used to report employment in mine – (1) percent of household with family members working in mine; (2) percent of individuals who are working in mine by gender and age. In the next step, occupational health from working in mine is analyzed. I assume that incidences of different diseases (H) are expressed as a function of working in mine (W) as shown in equation (1). In addition, comparison table of incidences of diseases among mine employee and non-employee is also created. The following equation (2) estimates environmental health by assuming that incidences of different diseases (H) are expressed as a function of distance to mine (D). Later on in equation (3), occupational health from working in mine (W) is reanalyzed by assuming that working in mine is a function of individual characteristics (I), household characteristics (C), distance to mine (D) and wage rate in agriculture job (A). The last equation (4) shows that the incidences of different diseases are function of individual characteristics (I), household characteristics (C), distance to mine (D) and working in mine (W) which is a function of determinants as in equation (3).

$$H_i = f\,(W_i) \tag{1}$$

$$Hi = f(\,D_i\,) \tag{2}$$

$$H_i = f\,(W_i\,(I_i\,, C_{i,}\, D_{i,}\, A_i\,)) \tag{3}$$

$$H_i = f\,(I_i\,, C_{i,}\, D_{i,}\,, W_i\,;\, W_i\,(I_i\,, C_{i,}\, D_{i,}\, A_i\,)) \tag{4}$$

The variables used in each group are:

The incidence of different diseases (H): a binary variable of incidence of diseases

Working in mine (W): a dummy if individual is employed in mines

Distance to mine (D) : distance to nearest iron ore mine

Individual characteristics (I): age, gender, education

Household characteristics (C): caste, production asset, consumer asset, quality of house, distance from their house to pave roads, distance from their house to primary health center

Wage rate in agriculture job (A): wage in agriculture

4.4.1 Probit model for incidences of diseases

For the analysis of these data, the binary choice models are appropriate (Amemiya, 1981). The linear probability, logit and probit are three common binary choice models. However, since the liner probability model has several statistical deficiencies, it is not appropriate for this study (Capps & Kramer, 1985). The logit model is associated with the logistic distribution; whereas the probit model is associated with a normal distribution. The applications of logit and probit are likely to give similar results based on the distribution (Maddala, 1986). Thus, the probit model is used in this study due to the appropriate and convenience. The following probit model is estimated:

$$Y_i = X_i\beta + \varepsilon_i \qquad (5)$$

where

Y_i is an observed dichotomous dependent variable which takes value 1 when the *i*th individual is infected with diseases and 0 otherwise;

X_i is a vector of explanatory variable;

β is a vector of parameters to be estimated; and

ε_i is an error tem, which is assumed to have standard normal distribution.

The probability, *Pi*, of the incidence of diseases on the *i*th individual is defined by

$$P(Y_i = 1 \mid X) = \Phi(X_i\beta) \qquad (6)$$

where P denotes probability, and Φ denotes the distribution function for the standard normal distribution.

The magnitude of the marginal effect of an explanatory variable upon the probability of the incidence of diseases cannot be assessed directly from the parameter estimates. For a non-dichotomous variable, such as age, wage, the marginal probability is defined by the partial derivative of the probability that $Y_i = 1$ with respect to that variable. For the *j*th explanatory variable, the marginal probability is defined by

$$\partial P_i / \partial X_{ij} = \varphi\,(X_i\beta)\,\beta_j \qquad (7)$$

where $\varphi(.)$ denotes the standard normal density function and β_j is the coefficient of *j* th explanatory variable

This model can be interpreted as one unit increase in the *j*th explanatory variable is associated with change in the probability of incidence of diseases. The marginal probability values are estimated at the mean values of the explanatory variables (Polson and Spencer, 1991). For a dichotomous variable, such as gender, the marginal probability should be defined as the difference between the probabilities of incidence of diseases when the variable takes the value 1 and 0.

4.4.2 Probit model for incidences of diseases with binary endogenous regressor

In this study, employment in mines is assumed to be endogenous and is estimated simultaneously with the incidence of diseases as in equation (3) and (4). This model, which has a structure similar to that of treatment effect model, except that the dependent variables are binary indicators, estimate the effect of an endogenous binary treatment from working in mine, W_i, on a variable Y_i, conditional on the independent variables X_i. The following probit model is estimated;

$$Y_i = X_i\beta + \delta W_i + \varepsilon_i \qquad (8)$$

$$W_i = X_i\gamma + u_{i.} \qquad (9)$$

where $(\varepsilon_i , u_{i.}| X_i) \sim N(0, 0, 1, 1, \rho)$

N(0, 0, 1, 1, ρ) indicates the standard bivariate normal distribution with correlation coefficients ρ. When ρ is zero the model for Y_i is the standard probit model.

Y_i is an observed dichotomous dependent variable which takes value 1 when the *i*th individual is infected with diseases and 0 otherwise. W_i is an endogenous dummy variable indicating whether individual works in mine. It is assumed that Wi is a function of the exogenous variable X_i and a random component $u_{i.}$

With this structure, the model falls into the general class of simultaneous equation models with dummy endogenous variables introduced by Heckman (1978). This is a specific case of the bivariate probit model, denoted by Greene (2007) as a recursive model of simultaneous equations, since the endogenous variable W_i appears on the right hand side of the second equation, but not vice versa. To simultaneously estimate the two regressions, we assume that error terms are jointly normally distributed and use maximum likelihood methods. This method allows you to model that correlation directly, thereby eliminating the omitted-variable bias. For identification, what this requires is that there be at least on exogenous variables in equation (9) that is not in equation (8). For this study, there is production asset variable that is associated with working in mine. This variable is denoted as exclusion restriction which is used in a simultaneous equation system.

In STATA, *biprobit* command estimates bivariate probit models. I can specify equation individually, in each of which a binary variable and independent variables.

4.5 Data and Variable

The empirical analysis is based on a household survey conducted in Orissa, India in 2006. The survey covered total 600 households in 20 villages of Joda and Keonjhar Sadar Block. The survey provided data on basic demographics, socioeconomic, recent illness and other variables that affect communities in Orissa.

4.5.1 The incidence of different diseases (H)

The main interest of this study is the impacts of mining on local health which represents with several incidences of diseases. The diseases that are associated with this study are (a) waterborne disease, (b) respiratory disease, (c) typhoid, (d) tuberculosis, (e) fever, (f) blood pressure, (g) jaundice, and (h) malaria. The reason that I select these eight diseases to study the impact of mining based on the literature reviews and common health problems in Orissa.

Mining causes water pollution in a number of ways. Mine waste has contaminated the sources of water which affects community health in term an increase rate of waterborne disease. The waterborne disease in this study covers loose stool, diarrhea and cholera. In addition, the impacts of mine have not only caused serious indoor air pollution for worker in mine, but have also affected air quality for the community. (Hedlund, Jarvholm, & Lundback, (2006) found that worker in mine had an increase risk for respiratory symptoms including recurrent wheeze, longstanding cough, and for physician-diagnosed chronic bronchitis. Ross & Murray, (2004) showed that workers in coal mine had pneumoconiosis, asbestos related diseases, lung cancer and other respiratory diseases even after mining operations cease. Maganu (1981) showed that the first reported cases of TB in Botswana occurred as late as the early 1930s and were related to migration of workers to South African mines. Recently, Ghosh, (2009) showed that mining migration has still caused TB crisis over the past decade. Khatua. & Stanley (2006) stated that the polluted Brahmani river from mining have made skin diseases, malaria, tooth diseases, eye infection, fever, jaundice, intestinal in the area.

The incidence of disease, which is dummy variable, equals to 1 if individual reports health problems and 0 otherwise.

4.5.2 Working in mines (W)

Since this study analyses the impact of occupational health from working in mines, the working in mine variable is derived from the household questionnaire. The household questionnaire has record of occupation details of every individual of 600 households. Working in mine, which is a dummy variable, equals to 1 if individual reports to be working as a non-farm worker as factory worker, and 0 otherwise.

4.5.3 Distance to mine (D)

This study analyses the impact of environmental health based on exposure to mines. GIS information on location of mines and villages based on the Euclidean distance from each village to the nearest mine used in this study.

4.5.4 Individual characteristics (I)

The individual characteristics for this study are age, gender, and education. Individual age information comes from the household questionnaire which asked how old of each member in household in unit of year, month and day. I convert the answer in month and day into year. Gender information is a dummy variable, equals to 1 if individual reports to be male, and 0 if individual reports to be female. Individual education information comes from the household questionnaire which asked how many years of education.

4.5.5 Household characteristics (C)

Household characteristics for this study are caste, production asset, consumer asset, quality of house, distance from the house to pave roads, and distance from the house to primary health center. Caste information is derived from the household questionnaire that asked what the government assigned category is. Caste variable is a dummy variable, equals to 1 if household reports to be Scheduled Castes (SC) or Scheduled Tribes (ST), and 0 otherwise. According to the central government policy, fifteen per cent of India's populations are SC. Fifteen per cent of the government jobs and fifteen per cent of the students admitted to universities must be from SC. Seven per cent of India's populations are Scheduled Tribes; meanwhile seven per cent of jobs are reserved for them. The Other Backwards Classes (OBC) are about fifty per cent of India's population, but only twenty seven per cent of government jobs are reserved for them. Since reservation has provided very real benefits to the SC/ST group, a proxy for caste variable is set to 1 when household is in SC or ST.

Production asset variable is calculated by counting number of the different types of agriculture production assets owned by household. The questionnaire reports whether household owns any agriculture production asset, such as, large tractor, small tractor, machine pulled plow, animal pulled plow, mechanical water pump, sprinkles, threshers, rice winnower, mill, machine to process, insecticide pump, ox cart, small cart pulled, shovels, axes and machetes, nets, traps, and saws. Binary variable is created for whether household owns any of these assets or not.

Consumer asset variable is calculated by counting number of the different types of consumption assets owned by household. The questionnaire reports whether household owns any consumer durable asset, such as, refrigerator, washing machine, sewing machine, generator, electric fan, television, video player, tape recorder, camera, bicycle, motorcycle, car, truck, radio, telephone, cell phone, mosquito net, clock and watch, pressure cooker, mixer, mattress, bed, chair, table, almirah (large cabinet or chest), and gold jewelry. Binary variable is created for whether household owns any of these assets or not.

The proxy variable for poor quality of house is set to 1 when a house used 2 or more poor quality materials for floor, walls, and roof, and 0 otherwise. Bad quality materials are wood, bamboo, earth, mud, raw brick, grass and thatch.

Distance from the house to pave roads variable is from household questionnaire how far from house to nearest all weather road in minutes. Distance from the house to primary health center is from household questionnaire how far from house to nearest household facility in minutes.

4.5.6 Wage rate in agriculture job (A)

Wage rate in agriculture job is derived from household questionnaire on hire-in wage for agriculture in rupee**.** This wage rate information represents the opportunity cost if individual switches to work in mine instead.

Descriptive statistics are reported in Table A4.1

4.6 Results

This section presents data and relevant discussions based on survey data and empirical models. From 2656 individuals in 600 households, average reported age is 29 years, from around 3 months to 105 years. The average education is about 3 years of school with range from no education to 18 years of school. Majority of household is from Scheduled Casted (SC) and Schedule Tribe (ST). In addition, most of house quality which is an important indicator of living standard is considered to be bad based on the material used for wall, floor and roof. Household owns about three different kinds of production asset; meanwhile household owns about five different kinds of consumer assets. Average distance from house to nearest all weather roads is around 30 minutes; whereas average distance from house to health facility is around 47 minutes. Average distance to mine which represents mine exposure is around 8 kilometers with the closest one within less than one kilometer and the farthest one within 21 kilometers. In term of labor wage, average wage rate of hired labor is about 8 Rupee.

The incidences of illness are grouped based on two block locations; Joda and Keonjhar Sadar (Table A4.2). Individuals in Joda, which is closer to mine area report higher incidences of most illness, such as waterborne disease, ARI, typhoid, TB, fever, and jaundice than individuals in Keonjhar Sadar. Four common health problems in both blocks are malaria, ARI, waterborne diseases and fever. Intuitively, these health problems are related to living condition, income, hygiene, health education and health care service, which will consider in the next part.

4.6.1 Impact of mining on employment

One of the main impacts of mining, which is also the main reason that India government supports the mining sector, is the impact of mining on economic development through generating of local community income from employment. From the household questionnaire, working in mining absorbs about 7.94 per cent of total respondents (Table A4.3). Only 1.20 per cent of respondent is female who works in mine. The number of mine worker (211 people) is divided into three age –groups; children, adult, elderly in Table A4.4. Individual who is under 13 years old is counted as children; whereas individual who is over 60 years old is counted as elderly. Adult is individual who is between 13 and 60 years old. There was only one child who worked in a mine; meanwhile none of elderly individual is reported as mine worker. This is corresponding to the characteristics of job in mine, which involves standing for long periods, lifting moderately heavy objects, and climbing to work with tools. All of these works require physical strength and stamina.

4.6.2 Occupational health from working in mine

Although working in mine generates mine worker income that can support their health, it has its disadvantage in term health problem from working in mine. Table A4.5 presents the results from equation (1) when incidence of disease is associated with working in mine. Working in mine shows significantly positive impact on incidence of waterborne disease. Table A4.6 shows a comparison of incidence among mine worker and non mine worker, using chi-squared test. Waterborne disease, and tuberculosis are only two incidences that show statistically significant in the difference between working and non-working in mine based on chi-square test. Since there are other determinants behind employment decision, such as, age, gender, education, distance from work, and caste especially in India, the equation (3) is estimated. Table A4.7 shows that higher incidences of acute respiratory infection (ARI), tuberculosis, and fever are associated with working in mine when working in mine depends on both individual and household characteristics.

From empirical evidence, the decision to working in mine depends on age, education level, gender, caste, agriculture production asset and distance to mine. The estimated coefficients of age, education, male gender, and caste are significant and positive; whereas the estimated coefficients of distance to mine and are significant and negative. These results correspond to the fact that people are looking for jobs that are closer to their house.

Individuals tend to work in mine if they are living closer to the mine. In addition, individual tends to not work in mine if he owns a variety of agriculture productions assets.

4.6.3 Impact of mining on occupational and environmental health

In order to improve the estimation of impact of mining on local, other individual characteristics, and household characteristics that affect incidence of diseases are included in the study. The results from equation (4) are presented in Table A4.8. In order to identify the simultaneous equation systems, the agriculture production asset variable is used as exclusion restriction. Agriculture production asset is associated in working in mine equation, but not in incidence of disease equation.

Contrary to the first simple analysis, which work in mine is only variable on right hand side, working in mine does not appear to cause incidence of waterborne disease. In Table A4.8, individuals who live closer to the mine have higher incidence of waterborne disease, which implies that those individuals are exposing to poor water quality. In addition to waterborne disease, typhoid and fever are also associated with living close to mine. This supports the fact that typhoid is a disease transmitted through environment contamination and hygiene.

On the other hand, working in mine does appear to have a large impact on acute respiratory infection (ARI) and tuberculosis. The estimated coefficients of ARI and TB are positive and statistically significant. The empirical result also shows that working in mine can lower the incidence of fever. Income from working in mine could increase the standard of living and lower incidence of fever.

For other variables, the estimated coefficient of distance to health facility on incidence of malaria is negative and statistically significant. Moreover, longer distance from road can lower incidence of ARI, which supports the fact that individuals who live close to the road tends to expose more dust and air pollution. The dummy variable of poor quality of house also shows positive impact on incidence of ARI.

4.6.4 Impact of mining on environmental health

Table A4.9 shows the result from equation (2) when distance to mine is only variable on right hand side. If instead I had only considered impact of living close to mine, we would have blamed waterborne disease, ARI, typhoid and fever on living close to mine**.**

Compare to Table 4.8 which both environmental and occupation health indicators are included, living close to mine appears to be evidence only for waterborne disease, typhoid and fever. This is corresponding to the fact that those incidences of diseases are related to environmental change in water habitat and quality. While local people complain about the dust from living close to mine, it looks like that the incidence of ARI is not associated with living close to mine, but working in mine - which intuitively, makes sense.

4.7 Conclusion

This study analyzes occupational and environmental health as related to mining in Orissa, India. Although mining generates economic gains in term of value-added, employment and income, its impacts on the environment and public health are potentially significant and adverse. Distance to mine is used as a proxy for environmental degradation by mines and therefore an indicator of environmental health impacts. Waterborne disease, typhoid and fever are negatively associated with distance to mine. Turning to occupational health, ARI is obviously associated with working in mines. These findings provide important insights on the full impacts of mines, encouraging policy makers to look beyond the obvious positive economic impacts of mining. Of course, these may not be inevitable impacts of mines, but rather, possible to mitigate with appropriate regulation and enforcement, imposing accountability for local environmental and health quality. For example, mining operations perhaps could be required to support programs to provide safe water and sanitation. In sum, this study illustrates the importance of taking into account local community health when planning and investing in economic development.

4.8 References

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4.9 Appendix

Figure 4.1 India Map

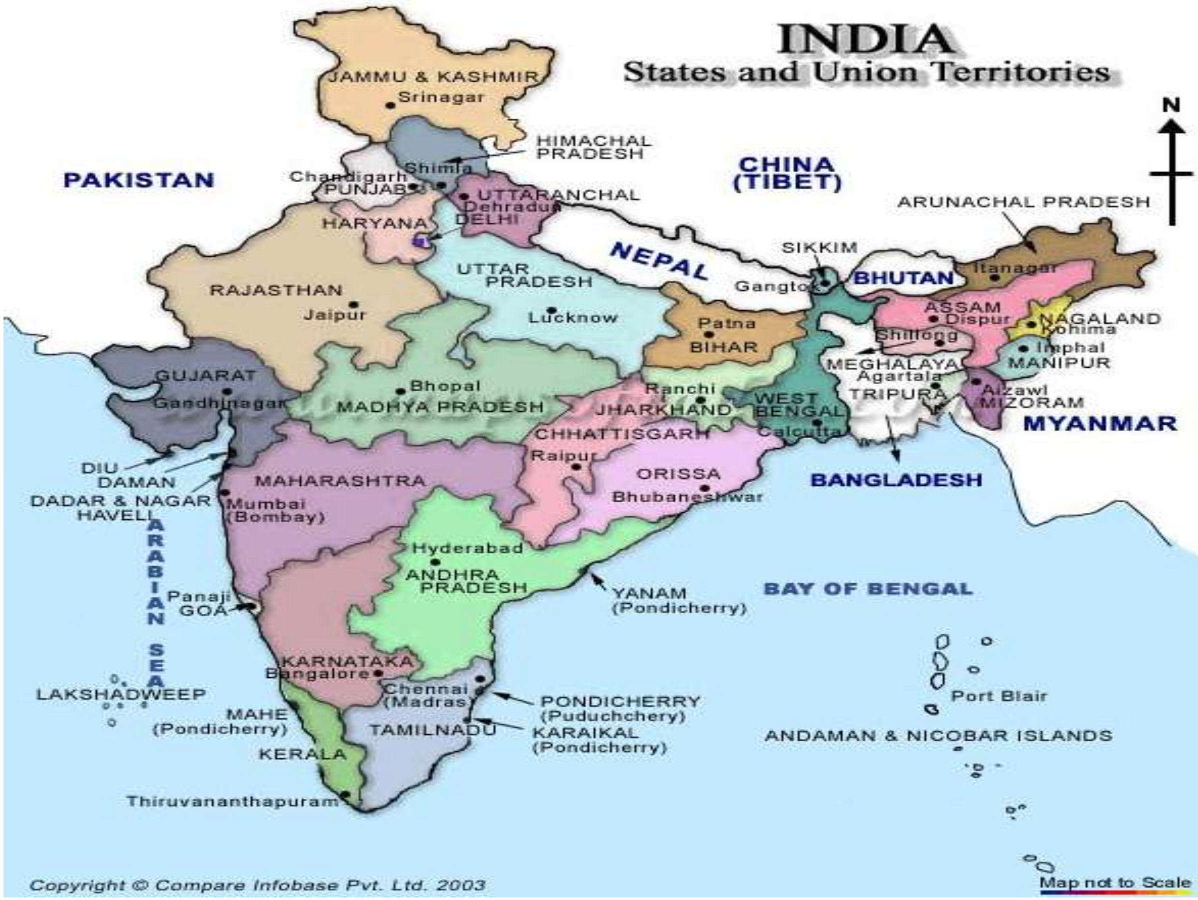

Figure 4.2 Orissa Map

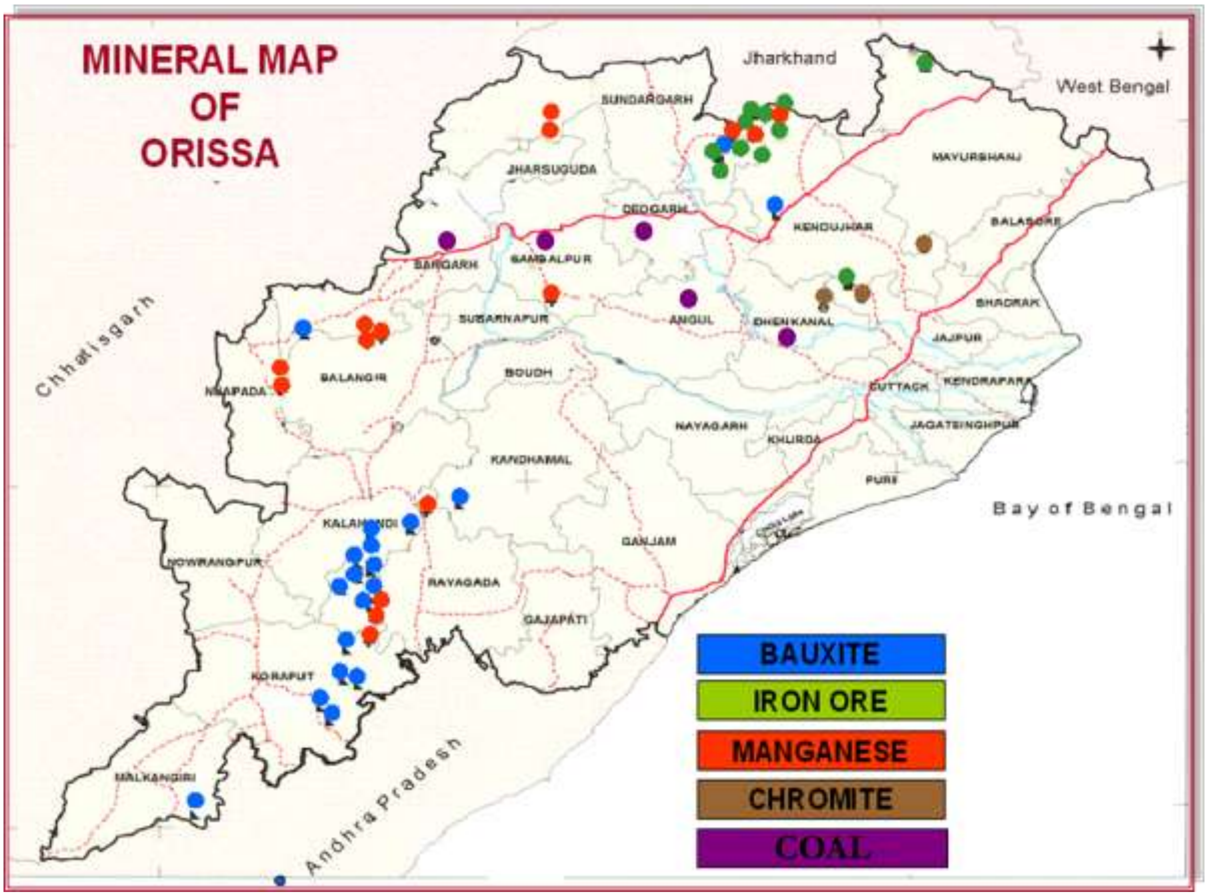

Figure 4.3 Block Map of Keonjhar

Figure 4.4 Conceptual Framework

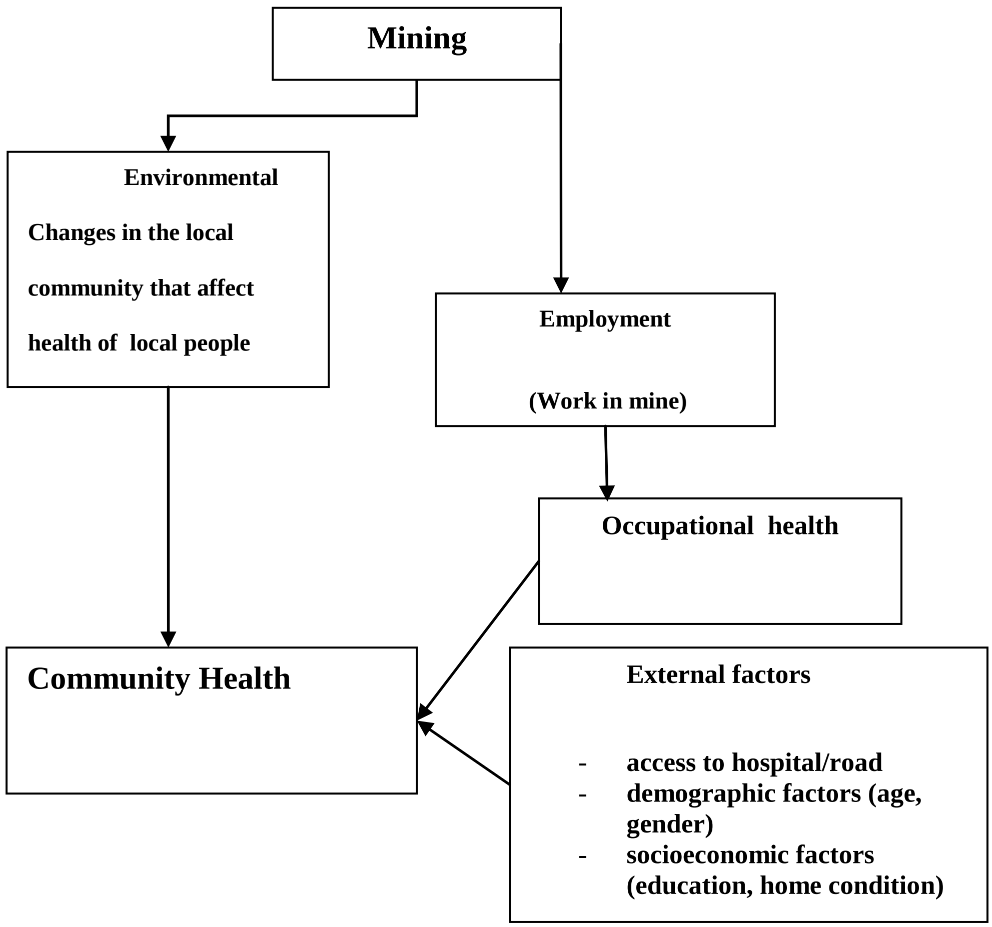

Table 4.1 Descriptive statistics of household and individual level variables in Orissa

Variables		Obs	Mean	Std. Dev.	Min	Max
Individual Variables						
Age (year)	age	2656	28.29	18.07	0.03	105.00
Male (dummy)	male	2656	0.51	0.50	0.00	1.00
Education (year)	edu	2656	2.92	4.02	0.00	18.00
Household Variables						
Caste (dummy)	caste	600	0.74	0.44	0.00	1.00
production asset	prodasset	600	2.38	1.16	0.00	7.00
consumer asset	conasset	600	4.48	3.19	0.00	18.00
poor house quality (dummy)	badhouse	600	0.76	0.43	0.00	1.00
distance to paved road (minutes)	droad	600	29.28	33.56	1.00	180.00
distance to health facility (minutes)	dhealth	600	46.83	37.14	2.00	160.00
distance to mine (km)	dmine	600	7.32	6.10	0.21	20.92
wage paid to agricultural workers (rupee)	Hirewage	600	7.66	14.31	0.00	60.00

Table 4.2 Number of individuals from 2656 individuals who had illness in past year

Block	waterborne disease*	ARI	typhoid	TB	fever	blood pressure	jaundice	malaria
Joda	158	353	46	9	99	7	4	478
(%)	-5.95	-13.29	-1.73	-0.34	-3.73	-0.26	-0.15	-18
K.Sadar	107	249	31	6	30	8	3	567
(%)	-4.03	-9.38	-1.17	-0.23	-1.13	-0.3	-0.11	-21.35

* Waterborne disease consists loose stool, cholera and diarrhea

Table 4.3 Employment in mine from 2656 individuals by gender

	Employment		
	not working in mine	working in mine	Total
Female	1,267	32	1,299
(%)	-47.7	-1.2	-48.91
Male	1,178	179	1,357
(%)	-44.35	-6.74	-51.09
Total	2,445	211	2,656
	-92.06	-7.94	-100

Table 4.4 Employment in mine from 2656 by gender and age

	Female	Male	Total
Children (<13 years)	0 0	1 -0.04	1 -0.04
Adult (13 - 60 years)	32 -1.2	178 -6.7	210 -7.91
Elderly (>60 years)	0 0	0 0	0 0
Total	32 -1.2	179 -6.74	211 -7.94

Table 4.5 Probit model of incidence of disease with working in mine (N=2656)

	waterborne disease	ARI	typhoid	TB	fever	blood pressure	jaundice	malaria
work in mine	0.2097	-0.0315	-0.0938	0.391	0.0845	0.2081	0.2187	-0.0541
(p-value)	-0.06	-0.75	-0.63	-0.11	-0.56	-0.46	-0.55	-0.55
constant	-1.3016	-0.7474	-1.889	-2.5822	-1.666	-2.5545	-2.813	-0.2661
(p-value)	0	0	0	0	0	0	0	0
Chi-square	3.31	0.1	0.24	2.19	0.33	0.51	0.32	0.35
(p-value)	-0.06	-0.75	-0.62	-0.13	-0.57	-0.47	-0.57	-0.55

Table 4.6 Respondent reported having incidence of illness based on working in mine (N=2656)

	Waterborne disease	ARI	typhoid	TB	fever	blood pressure	jaundice	Malaria
Not working in mine	236 -8.89	556 -20.93	72 -2.71	12 -0.45	117 -4.41	13 -0.49	6 -0.23	966 -36.37
Working in mine	29 -1.09	46 -1.73	5 -0.19	3 -0.11	12 -0.45	2 -0.08	1 -0.04	79 -2.97
Total	265 -9.98	602 -22.67	77 -2.9	15 -0.56	129 -4.86	15 -0.56	7 -0.26	1,045 -39.34
Chi2	3.62	0.09	0.23	2.99	0.34	0.59	0.38	0.35
Pr >chi2	0.06	0.75	0.63	0.08	0.56	0.44	0.53	0.55

Table 4.7 Probit model of incidence of disease with working in mine which depends on individual and household characteristics (N=2656)

	waterborne disease		ARI		typhoid		TB		fever		blood pressure		jaundice		malaria	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
Incidence of disease																
Work in mine	0.2205	0.51	0.7896	0.02	-0.0158	0.98	2.1471	0.03	1.0089	0.04	1.7342	0.20	0.413	0.56	-0.3424	0.19
Constant	-1.3025	0.00	-0.7946	0.00	-1.8948	0.00	-2.6105	0.00	-1.7025	0.00	-2.583	0.00	-2.8257	0.00	-0.2424	0.00
Work in mine																
Age	0.01	0.00	0.0098	0.00	0.01	0.00	0.0103	0.00	0.0102	0.00	0.0102	0.00	0.0099	0.00	0.0101	0.00
Edu	0.0224	0.04	0.0195	0.07	0.0225	0.04	0.0204	0.06	0.0238	0.03	0.0216	0.04	0.0228	0.03	0.0201	0.06
Male	0.8674	0.00	0.8542	0.00	0.867	0.00	0.8787	0.00	0.8236	0.00	0.8704	0.00	0.8687	0.00	0.8717	0.00
Caste	0.2792	0.01	0.2714	0.01	0.2762	0.01	0.2874	0.00	0.2625	0.01	0.2856	0.00	0.2805	0.01	0.2843	0.00
Dmine	-0.0638	0.00	-0.0678	0.00	-0.0639	0.00	-0.0633	0.00	-0.0657	0.00	-0.0632	0.00	-0.0637	0.00	-0.0628	0.00
Hirewage	0.0013	0.68	0.0012	0.70	0.0013	0.70	0.0013	0.69	0.0014	0.66	0.0012	0.71	0.0013	0.69	0.0006	0.85
Pprodasset	-0.1396	0.00	-0.1206	0.01	-0.1396	0.00	-0.1396	0.00	-0.1529	0.00	-0.1401	0.00	-0.1395	0.00	-0.1369	0.00
Constant	-1.9014	0.00	-1.8898	0.00	-1.8983	0.00	-1.92	0.00	-1.8276	0.00	-1.9137	0.00	-1.9031	0.00	-1.9112	0.00
Chi-square	184.55	0.00	211.88	0.00	183.51	0.00	197.77	0.00	199.05	0.00	189.4	0.00	184.07	0.00	189.88	0.00

Table 4.8 Probit model of incidence of disease in equation (4): (N=2656)

	waterborne disease		ARI		typhoid		TB		fever		bloodp		jaundice		malaria	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
Incidence of disease																
Age	0.0017	0.37	-0.0027	0.08	-0.0031	0.31	0.0157	0.01	0.0056	0.02	0.0242	0.00	-0.0101	0.31	-0.0011	0.45
Edu	-0.0321	0.00	-0.0182	0.01	0.0001	0.99	-0.0305	0.34	0.0127	0.29	0.0061	0.83	0.0622	0.04	0.0307	0.00
Caste	0.0767	0.35	-0.2011	0.00	-0.3052	0.01	0.2808	0.31	-0.0615	0.55	-0.0109	0.96	0.5234	0.20	-0.0677	0.25
Dmine	-0.0264	0.00	-0.0052	0.34	-0.025	0.02	0.0126	0.49	-0.0698	0.00	0.0104	0.59	-0.0115	0.66	-0.0006	0.92
Dhealth	-0.0012	0.21	0.0012	0.11	-0.0001	0.92	-0.001	0.73	0.0005	0.68	0.0012	0.68	-0.0009	0.83	-0.0017	0.02
Droad	0.0014	0.16	-0.0033	0.00	-0.0024	0.17	-0.0037	0.32	-0.0013	0.36	0.0029	0.25	0.0031	0.39	-0.0009	0.21
Badhouse	-0.0666	0.42	0.2451	0.00	-0.0655	0.59	-0.0557	0.81	-0.1003	0.31	-0.0274	0.92	0.1163	0.73	-0.0122	0.85
Conasset	0.0006	0.96	0.0277	0.00	-0.0195	0.27	-0.008	0.8	-0.0441	0.00	-0.0324	0.42	0.0411	0.30	0.0108	0.21
Work in mine	-0.4122	0.20	0.8288	0.04	-0.4152	0.42	1.7594	0.07	-1.0162	0.00	0.9656	0.39	0.3372	0.70	-0.2497	0.44
Constant	-1.0155	0.00	-0.7655	0.00	-1.1909	0.00	-3.22	0	-0.97	0.00	-3.635	0.00	-3.5296	0.00	-0.1885	0.11

Table 4.8 (continue)

	waterborne disease		ARI		typhoid		TB		fever		bloodp		jaundice			Malaria	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
Work in mine																
Age	0.0099	0.00	0.0102	0.00	0.0099	0.00	0.0100	0.00	0.0100	0.00	0.0099	0.00	0.0100	0.00	0.0100	
Edu	0.0234	0.03	0.0226	0.03	0.0224	0.04	0.0219	0.04	0.0213	0.04	0.0224	0.04	0.0225	0.04	0.0232	0.03
Male	0.8659	0.00	0.8558	0.00	0.868	0.00	0.8771	0.00	0.8803	0.00	0.8696	0.00	0.8685	0.00	0.8726	0.00
Caste	0.2853	0.00	0.3023	0.00	0.2826	0.00	0.2807	0.01	0.2841	0.00	0.2847	0.00	0.2793	0.01	0.2796	0.01
Dmine	-0.0639	0.00	-0.0653	0.00	-0.0639	0.00	-0.0638	0.00	-0.0645	0.00	-0.0637	0.00	-0.0637	0.00	-0.0631	0.00
Hirewage	0.0015	0.64	0.001	0.76	0.0016	0.63	0.0014	0.68	0.0008	0.81	0.0013	0.69	0.0013	0.69	0.0009	0.78
Prodasset	-0.1414	0.00	-0.1253	0.01	-0.1399	0.00	-0.1407	0.00	-0.1088	0.02	-0.1397	0.00	-0.1396	0.00	-0.1373	0.00
Constant	-1.9034	0.00	-1.9415	0.00	-1.9014	0.00	-1.9040	0.00	-1.9692	0.00	-1.9046	0.00	-1.9021	0.00	-1.9147	0.00
Chi-square	223.28		260.09		202.05		209.32		266.89		206.72		191.06		231.66	

Table 4.9 Probit model of incidence of disease with distance to mine : (N=2656)

	waterborne disease		ARI		typhoid		TB		fever		bloodp		jaundice		malaria	
	coef	p-value	coef	p-value	coef	p-value	coef	p-value	coef	p-value	coef	p-value	coef	p-value	coef	p-value
Dmine	-0.022	0.00	-0.015	0.00	-0.02	0.02	-0.002	0.90	-0.0582	0.00	0.0021	0.88	-0.006	0.78	0.0086	0.03
Constant	-1.131	0.00	-0.641	0.00	-1.759	0.00	-2.519	0.00	-1.324	0.00	-2.55	0.00	-2.75	0.00	-0.3345	0.00
N	2656		2656		2656		2656		2656		2656		2656		2656	
Chi-square	15.68	0.00	11.71	0.00	5.94	0.01	0.02	0.89	53.72	0.00	0.02	0.88	0.08	0.78	4.63	0.03