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Modeling natural resources scarcity and proverty effects on fertility in Honduras, Nepal, and Tanzania

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Dissertation Defense

ABSTRACT

Modeling Natural Resource Scarcity and Poverty Effects on Fertility in Honduras, Nepal, and Tanzania

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This dissertation examines whether the vicious circle theory applies in three developing countries characterized by high population growth. According to the vicious circle theory, natural resource scarcity coupled with poverty leads to population growth via positive effects on fertility particularly in rural areas of developing countries. Population growth then leads to a further increase in natural resource scarcity, creating a "feedback loop." This is the first study to use micro-level data to test and control for endogeneity using a two-stage Probit model (IVPROBIT). The existing literature has largely failed to address endogeneity in the relationship between natural resource scarcity and population growth. This study was conducted using cross-sectional data collected by Demographic and Health Surveys (DHS) in Honduras, Nepal, and Tanzania. This study compared the results of single equation models (traditional approach) and IVPROBIT models. The study found that IVPROBIT method consistently outperforms the traditional approach. The levels of statistical significance and magnitudes of the natural resource scarcity coefficients as measured by the time taken to get to the source of drinking water increase for IVPROBIT models. The results provide support for the vicious circle argument by showing that natural resource scarcity and poverty lead to increases in fertility for two of the three countries examined. The coefficients of natural resource scarcity were positively related to fertility. In addition, the coefficients of wealth index which measure households' wealth were negatively related to fertility. The results were consistent for Honduras and Nepal. This study draws a number of important conclusions. First, the analysis confirms that natural resource scarcity is endogenous to fertility. This means the results of the traditional approach may be biased by not addressing endogeneity. Second, protecting natural resources is not only good for the environment but also an important tool if reduced population growth is an objective. Third, reducing poverty is an important factor in reducing fertility. Fourth, the importance of other control variables such as women's education is important as revealed by the study findings. Moreover, targeting infant and child mortality may be a very effective means of reducing fertility.

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ACCEPTANCE PAGE

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CHAPTER 1

INTRODUCTION

The quest for better understanding the complex relationship between natural resources and population growth is one of the challenges that continue to intrigue researchers and policy makers. Most of the existing empirical literature in this area of research has focused on the exogenous impact of population growth on natural resources in developing countries. As a result, the existing literature is dominated primarily by two opposing views, which are Cornucopians and neo-Malthusians (Chenoweth and Feitelson, 2005). These two perspectives seem to agree that population growth has impact on natural resources. However, the Cornucopians assert that natural resource scarcity as a result of population growth creates innovation through human ingenuity.[1] On the other hand, the neo-Malthusians assert that population growth creates enormous pressure on natural resources which in turn leads to disaster and limits growth. However, neither of these two views can better explain the co-existence of sustained population growth and natural resource scarcity in developing countries.

In an attempt to explain the existence of sustained high population growth via increases in fertility in the face of increasing natural resource scarcity particularly in the

[1] In this study time taken to get to the source of drinking water is used as a proxy for natural resource scarcity. Other measures such as prices of natural resource products at various stages of processing, the price of the resource in situ, and the unit cost of extraction can be used as proxies for natural resource scarcity (Halvorsen and Smith, 1984). The term can also be used to mean increasing in deforestation and other environmental deterioration (Barbier, 1999).

rural areas of developing countries, a vicious circle theory was proposed (de Sherbinin, Carr, Cassels, & Jiang, 2007; de Sherbinin et al, 2008). According to this theory, natural resource scarcity coupled with poverty can lead to population growth via increases on fertility (Dasgupta, 1992, 1995a, 1995b, 2000).

Since the introduction of the vicious circle theory only a few empirical studies have examined it. These few studies contain conflicting results (Cleaver & Schreiber, 1994a; Loughran & Pritchett, 1997; Aggarwal, Netanyahu, & Romano, 2001; Filmer & Pritchett, 2002; Sutherland, Carr & Curtis, 2004; Biddlecom, Axinn, & Barber, 2005; Ghimire & Mohai, 2005; Bhattacharya, 2007). These studies revealed that there is no consensus in support or opposition of the vicious circle theory. Results from at least two of the studies (Loughran & Pritchett, 1997; Ghimire & Mohai, 2005) suggested that natural resource scarcity, rather than inducing population growth through demand for children acts as a check on population growth. However, the remaining six studies (Cleaver & Schreiber, 1994a; Aggarwal, Netanyahu, & Romano, 2001; Filmer & Pritchett, 2002; Sutherland, Carr & Curtis, 2004; Biddlecom, Axinn, & Barber, 2005; Bhattacharya, 2007) supported the vicious circle theory that natural resource scarcity has a positive and significant effect on the demand for children.

The conflicting results can partly be explained by the fact that the studies used different methods and measures of fertility. Most of these studies use as the dependent variable either the number of children ever born or desired family size, which is a count variable. The count dependent variable takes only non-negative integer values, which requires the use of special count data regression models (Cameron & Johansson, 1997; Cameron & Trivedi, 1998). However, the studies that have examined the vicious circle

theory have used econometric models that are not designed for count dependent variables. The use of these models can lead to biased results (Wooldridge, 2002).

Another possible source of variation is the use of inappropriate dependent variable. Some of the existing studies have used total number of children ever born (Loughran & Pritchett, 1997; Aggarwal, Netanyahu, & Romano, 2001) and number of living children (Sutherland, Carr & Curtis, 2004) as dependent variables. These dependent variables are a measure of cumulative fertility and they may distort the results because the covariates (natural resource scarcity and poverty variables) may not precede in time the event (total number of children ever born or number of living children).

In addition, the existing studies have largely failed to address the potential endogeneity problem. Endogeneity occurs when an explanatory variable on the right hand side of an equation is correlated with the error term (Brennan & Carroll, 1987). When it happens that a left hand side variable is also a cause of a right hand side variable, that right hand side variable is no longer exogenous, but endogenous. This further indicates that since the left hand side variable is influenced by the error term, so is the right hand side endogenous variable. With the exception of Bhattacharya (2007), the existing studies have treated natural resource scarcity as an exogenous variable contrary to what the vicious circle theory suggests. The main difference between this dissertation and that of Bhattacharya (2007) is that Bhattacharya used macro-level data to address endogeneity whereas this study used micro-level data. The use of micro-level data is useful because "many variables bearing on fertility are more accurately measured at the micro-level and biases resulting from aggregation over households and countries are eliminated (Al-Qudsi, 1998, p. 440)." According to the United Nations Population Fund (UNFPA,

1998), the use of micro-level data could be an alternative approach providing an early warning system for local areas that may be experiencing conditions similar to the argument presented by the vicious circle theory. The other difference between this study and Bhattacharya (2007) is that the current study examined rural areas of the three developing countries from three different continents. On the other hand, Bhattacharya's study focused on three communities in just one country only. In addition, most of the existing studies have not explicitly acknowledged the crucial role that poverty plays as emphasized by Dasgupta (2000).

In this study, alternative econometric methods and measures of fertility are employed using natural resource scarcity, poverty and other determinants of fertility estimates to test the vicious circle theory. This study attempts to resolve several gaps identified in the literature. The first research question that this study attempts to answer is to test and control for potential endogeneity problem in examining the impact of natural resource scarcity and poverty on fertility in developing countries. The existing studies have largely failed to test and address the issue of potential endogeneity. Various tests for identifying and correcting endogeneity as well as model estimations were employed to answer this important research question. In addition, this study examined the vicious circle theory by attempting to use appropriate statistical models and reasonable dependent variables. Another area examined in this study is the applicability of the vicious circle theory. This research question is explored by using micro-level data for three developing countries across three different continents. This is the first study to analyze the vicious circle theory in more than one country using micro-level data. This study uses data from

the 2004, 2005, and 2006 Demographic and Health Survey (DHS) in Tanzania, Honduras, and Nepal respectively.

This study is organized into five chapters. Chapter Two provides a review of the literature on a wide range of issues that are important to this study. Chapter Three presents the methods used in this study. Chapter Four presents the empirical results. Chapter Five provides summary and discussion of the results in comparison with the previous studies as well as recommendations and conclusions.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews literature on a wide range of issues that are relevant to this study of the vicious circle theory and population growth in developing countries. The review is organized around eight sections. Section One provides a brief review of the evolution of fertility determinants using microeconomic approach. Section Two provides a review of the literature of the predominant views on the relationship between population growth and the environment. Section Three reviews the theoretical framework of the vicious circle theory. Section Four provides a review of the evolution of the variables of interests used in this study: natural resource scarcity and poverty and their relationship with population growth via increases in woman's fertility. Section Five provides a review of the literature on the existing studies that empirically examined the vicious circle theory. Section Six highlights some of the limitations of the existing studies that examined the vicious circle theory. This section is important because it lays ground for the justification of this study. Section Seven provides a summary of this chapter. Section Eight presents hypotheses analyzed by this study.

The Conventional Microeconomic Approach to Fertility Determinants

The pioneering works of Becker (1960) and Mincer (1963) were useful both in predicting broad patterns of completed fertility and analysis of other dimensions of fertility (Michael, 1973). For example, Becker (1960) used the theory of demand for consumer durables to analyze the demand for children. In order to justify the use of the theory, Becker viewed children as durable goods, yielding primarily psychic income or satisfaction to parents. According to the theory, fertility is a function of income, child costs, knowledge, uncertainty, and tastes. For a normal good, the economic theory of demand assumes there is a positive relationship between income and demand for that good. If children are assumed to be normal good, the same is expected for the demand of children by parents.

However, Becker (1960) distinguished the quantity and quality of children to show that an increase in income is not expected to bring a significant increase in the demand for children. He argued that it is the quality and not the quantity of children that is positively related to the demand for children. According to Becker, since children are viewed as durable goods, the demand for children is treated in the same manner as the demand for other durable goods such as cars, houses, or refrigerators. For durable goods, quantity income elasticity usually is smaller than quality income elasticity. Therefore, most of the increase in income would be spent on the expenditures related to the quality of children. This argument is supported by the U. S. census data for 1910, 1940, and 1950 which show income as measured by a number of proxies was inversely related to fertility (Becker 1960).

With regard to child costs, knowledge, uncertainty, and tastes, Becker (1960) used historical data to show that there has been a decline in fertility as a result of a rise in the cost of children. The diffusion of knowledge, particularly that of contraceptive technologies was very important in explaining variations in fertility. He used the uneven distribution of contraceptive technologies in England and the United States prior to the 1960s to show that the upper class had lower fertility because it acquired the contraceptive technology earlier than the lower class. Since parents must produce their own children, there is uncertainty in the production or supply of children. Uncertainty comes in different ways such as the sex of children and the capability itself to produce children. This in turn affects fertility. According to Becker, as consumer durables, the demand for children is a function of parent's taste or preference for children relative to other goods that provide utility.

Next, Becker and Lewis (1973) extended the discussion of the microeconomic theory approach of fertility by refining the concept of quantity-quality tradeoff and its role in the fertility decision. The key feature of their analysis is the concept of shadow price of children in terms of their quantity and quality. They noted that the shadow price of children with respect to their number (i.e., the cost of an additional child, holding their quality constant) is positively related to the quality of children. Similarly, the shadow price of children with respect to their quality (i.e., the cost of a unit increase in quality, holding number constant) is positively related to the number of children. In fact, even though there is no reason to believe that education per child and number of children are close substitutes, the interaction between quantity and quality, depends closely on the number of children (Becker, 1981).

Michael (1973) argued that a parent's education is the accumulation of a stock of knowledge; the physical and mental skills that are acquired in the years spent schooling. These accumulations constitute what is known as productive human capital. It is apparent that investments in a woman's education heightens her earnings capacity, increases her time value in the labor market, and raises her full money income (Michael, 1973). According to Michael, these factors may, in turn, affect the relative costs of raising children and providing child services. These relative cost changes (concomitant with changes in wealth) may alter the quantity of child services that a household demands. Michael characterized this phenomenon as "pure income effect." It is further noted that a couple's education (especially that of women) is inversely related to fertility through delayed marriage and postponement of childbearing longer after marriage begins (Michael, 1973).

Galor and Weil (1996) added that the pure effect of an increase in household income holding other factors such the cost of bearing children constant is to raise the demand for children. However, they cautioned that if all childrearing is done by women, an increase in men's income will have such a pure income effect. On other hand, an increase in women's income raises both household income and the price of children. This phenomenon will have offsetting income and substitution effects on the demand for children.

The microeconomic approach to fertility determinants has played a crucial role in the understanding of factors leading to higher level of fertility rates. The approach was very useful in pointing out important determinants of fertility such as education, income, and contraceptive use. However, the approach failed to incorporate an important role of

natural resource availability. It is the emerging theory of vicious circle reviewed in the coming sections that helps in the understanding of the impact of natural resource availability and poverty on fertility rates in developing countries.

Population–Environment Nexus: The predominant Views

The nexus between population growth and environment is an important area of research that has brought much controversy. There are two diametrically opposing schools of thought on the relationship between population growth and the environment (Jackson, 1995). One school of thought which can be called neo-Malthusians, argues that a growing population exerts pressure on the environment (Hardin, 1968; Ehrlich, 1971; Ehrlich & Holdren, 1971; Meadows, Meadows, Randers, & Behrens, 1972; Talbot 1986, Sindiga, 1984; Meadows, Meadows, & Randers, 1992; Bilsborrow, 1992; May, 1993; Myers 1993; Bartlett, 1994; Pimentel, Harman, Pacenza, Pecarsky & Pimentel, 1994; Ehrlich & Ehrlich, 1996; Kates 1996; Renner, 1996; Pimentel, Huang, Cordova, & Pimentel, 1997; Smail 1997; Decker & Reuveny, 2005). Another school of thought that sets out a Cornucopian's view argues that a growing population does not necessarily exert pressure on the environment (Boserup, 1976, 1981, 1983; Simon, 1980, 1981a, 1981b, 1990, 1991, 1992). The following two subsections briefly review the two schools of thought.

The neo-Malthusian's Views

In his theoretical work which linked the relationship between commons and population growth, Hardin (1968, p. 1244), argued that "by any standards, the most rapidly growing populations on earth today are generally the most miserable." A

country's natural system is resilient when there are few people, but as population grows and becomes dense the natural chemical and biological recycling processes become overloaded. Hardin argued that environmental problems such as air and water pollution are a consequence of population growth. He further noted that population growth becomes a problem because of finite natural resources such as food and energy.

For example, Ehrlich (1971) asserted that in relation to food availability and environmental deterioration, overpopulation is the dominant problem on the face of the Earth. For example in developing countries people are not able to produce enough food to feed their populations. Ehrlich noted that even in developed countries people are not able to produce enough food but rather depend on their wealth to buy food from somewhere else. But when food is not available for sale, even in developed countries they find out that money is useless. Ehrlich noted that due to overpopulation, people in developed countries do not have enough resources to support their affluent lifestyles. As a result they end up consuming more than their share of world's natural resources. Ehrlich added that due to overpopulation, people in developed countries have exceeded their environmental capacity to dispose of their wastes. According to Ehrlich, from time immemorial, it takes less and less time for world's population to double. It is pointed out that it took more than a century for the world population to go from 1 billion to 2 billion in 1930, it took only 30 years until 1960 to add the third billion, the fourth billion was added between 1960 and 1975, and the five billion was passed in 1987 (O'Neill, Mackellar, & Lutz, 2001). The sixth billion was added in 1999. Ehrlich (1971) observed that doubling population leads to more than doubling environmental deterioration.

Ehrlich (1971, p. 44) was convinced that environmental deterioration such as "too many cars, too many factories, too much detergent, too much pesticide, multiplying contrails, inadequate sewage treatments plants, too little water, too much carbon dioxide - all can be traced easily to too many people." He went further to say that regardless of changes in technology or resource consumption and distribution, an environmental crisis is bound to happen unless the current rates of population growth are slowed.

To emphasize their point that technological changes is not a panacea to environmental problems, Ehrlich and Holdren (1971) argued that technological fixes suffer from limitations in scale, lead time, and cost. The authors gave an example of desalting seawater for agriculture, new irrigation systems, and high-protein diet supplements all prove too inadequate in practice. They argued that these technological fixes are too little, too late, too expensive or they have sociological costs which reduce their effectiveness. Ehrlich and Holdren argued that technological innovations such as synthetic organic pesticides and inorganic nitrogen fertilizers have created enormous environmental problems. The authors made explicit that they are not against technological attempts. However, they noted that technological attempts tend to be slow, costly, and insufficient in scale. More importantly, Ehrlich and Holdren pointed out that the measures most often *shift* our environmental impact rather than alleviate it. They gave an example of the first generation of smog-control devices which increased emissions of oxides of nitrogen while reducing those of hydrocarbons and carbon monoxide. Ehrlich and Holdren argued that if population growth is allowed to continue unabated, even the most wisely managed technology will not keep the environment from being overstressed.

Panayotou (2000, p. 10) noted that Ehrlich (1971) views were richer in rhetoric than evidence. *Limits to Growth* a publication by Meadows, Meadows, Randers, and Behrens (1972) attempted to provide the evidence that Ehrlich (1971) lacks. Meadows et al used a system dynamics computer model as a tool to aid their own understanding of causes and consequences that characterized the world. The system dynamics model assumed a positive feedback loop also known as a vicious circle. Meadows et al asserted that population, food production, industrialization, pollution, and consumption of nonrenewable natural resources are increasing at an exponential rate. In their world model of dynamic systems, Meadows et al started with what they called "world model standard run." This standard model assumes there will be no great changes in the future with regard to human values or in the functioning of the global population-capital system as it has operated for the last one hundred years. The results of the standard run showed that the system collapses well before the year 2100 because of nonrenewable resource depletion.

Meadows et al (1972) used various optimistic models but still resulted to an end of growth before the year 2100. In one of their world models which assumed "unlimited" resources, pollution controls, increased agricultural productivity, and "perfect" birth control, it shows that growth is stopped before the year 2100 because of overuse of land which leads to erosion and drops in food productivity. They show that resources are severely depleted by a prosperous world population. Meadows et al (1972, p.141) noted that application of technological solutions alone has prolonged the period of population and industrial growth, but fails to remove the ultimate limits to growth. They concluded their study by noting that if status quo is accepted, growth in world population,

industrialization, pollution, food production, and resource depletion will necessitate the limits to growth on the planet sometime within the next one hundred years.

As a result of furor created by the *Limits to Growth,* twenty years later, Meadows, Meadows, and Randers (1992) published a sequel titled *Beyond the Limits*. Meadows et al (1992) realized that in the period of twenty years since their first publication, much has happened to bring about technologies, concepts, and institutions that can create a sustainable future. Therefore, *Beyond the Limits* was intended to document and reflect those changes. However, the conclusion was not significantly different from the previous work. Meadows et al (1992, p. xv) concluded that "human use of many essential resources and the generation of many kinds of pollutants have already surpassed rates that are physically sustainable. Without significant reductions in material and energy flows, there will be in the coming decades an uncontrolled decline in per capita food output, energy use, and industrial production."

Pimentel, Huang, Cordova, and Pimentel (1997) called for curtailment of human population growth in order to ensure a sustainable environment. The authors argued that there is no doubt that improved technology will assist in more effective management and use of resources, but it will not be able to produce unlimited flow of the vital natural resources that are raw materials for sustained agricultural production. For example, they pointed out that per capita fish catch is lower than ever before even though the size and speed of fishing vessels have improved. They gave an example of eastern Canada whereby due to greater efficiency, over-fishing has been so severe that cod fishermen have no fish to catch and as a result that the region's economy has been devastated.

Pimentel et al (1997) considered water withdrawn from Colorado River in the western states of the United States for irrigation and other purposes results the river being virtually dry by the time it reaches the Sea of Cortes, Mexico. The authors noted this is another example that no available technologies can double the flow of the Colorado River; however, effective water conservation can lessen this environmental problem. Pimentel et al suggested that strategies for the future must be aimed towards the conservation and careful management of resources needed for food production. The authors were convinced that once the world's finite resources are exhausted they cannot be replaced by human technology. In spite of advocating more effective conservation and other measures, Pimentel et al argued that human population growth needs to lessen in order to ensure a sustainable environment.

The Cornucopian's Views

In sharp contrast, the Cornucopian school of thought that believes in market mechanism and human ingenuity takes an opposite view from that of neo-Malthusians. This school of thought argues that natural resource scarcity created by population pressures can act as a catalyst to trigger technological innovation making scarcity ever less in the future (Urdal, 2005). Essentially, the cornucopian school of thought provides a contrasting view that higher population growth is good for the environment. This contrasting view argues that population growth, in the short term may cause temporary hardship, but in the long run it provides the necessary stimulus for technical changes and the discovery of new resources (Jackson 1995). For example Boserup (1976, 1981) discussed the interrelationships between demographic growth, on the one hand, and environment and technology, on the other.

According to Boserup (1981), it is higher population density necessitated by population growth that leads to technological changes. In the same vein Boserup (1976) pointed out that high population growth can also lead to specialization of labor. Specialization of labor may help some people to shift their efforts away from agricultural activities. It is easier for craftsmen and other specialists to find enough customers in a community with many people. As a result, Boserup argued that inhabitants of communities with few people remain jacks-of-all-trades and have lower levels of development.

Boserup (1976) seemed to admit that population pressures as a result of natural growth or immigration may increase to the point of exceeding the carrying capacity of land. If this happens, the environment is likely to deteriorate as happened in some parts of Southwestern Asia during ten millennia of agricultural exploitation of the environment (Boserup, 1976). However, Boserup added that sustained population growth in a primitive subsistence system does not always result in environmental deterioration.

Following Boserup's arguments, Simon (1980) argued that aggregate data revealed that in the long run population has positive effects upon the supply of arable land and decreases in the natural resource scarcity which includes food and energy. Contrary to neo-Malthusians who argue that agricultural land is fixed, Simon (1981a) argued that land is not fixed. Simon stated that the amount of agricultural land has been, and still is, increasing substantially and it will continue to be available where and whenever needed.

Echoing Boserup's argument, Simon (1980) hypothesized that population growth has a direct relationship with productivity because additional people create technological

advances by inventing, adapting, and diffusing new productive knowledge. Simon (1981, p. 196) stated that it is people's minds that matters economically. Simon noted that improvements in productivity through technological adoption and invention come from a human mind which is inseparable from a human body. According to Simon, it is a common sense then to assume that amount of improvement is dependent on the number of people available to use their minds. Critics would say that if there is a direct relationship between population size and technological advancements, then why are China and India, the two most populous countries on earth not that advanced? In anticipation of this criticism, Simon (1981a) noted that the two most populous countries do not produce as much new knowledge as does for example the United States. Simon noted that China and India fail to produce much new knowledge because they are relatively poor and are unable to educate relatively more people. He still argued that despite the poverty level, India has one of the largest scientific communities in the world because of its huge population size.

Simon (1981a) stated that in the long run, the most important effect of population size and growth is the contribution of additional people to the existing stock of useful knowledge. This contribution is substantial enough to overcome all the costs that come with population growth. He stated that technological advancements brought about by population growth are likely to speed up the development of cheap energy that is almost inexhaustible. Using the mineral copper, Simon pointed out that, for example, increases in population size increases the demand for copper which in turn increases the cost of getting copper. The increases in cost of copper may be a signal for copper "scarcity." However, Simon emphasized that as feedback from increases in the cost of copper,

discovery of new deposits, new methods of extracting the resource and new substitutes for the resource are all possible options.

Simon (1981a) noted that concomitant with the increases in knowledge are "economies of scale." Simon argued that the distinction between increases in knowledge and economies of scale is not obvious and they are both accelerated by population growth. According to Simon (1981a, p. 203), "economies of scale – the greater efficiency of larger-scale production – stems from (1) the ability to use larger and more efficient machinery, (2) the greater division of labor in situations where the market is larger, (3) knowledge creation and technological change, and (4) improved transportation and communication." The most important point here that Simon was making was that population growth is needed to increase the stock of knowledge as well as economies of scale. Increases in stock of knowledge and economies of scale are more likely to increase income. Increase in income, stock of knowledge, and economies of scale lead to using fewer natural resources such as land.

Simon (1981a, p. 225) gave an example of the United States, Great Britain and other developed countries. Despite the increase in their populations, the absolute number of farm workers is going down, and that the absolute amount of land per farm worker is going up. Simon made it clear that the combined increases of income and population do put pressure on the land as neo-Malthusians argue. "So the major constraint upon the human capacity to enjoy unlimited minerals, energy and other raw materials as at acceptable prices is knowledge. And the source of knowledge is the human mind. Ultimately, then, the key constraint is human imagination acting together with educated skills. This is why an increase of human beings, along with causing an additional

consumption of resources, constitutes a crucial addition to the stock of natural resources" (Simon, 1981a, p. 222).

Theoretical Framework of the Vicious Circle Theory

The relationship between population and natural resources is quite complex and as a result led to the emergence of a number of theories such as the vicious circle. The theory of vicious circle postulates that as natural resources are depleted, parents respond by having more children to meet additional labor demand that is needed in the acquisition of the receding natural resources (Nerlove; 1991, 1993; Nerlove & Meyer, 2000). Nerlove (1991, p. 341) argued that:

> "For example, as forests recede up the mountain sides, parents may perceive a greater benefit of having an additional child to gather firewood. More realistically, in a poor agricultural setting, lower quality environments may be associated with a greater livestock component in total production, whereas higher quality environments may be associated with a greater crop component. Arguably, children have a comparative advantage over adults in tending livestock in contrast to the heavier labor of planting, tilling, and harvesting crops. Thus environmental deterioration may well enhance the marginal productivity of children, at least relative to total family productivity."

The major assumption that Nerlove (1991) was making is that there is common ownership of natural resources. This common ownership leads to overexploitation of the natural resources. Nerlove added that, under communal ownership, when parents respond

to natural resource scarcity by having more children, they do not take into account that other mothers would respond the same way.

Dasgupta (1993, 1995a, 1995b) introduced the role of poverty in the vicious circle. Dasgupta (1995a, 1995b) focused his theory by using the poorest regions of the world such as sub-Saharan Africa and the Indian subcontinent. According to Dasgupta, as natural resources such as water and fuel wood become scarce, a child's labor can become more valuable to parents. This is particularly the case in many developing countries of sub-Saharan Africa where a child's labor is important in fuel wood collection and fetching water for domestic use. For example, Dasgupta (1993) reported that women and children in India and sub-Saharan Africa spend up to five hours a day on water collection. Dasgupta noted that a similar problem is associated with fodder and fuel wood collection in Africa where approximately 90 percent of the population uses fuel wood for cooking. Dasgupta reported that children in poor countries mind their siblings and domestic animals, fetch water, and collect fuel wood, dung, and fodder from about the age of six years. As these natural resources become increasingly scarce, parents respond by demanding more children, which in turn spur a vicious circle that traps families in poverty (Dasgupta, 1995a, 1995b).

The vicious circle theory can seemingly be counterintuitive in the sense that by demanding more children natural resources can become even more scarce at the same time parents have to commit substantial time and resources to taking care of their children. To address this concern, Dasgupta (1995a, 1995b, 1997, & 2000) focused on the vast numbers of small, rural communities in the poorest Indian subcontinent and sub-

Saharan Africa to hypothesize that population growth, poverty, and natural resource scarcity fuel one another.

To understand why the vicious circle is prevalent in these communities, Dasgupta (1995a, 1995b, 1997, & 2000) examined motives for childbearing in sub-Saharan Africa and the Indian subcontinent. He noted that one motive common to humankind for procreation relates to children as ends in themselves for various reasons such as family lineage and obeying traditional values as well as religion. In a closely-knit society such as those in many sub Saharan Africa countries, family size is not just a decision by the couple but is also influenced by traditional values (Dasgupta, 1995a, 1995b, & 1997). In these societies, there are strong and well-established norms that encourage couples to have as many children as biologically possible. In such an environment there are pressures for a household not to unilaterally break the norms.

In many poor countries where there are virtually no capital markets and social security system similar to those found in developed countries, childbearing is also viewed as a source of old age security (Dasgupta 2000; Dreze & Murthi, 2001). Also, in these societies, which are largely subsistence economies, children are viewed as productive assets. People in the rural areas of developing countries live by using natural resources directly from plants and animals. Much labor is needed even for such simple tasks as gathering fuel wood and fetching water in poor countries (Dasgupta, 1995a, 1995b). Also, children are demanded for their labor input in agriculture and help in converting open-access resources such as forests, grazing lands and fisheries (Dabholkar, de Sherbinin, & Ponniah, 1998, UNFPA, 2001). The demand for children is especially

higher in those agricultural economies that are not equipped with modern farming techniques because of their extreme poverty.

But perhaps the most important motive for higher fertility in most of the sub Saharan Africa countries as put forth by Dasgupta (2000) arises from the fact that parental cost of procreation is very low. He noted that in sub Saharan Africa fosterage within the kinship is a commonplace. In these communities, the responsibility to raise a child is shared among the member of the extended family. For example, Dasgupta reported that in parts of West Africa up to half the children have been found at one time to live with members of extended families other than their biological parents. He further reported that nephews and nieces have same rights to accommodation and other supports as the biological offspring.

As noted earlier, Dasgupta (2000) developed a framework that focuses on vast numbers of small, rural communities in the poorest regions of the world. According to the theory, at the household level, increased population size leads to overcrowding. A household faced with overcrowding and left to act on its own, is not expected to "internalize" crowding externalities[2]. In exploring the reproductive and environmental externalities, Dasgupta looked at the mechanisms through which reproductive externalities arise. Among the mechanisms related to his study are (1) cost sharing and (2) household labor needs and the local commons.

In cost sharing, Dasgupta (2000) noted that parental costs of procreation are lower when the cost of rearing a child is shared within the kinship. As aforementioned, he gave an example of Sub Saharan Africa where fosterage within the kinship is very common.

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[2] "An externality occurs whenever the activities of one economic agent affect the activities of another agent in ways that are not reflected in market transactions" Nicholson, 1998, p. 730).

This common responsibility of rearing children creates a free-rider problem especially if it is perceived that benefits of having children exceed their share of costs. This perception leads parents to have many children. The general structure of the cost sharing as presented by Dasgupta is written as:

$$C = [nc + (N-1)n^*c]/N \quad 2.1$$

where C is the resource cost, n is the number of children, c is the cost of rearing a child, N is the number of couples within a kinship, and n* is the number of children each couple other than the one chooses to have. Suppose a couple expects to receive income from the next generation as follows:

$$Y = [ny + (N-1)n^*y]/N \quad 2.2$$

where Y is the income a couple expects to receive from the next generation and y is the income from a child. Denote the couple's aggregate utility function as:

$$U(Y) - K(C) \quad 2.3$$

both U(.) and K(.) are increasing and strictly concave functions. Both U and K have the same units. Essentially, because of the timing difference between costs incurred in minding children and the benefits received from their labor and care, equation 2.3 separates the benefits and costs in the household utility function. From the aggregate utility function (equation 2.3), it can be confirmed that the couple will choose the value of n at which:

$$yU`(Y) = cK`(C) \quad 2.4$$

Equation 2.4 simply states the couple's choice sustains a social equilibrium when $n = n^*$. According to Dasgupta this condition can only be met in a society where there is no reproductive free riding. As long as $yU`(Y) > cK`(C)$, it means that the couple's share of

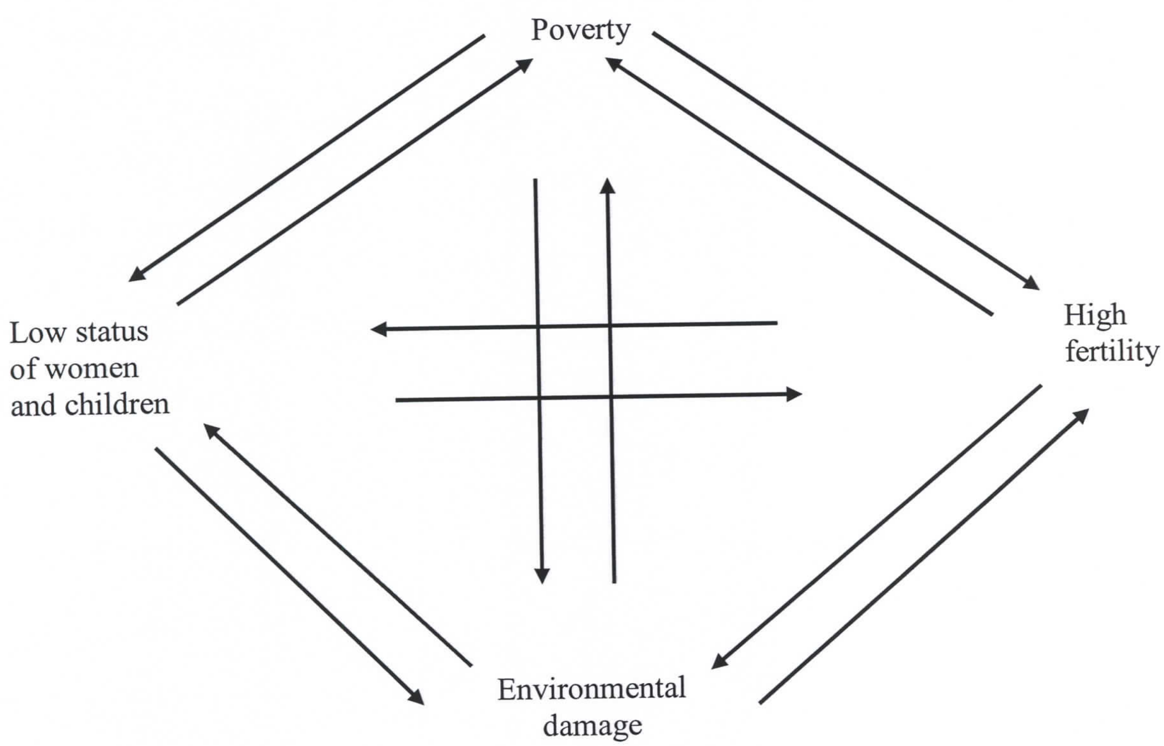
the benefits from having children is greater than their share of the costs. Therefore, the couple has incentives to have more children than otherwise.

As for the household labor needs and the local commons, Dasgupta (2000) and Maler (1998) noted that to a great extent, the poorest countries are largely agriculture-based subsistence economies. Due to extreme poverty, these countries lack access to the sources of domestic energy such as electricity for cooking and heating and tap water available in the developed countries. As a result, people in the poorest countries need more labor relative to wealthier countries even for simple tasks. People in these countries have to rely heavily on the local natural resources base such as forest for fuel wood and charcoal as cooking fuel. On a daily basis people have to spend several hours going a significant distance to fetch water for domestic use. When the forests recede as a result of overexploitation, people have to go far away from their dwellings to collect fuel wood.

In the poorest countries, labor productivity is very low because of scarce capital and environmental resources. This leads to the need for more hands to work. As a result parents in poor households of the poorest countries need their young children's labor. Where local resources are communally owned, parents pass some of the costs of their children onto the community by overexploiting the commons. Dasgupta (2000) acknowledged that when households are further impoverished due to overexploitation of local resources, the cost of the next children increases. However, Dasgupta noted that theoretical considerations suggest that, in certain circumstances, increased resource scarcity induces further population growth because of the need of more hands to work. According to Dasgupta, along this pathway, fertility, poverty, and natural resource scarcity would reinforce one another in an escalating spiral.

O'Neill, MacKellar, and Lutz (2001) provided a review of the vicious circle theory (see Figure 1.1). They pointed out that poverty, depletion of natural resources, high fertility, and low status of women are key factors of the vicious circle theory. These factors combine in a vicious circle that forms a poverty trap which may lead to local ecological breakdown. The authors argued that poverty makes it difficult to find an alternative source of natural resources. The low status of women and children devalues the increasing time and effort that they must devote to daily gathering of wood and other natural resources.

Figure 1.1 A vicious model



Source: A vicious circle model from O'Neill, Mackellar, and Lutz (2001).

In their recent work, Ruseski and Quinn (2007) developed a model that provides a theoretical explanation for the potential linkages between population growth, poverty, and local environment in the poorest rural communities of developing countries. Their model is based on the observation that parents in poor countries depend on the child labor such as fetching water and gathering fuel wood as a means of exploiting the local environment. In addition, their model assumes that as the local natural resources become scarce and distant due to over-exploitation, parents in rural areas of developing countries respond by having more children that could be seen to provide more helping hands during this needy time. Ruseski and Quinn (2007) showed that in the absence of well-defined property rights to local natural resources, parents may unilaterally demand more children believing that doing so enable them to exploit a greater share of the local natural resources. It is this way of unilateral thinking by each family that leads to rivalry in the commons that often result in too many children in each family. Ruseski and Quinn (2007) attributed this dynamical system of the population-environment-poverty trap to institutional failure in the exploitation of the commons. They suggested that population policies in developing countries should incorporate cooperative governing of the commons as one way of addressing the problem.

Both Dasgupta (2000) and Nerlove (1991) argued that communal ownership or lack of property rights on natural resources is one of the main factors that lead to increase in fertility when natural resources become scarce. This argument was supported by previous researchers (De Vany & Sanchez, 1979; Schutjer, Stokes, & Cornwell, 1980; Schutjer, Stokes, & Poindexter, 1983; Stokes & Schutjer, 1983; Carr, Pan, & Bilsborrow, 2006). For example Schutjer & Stokes (1982) provided an initial framework for

identifying the links between agricultural policy and fertility. They reviewed the empirical literature regarding connections between human fertility and land ownership. They found that literature supported the argument that land ownership tends to reduce fertility. However, Thomas (1991) argued that the statistical evidence in support of the negative relationship between fertility and landownership was inadequate.

The Evolution of the Explanatory Variables of Interest Used in the Study

This section reviews the natural resource scarcity and poverty as two main variables of interest used in this study that affect woman's fertility. The section is divided into two subdivisions. The first subdivision reviews the relationship between fertility and natural resource scarcity. The second subdivision reviews the relationship between fertility and poverty.

Natural Resource Scarcity and Fertility

Nerlove (1991) was among the pioneers who offered the beginning of the study to understand the complex interaction between population growth and natural resource scarcity. In his theoretical work, Nerlove saw ample reasons to suppose that in much of the developing countries, fertility is likely to react positively to increasing natural resource scarcity and environmental degradation. For example, he argued that children in developing countries often play an important role in activities such as tending livestock, collecting firewood and fetching water. For example, if firewood becomes scarce as a result of forests recede up the mountain sides, parents may perceive that it will be beneficial to add another child who will potentially help in firewood gathering. In short,

Nerlove argued that parents perceive the benefits of having more children to be higher under a stressed environment than under favorable environment conditions.

Cleaver and Schreiber (1994a) study was also among the earliest notable studies to theorize the link between firewood and water scarcity on fertility. According to the authors, demand for firewood and or commercial logging have significantly contributed to the degradation and destruction of forests and woodlands. As a result of this, deforestation leads to the deteriorating climatic and hydrological conditions. This means that deforestation does not only impact firewood but also water availability. As a result women and children have to spend hours daily in search of firewood and water.

Since in most developing countries, firewood and groundwater sources have generally been considered free goods for which anyone can have unimpeded access, parents respond to firewood and water scarcity by increasing the number of children. Girls are kept out of school to help the collection of firewood and fetching water. Lacking knowledgeable family planning decisions, once they reach childbearing age, these girls' fertility preference is likely to be affected by demanding a higher number of children (Cleaver & Schreiber, 1994a).

Dasgupta's (2000, 1995a, & 1995b) studies led to the publication of some empirical studies to specifically examine the vicious circle theory by using firewood and water scarcity as variables for natural resource scarcity. For example, in his own words, Dasgupta (2000, p.678): "Imagine now that the household faces an increase in resources scarcity. We are to interpret this in terms of receding forests and vanishing water holes. The index of resource scarcity could then be the average distance from the village to the resource base. So, an increase in resource scarcity would mean, among other things, an

increase in the number of children." Dasgupta's (2000) hypothesis assumes that firewood and water are common property for which anyone can have free access. In addition, according to Dasgupta, collecting firewood and fetching water in the developing countries are two complimentary activities done daily by children. With declining resources availability such as firewood (caused by forests receding and unavailability of water), each household would appear to demand more helping hands by having more children. In short Dasgupta (2000) hypothesized that as the common property resources (firewood and water) become scarce each additional child is assumed to provide a marginal benefit through collecting firewood and fetching water.

Poverty and Fertility

Becker (1960) used the theory of demand for consumer durables to analyze the demand for children. In order to justify the use of the theory, Becker viewed children as durable goods, yielding primarily psychic income or satisfaction to parents. According to this theory, among others, fertility is a function of income. For a normal good, the economic theory of demand assumes there is a positive relationship between income and demand for that good. If children are assumed to be a normal good, the same is expected for the demand for children by parents.

However, Becker (1960) distinguished the quantity and quality of children to show that an increase in income is not expected to bring a significant increase in the demand for children. He posited that it is the quality and not the quantity of children that is positively related to the demand for children. According to Becker, since children are viewed as durable goods, the demand for children is treated in the same manner as the demand for other durable goods such as cars, houses, or refrigerators. For durable goods,

quantity income elasticity usually is smaller than quality income elasticity. Therefore, most of the increase in income would be spent on the expenditures related to the quality of children. In fact even though Becker (1960) failed to confirm this theory universally, the U. S. census data for 1910, 1940, and 1950 show income as measured by a number of proxies is inversely related to fertility. In short, Becker argues that poverty is directly related to fertility.

The Review of the Studies Examining the Vicious Circle Theory

At least eight studies explored the impact of environmental scarcity on fertility in developing countries. The studies test the vicious circle theory that suggests that there is a positive feedback loop between population growth, poverty, and natural resource scarcity. See Table 2.1 for a summary of the eight studies discussed below.

The first study is that of Cleaver and Schreiber (1994a, 1994b) that used macro-level data from the World Bank's economic and social data base. The study used two different statistical analyses to test same hypotheses, using two separate data sets. The first set of statistical analysis used pooled cross-country time series of data. In this analysis, the statistical methodology used was fixed effects model which allowed for differences in the means of the observed variables in different countries. The second set of statistical analysis used simple cross-country data which were also less comprehensive than the first set of analysis. An ordinary Least Square (OLS) technique was used in this analysis.

For the pooled cross-country time series analysis, Cleaver and Schreiber (1994a) used data from forty-one countries in sub-Saharan Africa. The dependent variable for this

analysis which used fixed effects model was total fertility rate.[3] To control for the impact of environmental scarcity, the authors used rate of deforestation which was lagged by one year. The deforestation rate was measured as the percentage change in forested area from the previous year. The hypothesis was that the rate of deforestation is positively related to total fertility rates. The argument made by the authors was that the higher the rate of deforestation, the greater the need for family labor to help with wood gathering and water fetching. In addition, the study controlled for cultivable land per person which may also be linked to environmental scarcity measure. The hypothesis was that cultivable land per person is positively related to total fertility rates. The argument made was that the more cultivable land per person, the greater the need for family labor – or the higher marginal productivity of child labor.

One of the key findings of Cleaver and Schreiber (1994a) study was that if cultivable land per person is not used in the regression, the coefficient on deforestation is positive and highly statistically significant (at the 5% level). This finding suggests that the higher the rate of deforestation, the higher the total fertility rates. However, if the cultivable land per person is used, the coefficient on deforestation maintains the positive sign but becomes statistically insignificant. The authors suggested that the two variables are probably correlated and should not be used in the same equation.

For the simple cross-country data analysis which used OLS technique Cleaver and Schreiber (1994a) analyzed data set consisting of thirty-eight countries. One of the key findings is that the coefficient for deforestation rate was positive and statistically significant at the 2% level. This finding suggests that the use of cross sectional data as

[3] United Nations Children's Fund (2007) defines total fertility rate as the number of children who would be born per woman if she lived to the end of her childbearing years and bone children at each age in accordance with prevailing age-specific fertility rates.

this current study does supports the vicious circle theory. In short, both the pooled cross-country time series and cross- country analyses support the vicious circle theory (Cleaver & Schreiber, 1994a). The reservation being that for the time series data, the coefficient on deforestation became statistically insignificant when the cultivable land per person was also included. In addition, the effect of deforestation on total fertility rates for the time series data is small compared to its effect for the cross-sectional data.

The second study is that of Loughran and Pritchett (1997) that used data from Nepal Living Standards Survey collected in 1996. This study used cross-sectional data to test whether variation in fuel wood and water scarcity affects fertility by altering the relative value of children in resource collection activities. They estimated fertility models with alternative dependent variables. Their dependent variables are the total number of children born and three dichotomous variables indicating whether a woman had at least one child in the last two years, five years, and ten years. To control for the effect of environmental scarcity on fertility, they used time spent collecting fuel wood (fuel wood scarcity) and time per trip to collect water (water scarcity). For the model with the number of children ever born as the dependent variable, OLS estimation technique was employed. For the model with the dichotomous dependent variables, Probit estimation technique is used. For both models, fuel wood scarcity appears to have a negative impact and was statistically significant on both measures of fertility, which suggests that it reduces the demand for children. The variable water scarcity also reduces the probability of a birth in the last five years. However, the water scarcity variable was not statistically significant in its influence on the number of children ever born. Loughran and Pritchett concluded their study by suggesting that it appears that the perception of deforestation

and water scarcity by farmers in Nepal increases the perceived net cost of children, which leads to a reduction in demand for children. The findings imply that there is no positive relationship between environmental deterioration and the demand for children as suggested by the vicious circle theory.

The third study is that of Aggarwal, Netanyahu, and Romano (2001) which used data from the South African Integrated Household Survey (SAIHS) collected in 1993 to examine a positive link between fertility increase and environmental deterioration. Their sample size includes 3,332 and 3,383 rural and urban households respectively. In particular they examined the impact of fuel wood and water scarcity on fertility rates. They used several measures of resource scarcity as a measure of environmental deterioration such as average distance traveled and time per trip for collecting water and fuel wood. Tobit regression model is used with number of children ever born alive to women in the sample as dependent variable. The authors found a positive link between wood scarcity and number of children ever born alive. The effect of water scarcity on fertility is also positive but not significant. In addition, the authors used a Probit model as well. In general, their study suggests that there is a positive feedback between environmental deterioration and fertility rates.

The fourth study is that of Filmer and Pritchett (2002) which used data from the 1991 Pakistan Integrated Household Survey (PIHS) to empirically detect measurable effect by indicators of environmental scarcity on fertility. The data set is a nationwide survey of 4,800 households in which individual and household level data were gathered using a multipurpose questionnaire. The authors hypothesized that if children contribute to the household using their time to collect natural resources such as fuel wood from

common property, then local scarcity of those natural resources could potentially increase demand for children. A Probit regression model was conducted with a dummy variable, which measures whether birth occurred or not in the last five years leading to the time the survey was conducted. They found that children (at least female children for which they have the data) are relatively specialized in collection activities such fuel wood at young ages. One of the study findings substantiates the vicious circle theory that environmental scarcity could possibly raise demand for children.

The fifth study is that of Sutherland, Carr, and Curtis (2004) which used a cross-sectional data from the 1998/99 DHS to examine potential relationships between factors related to fertility and the access to and use of natural resources in Peten, Guatemala. Their sample size consisted of 894 women aged 15 to 49 and the study was restricted to female heads of household. An OLS regression model was conducted with the number of living children in a family as dependent variable, and socioeconomic variables as explanatory variables. Additionally, six variables, perception of land availability for children, farm size, security of land tenure, ownership of cattle, time to collect water in minutes, and collecting fuel wood were included as explanatory variables representing natural resources. However, their multiple regression findings show perception of land availability and ownership of cattle as the only two natural resource variables that are significantly and positively associated with the number of living children. This suggests that those who perceive land is available for their children had significantly fewer children than those who perceive land to be scarce. The positive association of the ownership of cattle with the number of living children is important and not only implies

that children provide larger economic benefits to the family but also the larger the number of cattle the greater the pressure on land.

The sixth study is that of Biddlecom, Axinn, and Barber (2005) which used a data set collected in Western Chitwan Valley in Nepal. The focus of their study was to investigate the relationship between environmental deterioration and men and women's family size preference and subsequent reproductive behavior. They used various measurements for environmental deterioration to explain their impacts on family size. In their study they used time to collect wood, time to collect fodder, and whether wood is publicly or privately owned as environmental measures. Two models were used to estimate the impacts of environmental effects on fertility behavior. For the first model an OLS technique was used to estimate the effects of environmental deterioration on family size preference. For the second model a logistic regression was used to estimate the effects of environmental deterioration on the likelihood of a woman's getting pregnant. The first model results show that environmental deterioration measures had positive impacts on family size preference. The second model results show that environmental deterioration increases the likelihood of woman getting pregnant. The results of Biddlecom, Axinn, and Barber provide support for the vicious circle argument that environmental deterioration leads to population growth through raising fertility rates.

The seventh study is that of Ghimire and Mohai (2005) that used data set collected by the Chitwan Valley Family Study from 1996 to 2000. The focus of their study was to examine the impact of environmental perceptions on contraceptive use in rural setting of Nepal. To account for environmental measures, respondents of the survey, among others, were asked to give their perceptions on three environmental concepts. The

concepts were agricultural productivity, groundwater table, and drinking water quality. Respondents were asked to measure perceptions of agricultural productivity by indicating whether agricultural productivity has increased, decreased, or stayed the same in the past three years. For groundwater table, the respondents were asked to measure perceptions of groundwater table by indicating whether there is a difference in the level of water table in their neighborhood's well or tube-well as compared to the past three years. For drinking water quality the respondents were asked to measure perceptions of water quality by indicating whether the drinking water is clearer or less clear.

Ghimire and Mohai (2005) used a logistic regression model to measure individuals' environmental perceptions on fertility behavior. The model was used to estimate the effects of environmental perception on contraceptive use. The results show that individuals who perceived that their environment had deteriorated made adjustment in their fertility behavior by using contraceptive. Their results do not provide support for the vicious circle argument. Instead their results show that environmental scarcity acts as a check on population growth.

The eighth and the latest study is that of Bhattacharya (2007) that used district level data from eight states of the southern, western, and central regions of India. This study did not use micro-level data in the analysis of the vicious circle theory. One of the foci of the study which is related to the current study is the analysis of the relationship between population growth and environmental quality. To account for population growth, Bhattacharya used natural growth rate (birth minus death) and the net migration rate (in-migration minus out migration). To account for environmental quality, the study used two measures. The first measure is satellite image based vegetation index that represents the

overall vegation quality of the study setting. This variable is used as a measure of 'greenness' which takes into account both agricultural as well as forest vegetation. Bhattacharya pointed out that this variable is a measure of biomass. The higher the value of the index, the higher is the average greenness of the study setting. The second measure of environmental quality is a measure of forest stock scarcity.

Bhattacharya (2007) used OLS, Generalized Method of Moments (GMM), and Three Stage Least Squares (3SLS) techniques for two specifications, one using the biomass and another forest stock scarcity as two different measures of environmental quality. The results of her study provide some support for the vicious circle theory. The results show that environmental degradation whether measured in forest biomass or forest resource scarcity lead to the increases in rural natural growth as well as rural in-migration. The coefficients for the measures of environmental quality were found to be statistically significant only when GMM and 3SLS techniques were employed.

Some Limitations of the Studies Examining the Vicious Circle Theory

The review of the literature of the eight studies that have tested the vicious circle theory reveals conflicting results. The studies have used different econometric models as well as varied measures of dependent variables. The differences in econometric models and measurement of dependent variables can partly explain the reason for the conflicting results.

This section which is divided into three subsections, highlight some of the limitations of the existing studies that have examined the vicious circle theory. The First subsection highlights the limitation arises from using inappropriate statistical model. The

Second subsection discusses the uses of inappropriate measures of dependent variables. The Third subsection highlights the limitation arises from ignoring possible endogeneity.

The Use of Inappropriate Statistical Model

As shown in Table 2.1, out of the five studies that used count dependent variables, three (Loughran & Pritchett, 1997; Sutherland, Carr, & Curtis, 2004; Biddlecom, Axinn, & Barber, 2005) have used OLS regression model and one (Aggarwal, Netanyahu, & Romano, 2001) has used Tobit model. For several years, OLS model was the main choice of estimating statistical modeling parameters. However, when the dependent variable is count data such as the number of children in a family, the use of OLS model can produce inefficient estimates and the standard errors are inconsistent (Caudill & Mixon, 1995, Hellerstein & Mendelsohn, 1993, Hellerstein, 1991, Shaw, 1988).

King (1988) pointed out several serious problems of using OLS on count data. The first problem is that OLS assumes a linear relationship. This assumption is an implausible functional form because it (OLS) does not constrain the expected number of events (such as total number of children ever born or number of living children to be positive as it should be. Wooldridge (2002) pointed out that for count data, OLS has shortcomings because the expected value from the dependent variable should be nonnegative for all independent variables. However, if the OLS estimator is used, there usually will be values for an independent variable that produce negative predicted value of the dependent variable.

The second problem raised by King (1988) is that OLS makes an unrealistic assumption that the difference say between 0 children and 1 child occurring in a particular interval is the same as the difference between, say 8 and 9 children. King notes

that in this case, the true relationship is not linear. As such a linear approximation would in most cases be meaningless. The third problem raised by King (1988) is that OLS estimator is statistically inefficient when applied on count data because the variance of the estimates is much higher than it could be. King argued that OLS does not take into account heteroskedasticity, the particular asymmetric form of the heteroskedasticity, the correct functional form, as well as the underlying Poisson distribution of the disturbances. King pointed out that OLS does not use all available information in the estimation; as such insufficiency and inefficiency occur.

King (1988) further argued that the OLS statistical problems on count data are more than just technical points. The problems usually result in substantively biased conclusions. King pointed out that in applications, coefficients of OLS in a count data will have wrong size and will often have incorrect sign. In addition, the OLS estimates will often be imprecise as such making many empirical analyses inconclusive. However, King noted that since the standard errors and test statistics from OLS are themselves biased, there will usually be no indication of the imprecision.

In his study that introduced the use of regression models based on the Poisson distribution as a tool of resolving common problems in count data, Osgood (2000) pointed out that OLS is poorly suited to count data. He found that OLS yielded negative fitted values when the dependent variable (crime rate) was count data. Osgood argued that this is a clear indication that OLS model severely distorts the relationship between explanatory variables and a dependent variable that takes only non-integer values.

Similarly, the use of Tobit model on the measures of fertility is inappropriate. The inappropriateness arises from the fact that Tobit model assumes that the dependent variable is censored at zero. In the words of Maddala (1992, p. 341):

> "Every time we have some zero observations in the sample, it is tempting to use the Tobit model. However, it is important to understand what the model … really says. What we have … is a situation where y_i*can *in principle*, take on negative values. However, we do not observe them because of censoring. Thus the zero values are due to nonobservability. This is *not* the case with automobile expenditures, hours worked, or wages. These variables cannot, in principle, assume negative values. The observed zero values are due not to censoring, but due to the decisions of individuals. In this case the appropriate procedure would be to model the decisions that produce zero observations rather than use the Tobit model mechanically."

To illustrate the consequences of using Tobit model for a count dependent variable that is not censored at zero, Sigelman and Zeng (1999) reanalyzed data from another study by Romer and Snyder (1994). Sigelman and Zeng demonstrated that by using Tobit model on uncensored data, the Tobit model can produce a poor fit to the data and can seriously bias parameter estimates.

Also, the use of Tobit model can lead to biased results due to its sensitivity to heteroscedasticity (Brown & Moffitt, 1983). In some cases it has been found that the estimates of Tobit model can be more severely biased than are OLS estimates (Johnson & DiNardo, 1997; Farrell & Walker, 1999; Brown & Moffitt, 1983).

The most popular model for count data is the Poisson regression model (Wooldridge, 2002). However, Poisson regression model is based on strong assumption that the probability of an occurrence is constant at any point in time and that the variance of an occurrences is equal to its mean (Kennedy, 2003). In practice this assumption is very unlikely (Caudil & Mixon, 1995). This assumption is relaxed by using negative binomial regression model that can handle a situation whereby variance of an occurrence can be higher than its mean (Kennedy, 2003; Wooldridge, 2002; Cameron & Trivedi, 1998). Hilbe (2007) points out that negative binomial regression is a common alternative to Poisson regression models when dealing with overdispersion.[4]

The Use of Inappropriate Measures of Dependent Variables

Three (Loughran & Pritchett, 1997; Sutherland, Carr, & Curtis, 2004; Aggarwal, Netanyahu, & Romano, 2001) out of the eight existing studies that have examined the vicious circle theory have used a cumulative measure of dependent variable. These studies have used dependent variables such as total number of children ever born, total number of children born alive, and number of living children. While these measures of fertility have been widely used (De Tray, 1973; Bollen, Glanville, & Stecklov, 2002; Hondroyiannis, 2004; Kabir, Khan, Kabir, Rahman, & Patwary, 2005; Nahmias & Stecklov, 2007) as dependent variable in the economics and demographic literature, they may not precede natural resource scarcity. Bollen et al 2002 pointed out that using cumulative measure of fertility such as children ever born as the dependent variable may be problematic. They argue that children ever born may not accurately reflect the current association between independent variables and fertility.

[4] Overdispersion occurs when the response variance is greater than the mean (Hilbe, 2007).

Table 2.1 Summary of existing studies that tested the vicious circle theory

Author	Study Title	Dependent Variable	Methods	Support Theory
Cleaver and Schreiber (1994a)	Reversing the spiral: the population, agriculture, and environmental nexus in sub-Saharan Africa	Total fertility rates	Fixed Effects Ordinary Least Square	Yes
Loughran & Pritchett (1997)	Environmental scarcity, resource collection, and the demand for children in Nepal	Number of children ever born. Binary variable for a birth in the last 5 years.	Ordinary Least Square Probit	No
Aggarwal, Netanyahu, & Romano (2001)	Access to natural resources and the fertility decision of women: The case of South Africa	Number of children ever born alive. Binary variable for a birth in the last 5 and 10years.	Tobit Probit	Yes
Filmer & Pritchett (2002)	Environmental degradation and the demand for children; searching for the vicious circle in Pakistan	Birth in the last five years.	Probit	Yes
Sutherland, Carr, & Curtis (2004)	Fertility and the environment in a natural resource dependent economy: evidence from Peten, Guatemala	Number of living children in a family.	Ordinary Least Square	Yes
Biddlecom, Axinn, & Barber (2005)	Environmental effects on family size preferences and subsequent reproductive behavior in Nepal	Family size preference. Likelihood of woman's getting pregnant.	Ordinary Least Square Logistic	Yes
Ghimire & Mohai (2005)	Environmentalism and contraceptive	Contraceptive use.	Logistic	No

	use: How people in less developed settings approach environmental issues			
Bhattacharya (2007)	Development and the environment: Empirical evidence from India	Natural growth rates and Net migration	Ordinary Least Square, two-step GMM, and Three-stage Least Squares (3SLS)	Yes

The Issue of Endogeneity

This section is divided into two subsections. Subsection One attempts to answer the question: what is endogeneity? Subsection Two provides brief details of some of the available econometric approaches designed to deal with the problem of endogeneity.

What is Endogeneity?

Endogeneity occurs when an explanatory variable is correlated with the error term. This is in violation with one of the classical assumptions of the Ordinary Least Square (OLS). In other words, the presence of endogeneity problem suggests that there are endogenous variables that are jointly determined in a system of simultaneous equations. Endogeneity has important implications for the statistical analysis. Failure to correct endogeneity can lead to biased coefficients estimates (Hamilton & Nickerson, 2003). For example, see the following regression model:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_K X_{Ki} + \epsilon_i \qquad 2.5$$

Where:

Y_i = dependent variable

β_0 = intercept coefficient

β_1, β_2, and β_K are slope coefficients

X_{1i}, X_{2i}, and X_{Ki} are independent variables

ϵ_i is an error term.

One of the OLS assumptions assumes that the observed values of the explanatory variables are known and uncorrelated with the error term. The explanatory variables are considered to be predetermined outside the model. When an explanatory (regressor) variable (say X_{2i}) is correlated with the error term ϵ_i, the variable X_{2i} is called endogenous which means it is determined within the model. If for some reasons this assumption is violated, the estimated coefficients will be biased. Endogeneity bias is also called simultaneity bias (Studenmund, 1997).

As aforementioned, the theory of vicious circle assumes that population growth, environmental degradation or natural resource scarcity, and poverty are endogenous. This means that for one to empirically examine the theory, issues concerning endogeneity need to be addressed.

Some of the Econometric Approaches for Dealing with Endogeneity

In dealing with the problem of endogeneity, a number of methods have been designed to come up with an instrumental variable.[5] Such methods are Two-Stage Least Squares (2SLS), Full Information Maximum Likelihood (FIML), and a procedure called IVPROBIT which uses a two-stage Probit model with an endogenous continuous explanatory variable, just to mention a few. Here is a brief explanation of each:

[5] Instrumental variable is a variable used to replace an endogenous regressor. Instrumental variable must have two characteristics: "First, it must be contemporaneously uncorrelated with the error; and second, it must be correlated with (preferably highly so) the regressor for which it is to serve as an instrument" (Kennedy 2003, p. 159).

2SLS "is a method of systematically creating instrumental variables to replace the endogenous variables where they appear as explanatory variables in simultaneous equations systems" (Studenmund, 1997, p. 541). The main challenge to find a good instrumental variable is to find explanatory variables that are correlated with the endogenous variable that the instrumental variable is intended to replace.

As the name suggests, the procedure for 2SLS consists of two stages (Kennedy, 2003). The stages are:

(1) Regress an endogenous variable acting as an explanatory variable in the equation being estimated on all the exogenous variables to estimate values of the endogenous variable.

(2) Use the estimated values as instrumental variable from step one as endogenous variable and the included explanatory variables as regressors on OLS.

Kennedy (2003, p. 191) noted that in FIML "technique estimates of *all* the reduced-form parameters (rather than just those corresponding to the endogenous variables included in a particular equation) are found by maximizing the likelihood function of the reduced-form disturbances, subject to the zero restrictions on *all* the structural parameters in the system."[6]

However, the use of 2SLS method works well when the dependent variable and endogenous regressors (explanatory variables) are either continuous or binary which assume that the outcome of interest can be modeled using linear regression model such as OLS (Deb, Li, Trivedi, and Zimmer, 2006). When the dependent variable is a non-

[6] Reduced form equation is derived by solving a simultaneous equation system so that an endogenous regressor is expressed as a linear function of all the exogenous variables (Kennedy, 2003 p. 181).

negative integer (count data), linear instrumental variables methods such as 2SLS do not work well.[7]

Techniques for instrumental variables to deal with endogeneity in count data regression models such as Poisson and negative binomial models are largely underdeveloped (Windmeijer and Santos Silva, 1997). However, there are ongoing efforts in the field of health economics trying to establish techniques to deal with endogeneity in count data regression models (Mullahy 1997; Windmeijer & Santos Silva, 1997; Schellhorn, 2001; Deb, Li, Trivedi, & Zimmer, 2006).

For example, Mullahy (1997) designed and used a special instrumental variable which is derived by transforming a regression equation such as Poisson to obtain a residual function that is additively separable in the problematic unobservable.[8] Windmeijer and Santos Silva (1997) used generalized method of moments (GMM) estimation technique for the count data. Windmeijer and Santos Silva's GMM model had a binary endogenous regressor which was corrected by using simultaneous equations. Since their (Windmeijer & Santos Silva) endogenous regressor was binary, they used a logit estimation of the reduced form to come up with an instrumental variable that was used to replace the endogenous regressor. Schellhorn (2001) used similar technique used by Windmeijer and Santos Silva. Essentially, despite the varying techniques by the existing studies to deal with endogeneity problem when the dependent variable is count data, most of the techniques require additional variables that are not directly related to the count dependent variable to estimate a good instrumental variable.

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[7] Examples of non-negative integers include number of doctor's visits, number of children born, numbers of cigarettes smoked and many others. See Cameron & Trivedi (1998) for many other examples.

[8] The main reason for the presence of endogenous regressor is that it is the function of unobservable variables.

IVPROBIT, this procedure estimates the endogenous variable as a linear function of the instrumental variables and corrects the second step standard errors (Wooldridge, 2002).[9] In the IVPROBIT procedure, the second stage assumes the dependent variable is dichotomous. This study employs IVPROBIT procedure to address endogeneity because of the nature of dependent variables used.

Ignoring the Problem of Potential Endogeneity by the Existing Studies

The existing research that has examined the vicious circle theory is complicated by the potential endogeneity of natural resource scarcity and poverty. Failure to reach consensus on the validation or invalidation of the vicious circle theory among the existing studies arises in part from the fact that there are strong theoretical reasons to believe that fertility, natural resource scarcity, and poverty are jointly determined (Dasgupta, 2000). The existing studies on the vicious circle theory which are largely based on examining the impact of natural resource scarcity on fertility have treated their measures of natural resource scarcity as exogenous independent variables. The only exception is the Bhattacharya (2007) study that deliberately addressed the problem of endogeneity.

At least two other of the eight existing studies that have examined the vicious circle theory have acknowledged and tried to address the problem of potential endogeneity, albeit inappropriately (Loughran & Pritchett, 1997; Aggarwal, Netanyahu, & Romano, 2001). These two studies started their examination of the vicious circle theory by using total number of children ever born as dependent variable. They then acknowledge the potential problem of endogeneity of natural resource scarcity. They argue that by using recent measures of fertility such as a dichotomous variable which

[9] This procedure will be discussed in detail in the method section in Chapter Three.

indicate whether or not a woman had at least one birth in the last ten years, the last five years, the last three years, and the last two years may address the problem as opposed to using the cumulative measures of fertility. However, these studies failed to apply the widely available diagnostic tests to see if they have addressed the problem of endogeneity. As this study reveals, even the use of recent measures of fertility as advocated by Loughran and Pritchett (1997) and Aggarwal, Netanyahu, and Romano (2001), do not address the problem of endogeneity. Instead acceptable methods to address endogeneity problem should be used.

Summary

In summary, a review of the conventional microeconomic approach to fertility is useful in identifying some of the important factors that determine women's fertility. The approach shows that factors such as women's education and income are very critical in understanding various dimensions of fertility. The review of the two major schools of thoughts reveals that each school of thought represents a particular view on how population growth and the environment interact. Essentially, the two schools seem to agree that there is a relationship between population growth and environment; however, there are differences on how the relationship is examined from the two views. The review shows that the two schools of thoughts are diametrically opposed and the disagreements seem to be far from over.

The review of the vicious circle theory provides a framework toward understanding the complicated relationship between environment, poverty, and

population growth via increases in fertility. For the theory of vicious circle to be practical, some assumptions need to be met. The main assumptions are:

- The theory of vicious circle is expected to be applicable in rural communities of the poorest regions of the world where there is much reliance on natural resources for livelihood (Dasgupta, 2000),
- Children play an important role in collection activities of natural resources such as fetching water and gathering firewood,
- There is communal ownership of natural resources such as village ponds and water wells, local forests and woodlands in such a way that the depletion costs of collected goods from these resources do not fall entirely on the household (Filmer & Pritchett, 2002).

These assumptions are examined in Chapter Three, to see whether the countries analyzed in this study meet the above criteria.

The reviewed background studies on the subsection about the evolution of the variables of interest which are natural resource scarcity and poverty is useful in providing the basis as well as justification for using them in this study. The review shows that time to get to the source of drinking water as used in this study as a proxy for natural resource scarcity has been widely used by the previous studies.

The review of the existing studies that empirically examined the vicious circle theory gives an account of the relationship between natural resource scarcity and population growth via positive effects on fertility. The review reveals that there is no consensus in favor or disfavor of the vicious circle theory. This particular finding shows that more research is important in this area for better understanding of the complex

relationship presented by the vicious circle theory. In addition, more research is important in order to have consensus as far as the theory of vicious circle is concerned.

This literature review chapter also reveals some important limitation of the existing studies. As shown above, some studies have used inappropriate statistical methods. Also, most of the previous studies have used measures of dependent variable that may not be appropriate to examine the vicious circle theory. Most importantly, with the exception of one most recent study (Bhattacharya, 2007), the existing studies have failed to address the potential problem of endogeneity. It is important to emphasize here that while the Bhattacharya study addressed the endogeneity problem, its analysis was based on macro-level data. This may be a problem when examining a household decision-making (Al-Qudsi, 1998).

This study is intended to address the limitations of the existing studies by using dependent variables that measure more recent measures of fertility as well as acceptable statistical models. In addition, as a key contribution, this will be the first study that used micro-level data to address the problem of endogeneity of natural resource scarcity. In this manner, this dissertation will contribute to the emerging literature that explores and tests the theory of the vicious circle.

Hypotheses

This study tests three hypotheses based on gaps and controversies in literature described above.[10]

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[10] Suppose a model is written as $y = x_1\beta_1 + x_2\beta_2 + \mu$, and the interest lies in testing β_2 the null hypothesis can be written as H0: $\beta_2 = 0$ against H1: $\beta_2 \neq 0$ (Wooldridge, 2002).

1. Is natural resource scarcity (NS) an endogenous explanatory variable in the fertility model?

Since this study uses IVPROBIT approach, the Wooldridge (2002, p. 472 - 475) approach is followed to test this first hypothesis:

For example a model is written as:

$$PB_{it}^* = \beta_0 + \beta_1 NS_{it} + \beta_2 X + \epsilon_1 \qquad 2.6$$

$$NS = \delta_0 + \delta_1 X + \delta_2 Z + \mu_1 \qquad 2.7$$

$$PB_i = 1[PB_{it}^* > 0] \qquad 2.8$$

Where:

PB_{it} = indicator variable which takes a value of 1 if a woman i has had a birth in time t, otherwise it takes a value of 0,

NS_{it} = a measure of natural resource scarcity for individual i measured in time in minutes taken to get to the source of drinking water at time t,

X and Z = explanatory variables,

β_0 and δ_0 = intercept coefficients, and

$\beta_1, \beta_2, \delta_1, \delta_2$ = are slope coefficients

Where (ϵ_1 , μ_1) has a zero mean, bivariate normal and is independent of Z. Equations 2.6 and 2.8 are structural equations. Equation 2.7 is a reduced form for NS, which is endogenous if ϵ_1 and μ_1 are correlated. If ϵ_1 and μ_1 are independent, there is no endogeneity problem. Then the hypothesis can be stated as:

H_0: Corr $(\epsilon_1, \mu_1) = 0$

H_1: Corr $(\epsilon_1, \mu_1) \neq 0$

According to Wooldridge, the model is applicable when the endogeneity arises due to omitted variables or measurement error. Wooldridge noted that the model may also be applicable to the case where PB and NS are determined jointly. The above hypothesis is tested using three tests discussed in Chapter Three.

2. Does natural resource scarcity (NS) lead to higher fertility?

   H_0: $\beta_1 = 0$

   H_1: $\beta_1 > 0$

   Where: β_1 is the coefficient of NS.

3. Does household poverty measured by wealth index (WI) lead to higher fertility?

   H_0: $\beta_2 = 0$

   H_1: $\beta_2 < 0$

   Where: β_2 is the coefficient of WI.

Hypotheses 2 and 3 are tested by estimating Probit models discussed in Chapter Four.

CHAPTER 3

STUDY SITE, DATA, AND EMPIRICAL MODELS

This chapter describes the study site, data, and principal estimation techniques used in the data analysis. The chapter includes the discussion of potential endogeneity, correcting and testing for it. Different techniques for testing endogeneity are discussed here. The chapter also discusses alternative techniques that are used to prove the validity of identifying instrument used in correcting endogeneity. In addition the chapter proposes an identifying instrument that this study uses. The chapter concludes with an explanation of the method that this dissertation uses to identify and correct for multicollinearity.

Study setting

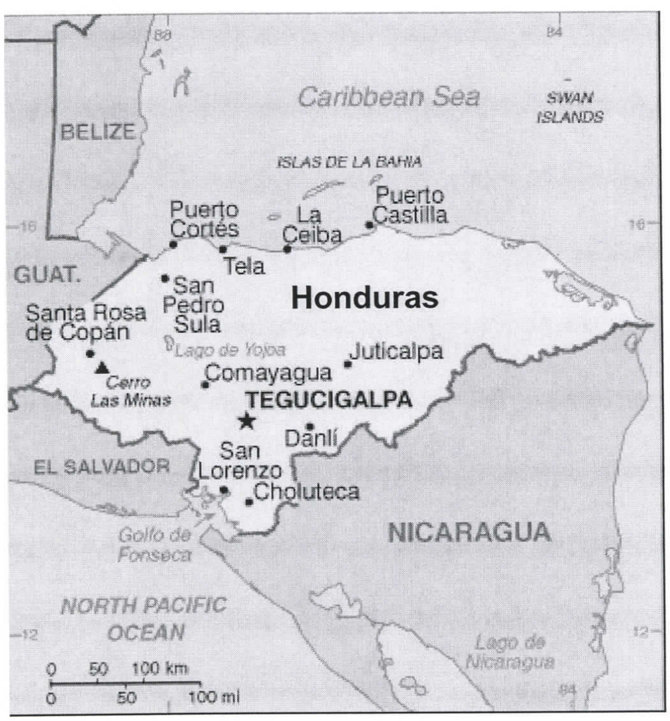
The rural areas of Honduras, Nepal, and Tanzania are examined in this study. The countries were selected on the following bases: First, all are developing countries as the theory vicious circle emphasizes. Second, surveys for these three countries have the lowest proportion of missing variables of interest, of all the countries in the DHS dataset at the time of the analyses. Third, the countries are believed to be representatives of their respective continents. Fourth, in rural areas of the countries, children play an important role in fetching drinking water as shown below in the subsections of this section. This

section is divided into three subsections; (1) Honduras, (2) Nepal, and (3) Tanzania. Each subsection gives some basic information related to this study on a country background

Honduras

Honduras is located in Central America, bordering the Caribbean Sea between Guatemala and Nicaragua and bordering the Gulf of Fonseca (North Pacific Ocean), between El Salvador and Nicaragua (see Figure 3.1). The country has a total area of 112,090 square kilometers of which 111,890 square kilometers is covered by land and the remaining 200 square kilometers is covered by water (Central Intelligence Agency, 2008a).

Figure 3.1 Map of Honduras



Source: Central Intelligence Agency, 2008a

In 2006, the population of Honduras was estimated to be about 7 million and growing at the rate of around 2.0 percent per year (World Bank, 2008a). The World Bank (2008b) classifies Honduras as a lower-middle-income economy.[11] According to the International Fund for Agricultural Development (n.d), Honduras is the third poorest country in Latin America and the second poorest in Central America. Since 1997 poverty levels have remained unchanged. The International Fund for Agricultural Development reports that about 74 percent of the country's poor and 86 percent of the extremely poor reside in rural areas. This makes the case that poverty is more of a rural problem in Honduras. Agriculture, which is the most important sector of the economy, employs about two-thirds of the country's labor force (Zelaya & Larson, 2004).

According to World Bank (2008a) in 2004 about 87 percent of the Honduras population had access to improved water source. The joint report by World Health Organization and United Nations Children's Fund (2000) shows in 2000, about 82 percent of rural populations in Honduras had access to clean water. However, this figure can be misleading as it represents only the proportion with access to a government-established water system and not the proportion of systems functioning at acceptable standards of water quality (Henderson, Sack, & Toledo, 2005).

In 1998 Hurricane Mitch was responsible in devastating much of the countryside. The World Health Organization and United Nations Children's Fund (2000) joint report pointed out that Hurricane Mitch caused US $58 million of damage in Honduras. Among others, the hurricane devastated 1,683 water mains; as a result, approximately 4.5 million

[11] The World Bank classifies its member countries into low income, lower middle income, upper middle income, and high income. According to the Bank using 2006 Gross National Income (GNI) per capita, lower income are economies with a GNI per capita of $905 or less; lower middle income are economies with a GNI per capita of, $906 – 3,595; upper middle income are economies with a GNI per capita of, $3596 – 11,115; and high income are economies with a GNI per capita of, $11,116 or more.

people lost access to drinking water. In 1998 this was an equivalent of 75 percent of the population in Honduras. The effects of the hurricane are still felt by the people of Honduras.

In addition to the havoc created by the Hurricane Mitch, Honduras has experienced environmental problems such as erosion brought by deforestation, slash-and-burn, and other unsustainable agriculture practices (Zelaya & Larson, 2004). In addition to deforestation, mining activities are responsible for polluting the country's most significant source of freshwater (Lago de Yojoa) and several rivers and streams, with heavy metals.

It is not uncommon for a Honduran family to have as many children as ten (Zelaya & Larson, 2004). It is very common for young children to work on the farms, carrying water, caring for garden and livestock, and, gathering firewood. "Young girls six to seven years old have traditionally been responsible for fetching water from wells and creeks miles from their homes" (Zelaya & Larson, 2004, p. 95). Traditionally, boys are responsible for gathering firewood and helping in agricultural activities.

Nepal

Nepal is located in Southern Asia, between China and India (see Figure 3.2). The country has a total area of 147,181 square kilometers of which 143,181 square kilometers is covered by land and the remaining 4,000 square kilometers is covered by water (Central Intelligence Agency, 2008b). In 2006, the population of Nepal was estimated to be about 28 million and growing at the rate of around 2.0 percent per year (World Bank, 2008b). The World Bank (2008b) classifies Nepal as a low-income economy. According to the International Fund for Agricultural Development (n.d), approximately 40 percent

of the Nepalese live below the poverty line of US $12 per person per month and most indicators suggest that the problem is on the rise.

Figure 3.2 Map of Nepal

Source: Central Intelligence Agency, 2008b

According to the International Fund for Agricultural Development (n.d) a majority (about four fifths) of the working population lives in rural areas and depend on subsistence farming for livelihoods. According to the Rural Poverty Portal of the International Fund for Agricultural Development, most households in rural Nepal have little or no access to clean drinking water and sanitation services. The rural population in Nepal is generally illiterate, has large families and is poor. A variety of factors have been attributed to rural poverty in Nepal. According to the International Fund for Agricultural Development, chiefs among them are; landownership is traditionally concentrated in the

hands of the few, growing population, and the harsh climate. Overgrazing and deforestation have been cited as problems leading to poverty in rural areas of Nepal.

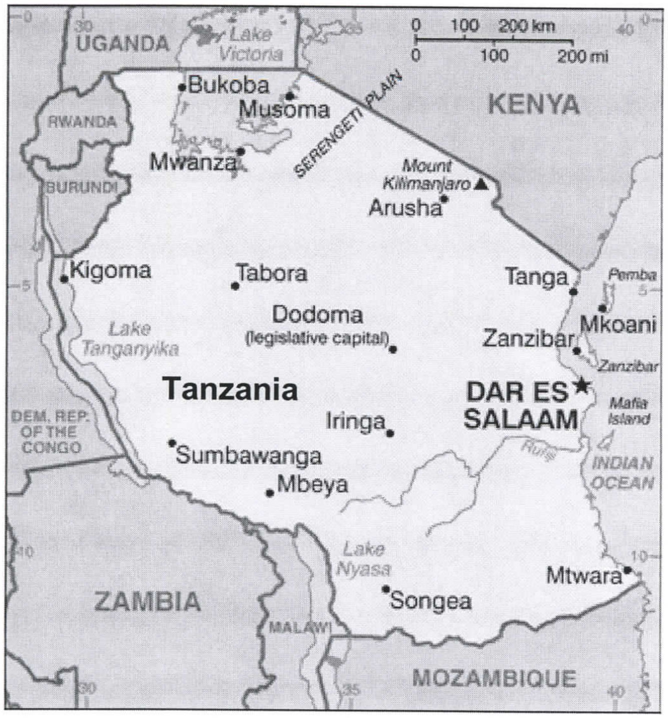
According to World Bank (2008a) in 2004 about 90 percent of the Nepal population had access to improved water source. The joint report by World Health Organization and United Nations Children's Fund (2000) shows in 2000, about 80 percent of rural populations in Nepal had access to clean water.

In Nepal, children play an important role in collection of natural resources and other domestic chores. As young as 6 years old, a Nepalese girl is looking after other younger siblings, fetching water, and other domestic chores (Yamanaka and Ashworth, 2002). As the age increases, girls' roles in the household also increase to collection of other natural resources such as fodder and firewood. The Yamanaka and Ashworth study of the rural Nepal found out that fetching water was a major domestic activity for younger girls. The amount of fetched water by these younger girls was closely correlated with the family size and the number of domesticated livestock.

Tanzania

Tanzania is located in Eastern Africa, bordering the Indian Ocean, between Kenya and Mozambique (see Figure 3.3). The country has a total area of 945,087 square kilometers of which 886,037 square kilometers is covered by land and the remaining 59,050 square kilometers is covered by water (Central Intelligence Agency, 2008c). In 2006, the population of Tanzania was estimated to be about 39 million and growing at the rate of around 2.5 percent per year (World Bank, 2008a). The World Bank (2008b) classifies Tanzania as a low-income economy.

Figure 3.3 Map of Tanzania



Source: Central Intelligence Agency, 2008c

According to the International Fund for Agricultural Development (n.d), from 1985 to 2001, Tanzania was able to halve poverty in the rural areas. However, poverty is still widespread and acute, particularly in the rural areas where about 85 percent of the country's poor people live. Agriculture is the main source of income and livelihood of the poor people in the rural areas. According to the Tanzania Household Budget Survey conducted in 2000/01, rural areas have the highest poverty levels. The survey found out that about 39 percent of the population in rural areas lives below the poverty line.

According to the Tanzania National Bureau of Statistics (2002) that conducted Tanzania Household Budget Survey of 2000/01, 44 percent of the households used unprotected sources of drinking water which includes wells and springs and surface water

such as rivers and lakes. The survey revealed that about 53 percent of the rural households get their drinking water from unprotected sources. The survey further revealed that only 49 percent of the rural households access their drinking water supply within one kilometer, the remaining households must travel longer distances to fetch drinking water. Many rural communities of Tanzania are characterized by water scarcity (Madulu, 2003). Young children in rural Tanzania often play an important role in household activities such as fetching water and firewood collection as well as preparing meals, caring for younger siblings, and sometimes caring for ill household members (Burke & Beegle, 2004).

Interestingly, the descriptions of the study setting above show that Honduras, Nepal, and Tanzania met the criteria for the examination of the vicious circle as explained in Chapter Two. For example, the discussion above shows that in the three countries there is much reliance on natural resources for livelihood. In addition, in the three countries, children play an important role in collection of natural resources for domestic uses.

Data

The data for this dissertation are drawn from the Demographic and Health Surveys (DHS). This study uses cross-sectional data from surveys conducted in 2005, 2006, and 2005 for Honduras, Nepal, and Tanzania respectively.

The Honduras 2005 DHS is a nationally representative sample of individual women between ages 15 and 49. The total sample for Honduras contains 19,948 individual women. The Nepal 2006 DHS is a nationally representative sample of

individual women between ages 15 and 49. The total sample for Nepal contains 10,793 individual women. The Tanzania 2004 DHS is a nationally representative sample of individual women between ages 15 and 49. The total sample for Tanzania contains 10,329 individual women. In this study the units of analysis are individual women in the childbearing years (ages 15-49).

The DHS data are broadly comparable surveys.[12] DHS data have been conducted with virtually identical survey instruments in more than 40 countries as such provide a reasonable comparison among countries as this very study intends to do.[13]

Macro ORC (Opinion Research Corporation) based in Maryland (USA), in partnership with other agencies implement the DHS projects. DHS project was initiated by the United States Agency for International Development (USAID) to provide data and analysis on the population, health, and nutrition of women and children in the developing countries. Most funding for DHS comes from USAID. Since 1984 more than 200 nationally representative DHS surveys have been conducted in 70 countries throughout Africa, Asia, the Near East, North Africa, Latin America and the Caribbean. The DHS surveys are normally conducted in four phases over a period of 18-24 months. The sample sizes are large, usually between 5,000 and 30,000 households. The DHS surveys instrument is designed to be fairly comprehensive as well as nationally representative.

The DHS data were collected at the individual as well as the household levels. The individual level came from responses from a series of questions that a woman between the ages of 15 to 49 is supposed to answer. At the household level the data contain information from all members of household such as spouses or partners and

[12] See Rafalimanana and Westoff (2000).
[13] See Filmer and Pritchett (2001).

children. The DHS instrument asked respondents to report retrospectively on a wide range of demographic variables. Respondents were asked a series of demographic and socioeconomic questions such as educational attainment, type of cooking fuel, time taken to fetch drinking water, family planning, family nutrition and health, type of residence (rural vs. urban), mortality, fertility and other socioeconomic variables.

Although the quality of the DHS data is potentially limited by problems of recall (due to lapse of memory) and possible underreporting of certain types of behavior due to social norms, researchers view the data as highly reliable for use in demographic analysis.[14] Also, developing countries as well as international benefactor agencies have long relied on DHS data to monitor a variety of programs that include family planning and child survival.[15] Even though there is a very wide application of DHS data in the demographic research, its application in environmental research is emerging as well.[16]

The primary focus of the study is to examine whether proxies for natural resource scarcity and poverty have an affect on fertility and control for other determinants of women's fertility. For this reason, woman's individual data are used.

Variables

Table 3.1 presents the variable notations and descriptions used in the descriptive statistics and empirical models. As the table shows, with the exception of natural resource scarcity (NS) and poverty (WI) all the variables are dichotomous.

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[14] See Ali, Cleland, and Shah (2003)
[15] See Stanton, Abderrahim, and Hill (2000)
[16] See Sutherland, Carr, and Curtis (2004) and Dasgupta, Deichmann, Meisner, and Wheeler (2005)

Dependent Variables

This dissertation used two alternative measures of dependent variables in the empirical models. The first measure is a binary variable which takes a value of 1 if a woman had at least one birth in the last three years preceding the survey, otherwise 0. The second measure is also a binary variable which takes a value of 1 if a woman had at least one birth in the last five years preceding the survey, otherwise 0.

Key Variables

The key explanatory variables are measures of natural resource scarcity (NS) and wealth index (WI). For the variable NS, this study uses time (in minutes) taken to get to the source of drinking water. Note that the NS coefficient is hypothesized to be positive as suggested by the vicious circle theory. However, the few existing studies show that there is no consensus on the expected sign of the NS coefficient. To measure poverty, this study uses WI which is a broad measure of a respondent's household wealth. The variable WI incorporates almost all indicator variables of household assets and utility services including country-specific items. DHS official used PCA to assign the indicator weights. WI is an ordinal measure which ranges from 1 through 5, with higher levels indicating more family wealth.

Table 3.1 – Variables descriptions

Variables	Definitions
<u>Dependent variables</u>	
PB3	1 = if a woman had a birth in the last three years preceding survey 0 = otherwise
PB5	1 = if a woman had a birth in the last five years preceding survey 0 = otherwise
<u>Key variables</u>	
NS	An indicator of natural resource scarcity measured in minutes per trip to get to the source of drinking water
WI	Wealth index, it is an ordinal measure of household wealth (1 to 5)
<u>Control variables</u>	
Edup	1 = if a woman has attained primary education level 0 = otherwise
Edus	1 = if a woman has attained secondary education level 0 = otherwise
Eduh	1 = if a woman has attained higher education level 0 = otherwise
Age1924	1 = if woman is in the aged between 19 to 24 years old 0 = otherwise
Age2529	1 = if woman is in the aged between 25 to 29 years old 0 = otherwise
Age3034	1 = if woman is in the aged between 30 to 34 years old 0 = otherwise
Age3539	1 = if woman is in the aged between 35 to 39 years old 0 = otherwise
Age4044	1 = if woman is in the aged between 40 to 44 years old 0 = otherwise
Age4549	1 = if woman is in the aged between 45 to 49 years old 0 = otherwise

Table 3.1 – Contd…

Variable	Definitions
Knows	1 = if a woman has correct knowledge of ovulatory cycle 0 = otherwise
Sonp	1 = if a woman has indicated son preference 0 = otherwise
Emar	1 = if a woman is ever married 0 = otherwise
Cmort	1 = if a woman ever experienced infant and/or child death 0 = otherwise
Cuse	1 = if a woman used contraceptive use before first birth 0 = otherwise
<u>Identifying variable</u>	
Improved	1 = if the drinking water is obtained from an improved source 0 = otherwise

Control Variables

In addition to the variables NS and WI, this study uses the following standard control variables of fertility.

Woman's education: A large body of research has suggested that woman's education is the powerful predictor of fertility (Hirschman & Guest, 1990; Martin, 1995). This study uses a series of dichotomous variables for the highest education level attained by respondents. Woman's education is categorized into no education as a reference category, primary education, secondary education and higher education. The coefficients for education levels are expected to have negative signs.

Woman's age: A series of dichotomous variables are used to characterize the respondent's age group. Seven 5-year interval age groups are defined. Age group 15 to 19 years is used as a reference category. Mensch, Arends-Kuenning, and Jain (1996) and Ali, Cleland, and Shah (2003) used similar approach. This approach is useful in acknowledging that women in different age groups are in different stages of their reproductive life. In a model where the dependent variable is the total number of children ever, the coefficients of woman's age are expected to be positive. In this case an increase in woman's age is expected to increase the number of children ever born because of longer reproductive span. With the measures of recent fertility such as the binary variables indicating whether or not a woman had at least one birth in the last three or five years, the coefficients for women in lower age groups are expected to have positive signs while those of higher age groups are expected to have negative signs.

Knowledge of ovulatory cycle: This variable is intended to assess woman's reproductive knowledge. This variable is particularly important in developing countries where the number of unwanted births is very high partly because women do not know their reproductive cycle. The variable was constructed by asking a woman when during her monthly cycle she thinks she has the greatest chance of becoming pregnant. This variable has been employed in previous studies (Martin & Juarez, 1995). The coefficient for knowledge of ovulatory cycle depends on woman's age group.

Children's sex preference: Previous studies (Khan & Khanum, 2000; Hank & Kohler, 2003) have concluded that son preference is an important determinant of fertility rates particularly in developing countries. Arnold, Choe, and Roy (1998) concluded that son preference fundamentally affects demographic behavior. Son preference is embedded

in cultural and religious traditions and community norms as well as economical factors (Hank & Kohler, 2000). These factors influence attitudes and behavior. In this study the variable that measure son preference was constructed by combining woman's responses on two questions. In the first question a woman was asked, ideally, how many boys she would like to have. In the second question a woman was asked, ideally, how many girls she would like to have. If the ideal number of boys is higher than the ideal number of girls, then, the variable is coded 1 which suggests that a woman has indicated son preference, otherwise it is coded 0. The coefficient for sex preference variable is expected to be positive.

Marriage: Marriage is an important variable when one examines factors that influence fertility. This is not to say that childbearing is entirely restricted to marriage (Bongaarts, Frank, & Lesthaeghe, 1984). Marriage is coded 1 for women who are either currently married or were married before, otherwise the variable takes a value of 0. The coefficient for marriage is expected to be positive.

Child mortality: Infant and child mortality is one of the factors that influence woman's fertility. Infant and child mortality can affect woman fertility in two ways (Benefo & Schultz, 1996). First, it induces the woman to replace the child who dies. This can happen through biological feedback or through behavioral adaptation. Second, in a society that experiences higher child mortality rates, parents can adapt their fertility behavior by anticipating a certain level of child mortality they will experience on average. In this study child mortality combines both infant and child mortality. Therefore, the variable is coded 1 if a woman has experienced death of child under the age of 5;

otherwise, the variable is coded 0. The coefficient for child mortality variable is expected to have positive sign.

Contraceptive use: This is an important determinant of fertility, particularly if the user of a contraceptive use with the aim of limiting family size (Bongaarts, Frank, & Lesthaeghe, 1984). Reductions in fertility due to contraceptive use are attributed to the success of family planning programs (Gertler & Molyneaux, 1994). In this study contraception was measured by coding the variable 1 if a woman started using contraception before she had any birth. If a woman has at least one birth and started using contraception, then the variable takes a value of 0. It is expected that the variable will have a negative coefficient on the fertility model suggesting that contraceptive use before a woman has a birth reduces the number of children born per woman.

Descriptive statistics

The descriptive statistics for the Honduras, Nepal, and Tanzania DHS data set are shown in Table 3.2 below. The data are nationally representative of all rural women who participated in the most recent surveys. Mean total number of children ever born per woman differ in the three countries. Tanzanian rural women tended to have more children ever born (3.2) compared to their counterparts in Nepal (2.6) and Honduras (2.9). Figure 3.4 using data from the United Nations Population Fund (UNFPA, 2008) also highlights the fertility differences among the three countries. The figure compares the total fertility rate for the three countries. From the figure it is also evident that from around mid 1970s to the foreseeable future, Tanzania leads both Nepal and Honduras in terms of fertility rates. The figure also shows remarkable success achieved by Honduras. In 1950s

Honduras total fertility rate was 7.5 compared to that of 3.7 by the year 2005. This represents a decline in total fertility of about 50%. Total fertility rates in the three countries are expected to decline. However, as figure 3.4 shows, Tanzania is still expected to have higher rates compared to Nepal and Honduras for the foreseeable future.

Table 3.2

Descriptive statistics

	Honduras		Nepal		Tanzania	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Fert	2.9393	2.9299	2.5927	2.3941	3.2133	2.9808
PB3	0.3374	0.4728	0.2983	0.4575	0.4793	0.4996
PB5	0.4624	0.4986	0.4063	0.4912	0.5834	0.4930
NS	3.9528	12.6583	9.3735	14.9398	41.7261	58.0688
WI	2.0628	1.0512	2.6566	1.3134	2.7522	1.2911
Noedu	0.1076	0.3099	0.5899	0.4919	0.2931	0.4552
Edup	0.7448	0.4360	0.1777	0.3823	0.6148	0.4867
Edus	0.1394	0.3464	0.2093	0.4069	0.0832	0.2761
Eduh	0.0082	0.0900	0.0231	0.1502	0.0090	0.0942
Age1519	0.2240	0.4167	0.2296	0.4206	0.2198	0.4141
Age2024	0.1920	0.3939	0.1847	0.3881	0.1854	0.3886
Age2529	0.1605	0.3671	0.1604	0.3670	0.1709	0.3765
Age3034	0.1355	0.3423	0.1210	0.3261	0.1436	0.3507
Age3539	0.1111	0.3143	0.1182	0.3228	0.1111	0.3142
Age4044	0.0954	0.2938	0.1026	0.3035	0.0917	0.2887
Age4549	0.0813	0.2734	0.0835	0.2767	0.0775	0.2675
Knows	0.0636	0.2441	0.1842	0.3877	0.2153	0.4110
Sonp	0.17389	0.3790	0.3326	0.4712	0.2117	0.4085
Emar	0.74918	0.4335	0.8107	0.3918	0.7852	0.4107
Cmort	0.13468	0.3414	0.2234	0.4165	0.2953	0.4562
Cuse	0.09271	0.2900	0.0458	0.2090	0.0247	0.1552
Improved	0.76628	0.4232	0.7701	0.4208	0.4440	0.4969

Among 11,642 rural women surveyed in Honduras, 34 percent and 46 percent had at least one birth in the last three and five years preceding the survey, respectively. Likewise for 7,844 rural women surveyed in Nepal, it is 30 percent and 41 percent preceding the survey, respectively. Whereas in Tanzania, among 7,816 rural women surveyed, 48 percent and 58 percent had at least one birth in the last three and five years preceding the survey respectively.

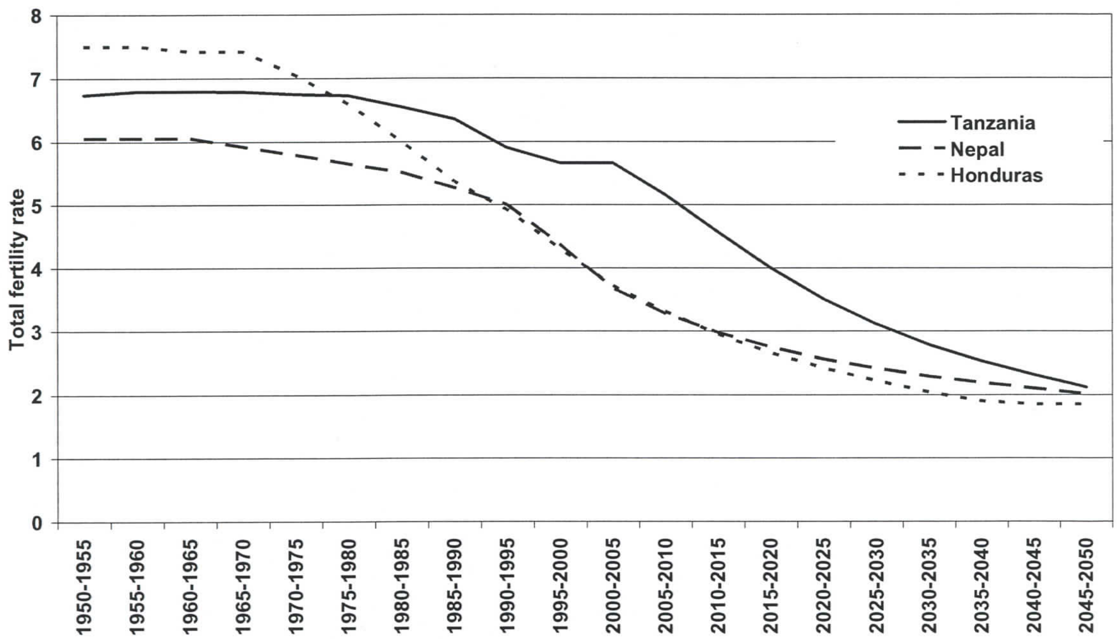
The average time taken to get to the source of drinking water was about 4 minutes in the rural areas of Honduras. In the rural areas of Nepal the average time taken to get to the source of drinking water was about 9 minutes in the rural areas. Tanzania had the highest (about 42 minutes) average time to get to the source of drinking water in the rural areas.

Wealth index shows a mean of 2.1 for Honduras, 2.7 for Nepal, and 2.8 for Tanzania. This implies that majority of rural women in Tanzania followed by Nepal are relatively wealthier as compared to their counterparts in Honduras.

Table 3.2 also shows that fewer women in rural Honduras had no formal schooling as compared to their counterparts in Nepal and Tanzania. About 59 percent of the surveyed rural women aged 15 to 49 in Nepal did not have formal education. Almost 74 percent of rural women in Honduras had attained primary level education compared to 18 percent for Nepal and 61 percent for Tanzania. About 14 percent of the surveyed rural women in Honduras had attained secondary level education compared to 21 percent for Nepal and 8 percent for Tanzania. Less than 1 percent of surveyed rural women in Honduras and Tanzania had attained higher education level compared to about 2 percent of the surveyed rural women in Nepal. The descriptive statistics do not show a clear

pattern in terms of educational attainment among the surveyed women for the three countries.

Figure 3.4 Total fertility rates by country



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision. 1950-2005 are historical estimates, 2005-2050 are projected estimates. The projections are based on medium variant.

In the three countries, majority of the surveyed women are in age group 15 to 19. Women in this age group comprise about 22 percent in Honduras and Tanzania and about 23 percent in Nepal. The proportion decreases with ascending age groups for the three countries.

Knowledge of ovulatory cycle is higher among rural women in Tanzania (22 percent) compared to Nepal (18 percent) and Honduras (6 percent). In the case of Tanzania, this finding is counterintuitive. One would expect women who are more

knowledgeable about their reproductive behavior would have fewer children. But this is not the case for Tanzania. It may be the case that these women use the knowledge to have more children.

Table 3.2 reveals that son preference is higher in Nepal. About 33 percent of rural Nepalese women have shown an indication of son preference as compared to Tanzania (21 percent) and Honduras (17 percent).

In the three countries majority of the surveyed rural women are either currently married or were married at some point in their lives. This implies that marriage is still considered an important institution in developing countries. This is an important finding because it suggests that an examination of reproductive behavior in developing countries have to incorporate marital status as this study does.

Child mortality is still higher in Tanzania as compared to Nepal and Honduras. About 30 percent of the surveyed rural women in Tanzania have experienced child death relative to 22 percent for Nepal and 13 percent for Honduras.

Modern contraceptive use prior to having first child was relatively higher in Honduras (9 percent) as compared to Nepal (5 percent) and Tanzania (only 2 percent). However, these figures are still very low which may suggest low contraceptive use among these countries contribute to higher levels of fertility rates.

Majority of rural women (77 percent) in Honduras and Nepal get their drinking water from an improved source. In Tanzania, only 44 percent of the surveyed rural women get their drinking water from an improved source.

Summary

In general, data from the three countries reveal several points of interest. Rural women in Tanzania tend to have more children than their counterparts in Honduras and Nepal. Natural resource scarcity as measured by the time taken to get to the source drinking water is more severe in rural areas of Tanzania than in the rural areas of Honduras and Nepal. In addition as revealed by the survey data, more than 50 percent of women in Nepal do not have formal education. Likewise, women in rural areas are more likely to experience death of child under five than their urban counterparts (urban data not included in this study). This is yet another indication that these countries are in developing countries and they do not differ significantly in terms of their household wealth.

Empirical Models

In analyzing the effect of natural scarcity and poverty on fertility in Honduras, Nepal, and Tanzania, this study uses two alternative measures of dependent variables. The dependent variables are dichotomous which takes a value of 1 if a woman had at least one birth in the last three years and the last five years preceding survey, otherwise 0. These models are based on studies by Loughran and Pritchett (1997); Aggarwal, Netanyahu, and Romano (2001) and Filmer and Pritchett (2002).

Loughran and Pritchett (1997) used binary variables for whether or not there was a birth in the last five years, the last three years, and the last two years in addition to the total number of children ever born as dependent variables. For independent variable they used natural resource scarcity (water scarcity) which is common to this study. In addition,

they used firewood scarcity as another measure of natural resource scarcity. These two measures of natural resource scarcity were measured in terms of minutes taken to collect the resources. Other independent variables used by Loughran and Pritchett which are somewhat common to this study are age, education, incidence of infant mortality, and knowledge of birth control.

Aggarwal, Netanyahu, and Romano (2001) used dichotomous variables for whether or not there was at least one birth in the last five years and the last ten years in addition to the total number of children ever born as dependent variables. For independent variables they used woman's age, education of woman, water scarcity, and predicted infant mortality which are somewhat common to this study. In addition, they controlled for distance from family planning worker or clinic and dummy for woman of African origin.

Filmer and Pritchett (2002) used dichotomous variable for whether or not there was at least one birth in the last five years as dependent variable. For independent variable they used woman's age and education which are somewhat common to this study. For measures of natural resource scarcity, they used firewood scarcity. This variable was measured in various ways: whether there was a problem with firewood supply, the average distance to the place where firewood was collected, the average time devoted to collecting firewood, density of cluster, and price of wood. These five measures of natural resource scarcity were included separately in different models along with the control variables.

The dependent variables used in the current study are closely related to current measures of natural resource scarcity and poverty as opposed to using total number of

children ever born which is a cumulative measure.[17] The following model which is the basis of the analysis in this dissertation is specified as:

$$PB_{it} = \beta_0 + \beta_1 NS_{it} + \beta_2 WI_{it} + \beta_3 X + \epsilon_1 \qquad (3.1)$$

Where:

PB_{it} = indicator variable which takes a value of 1 if a woman i has had a birth in time t, otherwise it takes a value of 0,

NS_{it} = a measure of natural resource scarcity measured in time in minutes taken to get to the source of drinking water for an individual i at time t,

WI_{it} = is a wealth index which measured household wealth for an individual i at time t,

X = is a vector of exogenous variables in the equation

β_0 = intercept coefficients, and

$\beta_1, \beta_2,$ and β_2 = are slope coefficients

ϵ_1 = is a stochastic error.

Since the dependent variable PB_{it} is dichotomous;

$$\begin{cases} 1 \text{ if a woman i have a birth in time t, i.e. } PB_{it} > 0 \\ 0 \text{ if a woman does not have a birth in a specified time period, i.e. } PB_{it} = 0 \end{cases}$$

a Probit estimation technique is used.

[17] For further discussion on this see Loughran and Pritchett (1997) and Aggarwal et al (2001).

Potential Endogeneity

Two variables enter the Probit models for whether or not there was at least one birth in the last three and five years as endogenous continuous and ordinal explanatory variables. These are natural resource scarcity (NS) and wealth index (WI). As explained previously, in applied econometrics, endogeneity usually occurs either because of omitted variables, measurement error, or simultaneity (Wooldridge, 2002).[18] In this study, simultaneity is the potential cause of endogeneity because of the nature of the theory of vicious circle that is examined here. According to the theory of vicious circle, over time, woman's fertility, natural resource scarcity and poverty are interlinked in a closed loop and that none of the three is the prior cause of the other two.[19] This suggests that when examining the effects of natural resource scarcity and poverty on fertility, both variables that represent natural resource scarcity and poverty are potentially endogenous explanatory variables. In addition, measurement error is also a potential cause of endogeneity.

In econometrics, endogeneity problem occurs when a variable that is thought to be exogenous is correlated with the error term in the structural equation. This means that in equation (3.1) above, the variables NS and WI are suspected to be correlated with the error term ϵ. In other words endogeneity occurs when unobservable factors that influence dependent variable PB_{it} are also influencing natural resource scarcity and poverty. If this is true, then the coefficients β_1 and β_2 in equation (3.1) are biased. However, since the proxy for poverty (WI) was constructed using Principal Component Analysis (PCA), then

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[18] Omitted variables appear when important explanatory variables are excluded from the model. Measurement error occurs when there is misspecification of the variable of interest. Simultaneity arises when at least one of the explanatory variables is determined jointly with dependent variable.

[19] For further discussion, see Dasgupta (2000, p. 623). In fact, Dasgupta explicitly believes that all the three variables are endogenous.

in this study WI is assumed to be exogenous.[20] This means that only the variable NS will be treated as endogenous explanatory variable in this study.

Correction for Endogeneity

The Endogeneity problem can be ameliorated by a system of simultaneous equations. In a system of simultaneous equations, the suspected endogenous explanatory (NS) becomes dependent variable. This technique requires the use of an instrumental variable (IV) Z not included in equation (3.1) above that can be used to identify the NS equation as follows:

$$NS = \delta_0 + \delta_1 WI + \beta_3 X + \beta_4 Z + \mu_1 \qquad (3.2)$$

Equation (3.2) is also known as reduced form equation for the endogenous explanatory NS. Since NS is a continuous variable, then NS (equation 3.2) is a linear function of WI and all the exogenous variables (X) in the structural equation (3.1), as well as one or more identifying variables Z. For the IV Z to be valid it must satisfy two conditions. First, Z must be uncorrelated with ϵ_1:

$$Cov\ (Z, \epsilon_1) = 0 \qquad (3.3)$$

Second, Z must be correlated with NS as shown in equation (3.2) above.

Since the main dependent variable (PB) in the structural equation is binary and the suspected endogenous variable (NS) in the reduced equation is continuous, the

[20] With some caveat, researchers have suggested the use of PCA as an alternative measure to correct endogeneity problem (Bowden and Turkington, 1984, p. 38; Pindyck and Rubinfeld, 1998, p. 350; Kennedy, 2003, p. 350). For a detailed discussion on PCA approach see Filmer and Pritchett (1999 and 2001).

IVPROBIT model is proposed as a method for testing and correcting for endogeneity. IVPROBIT is a STATA statistical software command that is used in this kind of analysis. IVPROBIT run the two equations (structural and reduced) jointly. The procedure involves two steps:

First, run the OLS regression NS on WI, X, and Z and save the predicted values. Note, as mentioned above, OLS is used in this first step because the dependent variable is continuous. Second, run the Probit regression PB on WI, X, and the predicted values of NS from the first step. It is worthwhile to note that IVPROBIT, while the best available estimator, is still inconsistent (Honore & Lewbel, 2002).

Tests for Endogeneity

There are at least two reasons that justify testing for endogeneity (Waters, 1999). First, if endogeneity is present and ignored, the estimated coefficients in the model are biased. Second, correcting for endogeneity when it does not exist results in larger standard errors. This creates unnecessary loss of precision (Ribar, 1994). This study uses three methods to test for endogeneity (Waters, 1999).

First method: Note that equations 3.1 and 3.2 are structural and reduced equations respectively. The question is whether NS in the structural equation is correlated with error term ϵ_1. If the error terms ϵ_1 and μ_1 are correlated, then NS is indeed an endogenous explanatory variable. Otherwise, endogeneity does not exist. The latest version of STATA 10 does this specific test of exogeneity automatically when running IVPROBIT. STATA output gives the Wald test which is used to test if the two error terms are correlated. If the test $\chi 2$ (chi-squared) statistic is not significant (that is the p-value is

larger than, say 0.10), then the suspected endogenous explanatory variable is in fact exogenous. This means that the error terms are in fact not correlated. If this is the case, then a Probit model works and there is no need to worry about endogeneity problem.

Second method: This method follows Bollen, Guilkey, and Mroz (1995) who suggest two steps method. The first step is to run the reduced form equation (3.2). Then the predicted values from the reduced equation are used in the second step which is to run the original equation (3.1) plus the predicted values obtained in equation (3.2). Note that in the second step; in addition of the predicted values from reduced form equation, all the variables in the right hand side of the equation (3.1) are included. Then a straightforward t-test for significance of the coefficient on the predicted values is performed. If the coefficient of the estimated predicted values is significant in explaining the original equation, then NS is an endogenous explanatory variable. Bollen, Guilkey, and Mroz (1995, p. 112) state that despite its simplicity; this approach "is almost as reliable as more complicated tests based on full-information maximum-likelihood estimation."

Third method: Comparing the coefficients of Probit and IVPROBIT. This method suggested by Ribar (1994) and applied by Waters (1999) involves comparison of the estimated effects of the dependent variable before and after correcting for endogeneity. A large difference in the coefficient, a change in the sign of the coefficient, or a change in the significance of the coefficient is an indication that NS is an endogenous explanatory variable.

Tests for IV Relevance

Studies suggest that if an IV is weak, then results from estimation are potentially worse than obtained from simply ignoring endogeneity (Hall, Rudebusch, & Wilcox,

1996; Stock, Wright, & Yogo, 2002; Hahn & Hausman, 2003, Ebbes, Wedel, & Bockenholt, [forthcoming]). In addition, finding suitable and relevant IV that satisfies the necessary conditions is often challenging (Greene, 2008) and once available its quality is often questionable. For this reason, it is important to investigate the validity of the IV.

As aforementioned above, for an IV to be valid, it must satisfy two requirements. First, it must be uncorrelated with the error in the structural equation. Second, it must be correlated with the explanatory variable for which it is to serve as an instrument (Kennedy 2003, p. 159).

This study investigates the validity of the IV in three ways. First, this study follows the standard approach suggested by Bound, Jaeger, and Baker (1995) of judging the IV from the F statistic of the identifying IV in the first-stage estimation. Staiger and Stock (1997) suggests that F statistic should not be less than 10 for a good IV.

Second, to test whether the IV is correlated with the endogenous explanatory variable, this study looks at the results from the first stage regression. If the coefficient of the IV is statistically significant in determining the endogenous explanatory variable, then it is appropriate.[21]

Third, this study also uses a method suggested by Davis and Kim (2002).[22] The procedure follows two steps. The first step is similar to the first stage regression in a two-stage stage least square, which is running the regression of the reduced model and then get and save the predicted values. The second step is regress the predicted values from the first step on all the explanatory variables (including the endogenous explanatory variable) in the structural equation. This second regression which is called auxiliary

[21] Brueckner and Largey (2008) use similar approach to determine the appropriateness of the IV.
[22] This method is a simplified version of Shea (1997) and Godfrey (1999).

regression is necessary to obtain the eigenvalues for the likelihood ratio test. The likelihood ratio test is simply LR = 1 – exp(- *c.v.* /N), where *c.v.* is the critical value for a $\chi 2$ distribution with a given degree of freedom. [23] If the eigenvalue is greater than LR, then null of no instrument relevance is rejected.

Identifying IV

Good judgment is required when choosing an IV. This study proposes "improved source of drinking water" as a possible identifying variable (Z) to correct for endogeneity. This identifying variable is a binary variable that takes a value of 1 if the source of drinking water is an improved one, otherwise 0. Improved sources of drinking water include water piped into residence, piped into yard or plot, private tap, communal tap, protected well, borehole, protected spring and rainwater. Unimproved sources of drinking water include unprotected well, unprotected spring, river and surface water, tanker, pond, and others.

Improved source of drinking water is essentially synonym to "access to safe drinking water." In defining access to safe drinking water, Gadgil (1998) found that walking distance or time from household to water source is the principal criterion in the rural populations. Therefore, intuitively, this variable could have a stronger impact on endogenous explanatory variable (time to get to the source of drinking water) without directly affecting dependent variable PB_{it} as required for its validity as instrument. All the tests suggested in the previous section are used to determine the relevance of this identifying IV.

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[23] The eigenvalue is the coefficient of the endogenous explanatory variable in the auxiliary regression (See Davis and Kim, 2002).

Checking Multicollinearity

The standard approach of correlation matrices is used in this study to determine if the explanatory variables in structural equation are collinear. Separate correlation matrices are run for each equation. Where unacceptably high levels of correlation are found to exist, the Probit regression models are run with and without the variables. If the inclusion of a single variable that is highly collinear with other variables causes the estimated coefficients on other variables to change, the variable is dropped from the regression model.

CHAPTER 4

EMPIRICAL RESULTS

The empirical results of this research are presented in two major sections. Section One presents results of estimated Probit single equations in which time taken to fetch drinking water (natural resource scarcity) is assumed to be an exogenous variable. This approach parallels the existing studies that failed to address endogeneity in examining the vicious circle theory. Section Two presents results of the two-stage Probit models that relax the assumption of natural resource scarcity exogeneity. The findings of models that assume natural resource scarcity as exogenous and those of IVPROBIT appear to differ from each other. Parameter estimates in the IVPROBIT models are superior to the traditional approach of using single equations. Some coefficients of natural resource scarcity that are not statistically significant under the Probit single equations become significant when estimating IVPROBIT. In additions, the level of statistical significance and magnitudes of the natural resource scarcity coefficients increase in the IVPROBIT models relative to the traditional approach. A 95% confidence interval is used.

In analyzing the data for the three countries in this study, multicollinearity does not seem to present problem. Kennedy (2003) noted that an absolute correlation value of 0.8 or 0.9 is an indication of the presence of multicollinearity. As Tables 4.1, 4.2, and 4.3 below show, no correlation absolute value of 0.8 is observed among the explanatory

variables. This implies that the key and control variables used in this study are independent from each other. Otherwise, the statistical results may be questionable.

Table 4.1

Honduras Correlation Matrix

	PB3	PB5	NS	WI	Edup	Edus	Eduh
PB3	1.0000						
PB5	0.7695	1.0000					
NS	0.0341	0.0333	1.0000				
WI	-0.1544	-0.1636	-0.1105	1.0000			
Edup	0.0781	0.1007	0.0103	-0.2038	1.0000		
Edus	-0.1241	-0.1584	-0.0465	0.3678	-0.6876	1.0000	
Eduh	-0.0304	-0.0343	-0.0211	0.1617	-0.1550	-0.0365	1.0000
Age2024	0.1951	0.2010	-0.0038	0.0128	0.0172	0.0425	0.0188
Age2529	0.1363	0.1998	-0.0137	0.0017	0.0558	-0.0456	0.0150
Aeg3034	0.0608	0.1089	0.0124	-0.0003	0.0464	-0.0695	0.0003
Age3539	-0.0113	0.0119	0.0120	-0.0045	0.0020	-0.0705	0.0287
Age4044	-0.0914	-0.0884	0.0220	-0.0158	-0.0238	-0.0733	-0.0067
Age4549	-0.1851	-0.1991	-0.0220	-0.0043	-0.0067	-0.0880	-0.0025
Knows	-0.0132	-0.0037	-0.0119	0.1161	-0.0737	0.0955	0.1290
Sonp	0.0324	0.0440	0.0044	-0.0205	0.0253	-0.0363	-0.0061
Emar	0.3274	0.4321	0.0069	-0.0555	0.1463	-0.2717	-0.0224
Cmort	0.0239	0.0616	0.0200	-0.1200	-0.0074	-0.1276	-0.0246
Cuse	0.0669	0.0546	-0.0253	0.1497	-0.0589	0.1159	0.0632
Improved	-0.0726	-0.0613	-0.3529	0.2916	-0.0558	0.1204	0.0392

	Age2024	Age2529	Age3034	Age3539	Age4044	Age4549	Knows
Age2024	1.0000						
Age2529	-0.2132	1.0000					
Age3034	-0.1930	-0.1732	1.0000				
Age3539	-0.1724	-0.1546	-0.1400	1.0000			
Age4044	-0.1583	-0.1420	-0.1286	-0.1149	1.0000		
Age4549	-0.1450	-0.1301	-0.1178	-0.1052	-0.0967	1.0000	
Knows	0.0044	0.0069	0.0274	0.0221	-0.0056	0.0000	1.0000
Sonp	-0.0095	0.0100	0.0196	0.0084	0.0138	0.0078	0.0028
Emar	-0.0279	0.1354	0.1689	0.1598	0.1535	0.1533	0.0363
Cmort	-0.1195	-0.0450	0.0261	0.0950	0.1570	0.2213	-0.0264
Cuse	0.1255	0.0015	-0.0392	-0.0509	-0.0716	-0.0723	0.0332
Improved	0.0113	0.0033	-0.0014	-0.0182	-0.0030	-0.0003	0.0338

	Sonp	Emar	Cmort	Cuse	Improved
Sonp	1.0000				
Emar	0.0551	1.0000			
Cmort	0.0226	0.2062	1.0000		
Cuse	-0.0076	0.0995	-0.0775	1.0000	
Improved	-0.0087	-0.0103	-0.0312	0.0538	1.0000

Table 4.2

Nepal Correlation Matrix

	PB3	PB5	NS	WI	Edup	Edus	Eduh
PB3	1.0000						
PB5	0.7882	1.0000					
NS	0.0579	0.0534	1.0000				
WI	-0.1263	-0.1347	-0.3067	1.0000			
Edup	-0.0014	-0.0152	0.0174	-0.0145	1.0000		
Edus	-0.0561	-0.0862	-0.0645	0.2527	-0.2392	1.0000	
Eduh	-0.0297	-0.0476	-0.0398	0.1663	-0.0714	-0.0791	1.0000
Age2024	0.3222	0.3059	-0.0007	0.0154	0.0554	0.0950	0.1041
Age2529	0.2124	0.2885	-0.0109	0.0042	-0.0060	-0.0421	0.0115
Age3034	-0.0001	0.0720	-0.0044	0.0009	-0.0262	-0.0698	-0.0414
Age3539	-0.0678	-0.0600	0.0085	-0.0104	-0.0751	-0.1282	-0.0431
Age4044	-0.1672	-0.1574	0.0094	-0.0354	-0.1034	-0.1565	-0.0352
Age4549	-0.1807	-0.2056	0.0006	0.0133	-0.0981	-0.1429	-0.0433
Knows	-0.0180	-0.0115	-0.0231	0.1200	-0.0153	0.1710	0.1570
Sonp	0.0441	0.0674	-0.0092	-0.1243	-0.0992	-0.2370	-0.0906
Emar	0.3151	0.3998	0.0081	-0.0570	-0.0963	-0.3505	-0.1338
Cmort	0.0069	0.0425	0.0428	-0.1189	-0.1324	-0.2323	-0.0783
Cuse	0.0772	0.0635	-0.0485	0.0907	0.0179	0.1362	0.1085
Improved	-0.0874	-0.0833	-0.3603	0.3397	-0.0131	0.0672	0.0127

	Age2024	Age2529	Age3034	Age3539	Age4044	Age4549	Knows
Age2024	1.0000						
Age2529	-0.2080	1.0000					
Age3034	-0.1766	-0.1621	1.0000				
Age3539	-0.1743	-0.1600	-0.1358	1.0000			
Age4044	-0.1610	-0.1478	-0.1255	-0.1238	1.0000		
Age4549	-0.1437	-0.1319	-0.1120	-0.1105	-0.1021	1.0000	
Knows	0.0390	0.0119	0.0002	-0.0079	-0.0361	-0.0305	1.0000
Sonp	-0.0987	0.0180	0.0480	0.1055	0.1226	0.0993	-0.1046
Emar	0.0531	0.1615	0.1653	0.1699	0.1516	0.1388	-0.0432
Cmort	-0.1590	-0.0342	0.0695	0.1223	0.2050	0.2442	-0.0677
Cuse	0.1488	0.0057	-0.0420	-0.0688	-0.0680	-0.0661	0.0549
Improved	-0.0433	0.0047	-0.0072	0.0040	0.0089	0.0146	0.0266

	Sonp	Emar	Cmort	Cuse	Improved
Sonp	1.0000				
Emar	0.2211	1.0000			
Cmort	0.1873	0.2592	1.0000		
Cuse	-0.0809	0.1012	-0.0720	1.0000	
Improved	-0.0178	-0.0174	-0.0227	0.0257	1.0000

Table 4.3

Tanzania Correlation Matrix

	PB3	PB5	NS	WI	Edup	Edus	Eduh
PB3	1.0000						
PB5	0.8107	1.0000					
NS	0.0366	0.0307	1.0000				
WI	-0.1009	-0.1120	-0.1629	1.0000			
Edup	0.0253	0.0382	-0.0143	0.0499	1.0000		
Edus	-0.0951	-0.1168	-0.0932	0.2933	-0.3805	1.0000	
Eduh	-0.0287	-0.0188	-0.0184	0.1424	-0.1201	-0.0286	1.0000
Age2024	0.1961	0.1781	0.0084	-0.0150	-0.0073	0.0531	-0.0069
Age2529	0.2100	0.2444	-0.0010	0.0177	0.0312	0.0097	0.0470
Age3034	0.1404	0.1779	0.0013	-0.0068	0.0482	-0.0533	0.0192
Age3539	0.0432	0.0889	-0.0064	0.0057	0.0212	-0.0298	0.0010
Age4044	-0.0991	-0.0587	-0.0014	-0.0235	-0.0627	-0.0090	-0.0067
Age4549	-0.2168	-0.2101	-0.0073	-0.0274	-0.1470	-0.0579	0.0029
Knows	0.0706	0.0846	0.0274	0.0543	0.0267	0.0238	0.0725
Sonp	0.0047	0.0199	0.0170	0.0191	-0.0262	0.0429	-0.0048
Emar	0.3977	0.4983	0.0349	-0.1146	-0.0543	-0.1900	-0.0164
Cmort	0.0925	0.1522	-0.0026	-0.0923	-0.0720	-0.1046	-0.0437
Cuse	-0.0272	-0.0428	-0.0042	0.0599	0.0395	0.0237	0.0199
Improved	-0.0456	-0.0497	-0.1489	0.3585	-0.0084	0.1954	0.0627

	Age2024	Age2529	Age3034	Age3539	Age4044	Age4549	Knows
Age2024	1.0000						
Age2529	-0.2166	1.0000					
Age3034	-0.1953	-0.1859	1.0000				
Age3539	-0.1686	-0.1605	-0.1447	1.0000			
Age4044	-0.1516	-0.1443	-0.1301	-0.1123	1.0000		
Age4549	-0.1383	-0.1316	-0.1187	-0.1025	-0.0921	1.0000	
Knows	0.0099	0.0510	0.0475	0.0109	0.0236	-0.0098	1.0000
Sonp	0.0278	0.0021	0.0068	0.0026	-0.0238	-0.0395	-0.0234
Emar	0.0211	0.1754	0.1866	0.1730	0.1619	0.1388	0.0951
Cmort	-0.1493	-0.0153	0.1149	0.1497	0.1878	0.2161	0.0145
Cuse	0.0642	-0.0088	-0.0228	-0.0484	-0.0420	-0.0399	0.0210
Improved	-0.0074	0.0119	-0.0036	0.0060	0.0069	-0.0138	0.0028

	Sonp	Emar	Cmort	Cuse	Improved
Sonp	1.0000				
Emar	-0.0097	1.0000			
Cmort	-0.0142	0.3120	1.0000		
Cuse	-0.0218	-0.0693	-0.0669	1.0000	
Improved	0.0218	-0.0640	-0.0537	0.0290	1.0000

Empirical Results of the Single Equation Models

The analysis starts by estimating empirical models for each country in which natural resource scarcity (NS) is assumed to be an exogenous variable, paralleling the common practice of the existing literature. The model is a single-equation Probit model of the form:

$$PB_{it} = \beta_0 + \beta_1 NS + \beta_2 WI + \beta_3 Edup + \beta_4 Edus + \beta_5 Eduh + \beta_6 Age2024 + \beta_7 Age2529 + \beta_8 Age3034 + \beta_9 Age3539 + \beta_{10} Age4044 + \beta_{11} Age4549 + \beta_{12} Knows + \beta_{13} Sonp + \beta_{14} Emar + \beta_{15} Cmort + \beta_{16} Cuse + \epsilon_1 \quad (4.1)$$

The model above is based on studies by Loughran and Pritchett (1997) and Aggarwal, Netanyahu, and Romano (2001). The dependent variables used in this study are similar to the above two existing studies. However, the variables used in this study are not exactly the same as the two existing studies. For example, Loughran and Pritchett (1997) used literacy (able to read and write) to account for schooling. This is a crude proxy for schooling. On other hand, Aggarwal, Netanyahu, and Romano (2001) used years of schooling as a proxy for schooling. As mentioned previously, in this study proxy for schooling is broken into levels such as primary, secondary and higher. No schooling was used as a reference category. In a similar vein, for a control variable age, both Loughran and Pritchett (1997) and Aggarwal, Netanyahu, and Romano (2001) used woman years as opposed to using age groups as this study and others do.

Table 4.4 presents Probit results for the single-equation model with the dependent variable of whether or not a woman had at least one birth in the last three years preceding the surveys, reporting coefficients, robust standard errors, and marginal effects. Marginal effect at the mean (see equation 4.2) is appropriate summary measure for models with categorical dependent variables (Long, 1997).

$$\text{Marginal change} = \{\partial \Pr(y = 1 \mid x)\} / \partial x_k \qquad 4.2$$

For example, given the estimation of (Wooldridge 2002):

$$E(y/x, c) \qquad 4.3$$

Where y is a dependent variable

x is a vector of explanatory variables

c is a vector of control variables

If an independent variable *x* is continuous, then the interest on marginal effect is:

$$\partial E(y \mid x, c) / \partial x \qquad 4.4$$

Equation 4.4 is usually called the partial effect of *x* on $E(y/x, c)$. If *x* is discrete, then the interest is in $E(y/x, c)$ evaluated at different values of *x* (for example 0 and 1 when *x* is binary), the elements of *c* fixed at the same specified values (see equation 4.5).

$$\{\Delta \Pr(y = 1 \mid x)\} / \Delta x_k = \Pr(y = 1 \mid x, x_k + \delta) - \Pr(y = 1 \mid x, x_k) \qquad 4.5$$

Equation 4.5 can be interpreted that for a change in variable x_k from x_k to $x_k + \delta$, the predicted probability of an event changes by $\{\Delta \Pr(y = 1 \mid x)\} / \Delta x_k$, holding all other variables constant. In other words, for the dummy variables, the marginal effects are computed by evaluating the variable at the value of 1, then to 0 while holding other variables at their means. Therefore, for dummy independent variable, the marginal effect is the difference in the probability when the dummy variable is equal to 1, then to 0 (Rhine & Greene, 2006).

Reporting marginal effect is an effective way for interpreting binary models such as Probit (Long, 1997). However, the existing studies on the examination of the vicious circle theory have ignored the usefulness of marginal effects concept. The usage of marginal effects is becoming very common with some recent studies reporting only marginal effects (Rhine & Greene, 2006) and others reporting both coefficients and marginal effects (Fisher, 2005). Note that in the tables of results in this study no marginal effects are reported for constant terms because the concept of marginal effects is based on partial derivative. From the rules of calculus, the derivative of a constant is equal to 0.

The results for single-equation model in Table 4.4 provide some support for the vicious circle argument that natural resource scarcity is positively associated with a woman having at least one birth in the last three years preceding surveys. However, the coefficient for natural resource scarcity is statistically significant at the 5% level for Nepal only. The coefficient for natural resource scarcity is not statistically significant for Honduras and Tanzania.

The results in table 4.4 also provide strong support for the vicious circle argument that income (wealth index) is negatively associated with the woman indicating at least

one birth in the last three years preceding the survey. The coefficient for the wealth index is negative and statistically significant at the 1% level for all the three countries. In other words, this is an indication that households with low incomes (living in poverty) tend to have many children as described by the vicious circle theory.

The coefficients for primary education are negative and statistically significant at the 1% level for Honduras and Nepal only. The coefficient for primary education is not statistically significant for Tanzania. The coefficients for secondary education variable are negative and statistically significant at the 1% and 5% levels for Honduras and Tanzania respectively. For Nepal the coefficient for secondary education is not statistically significant. The coefficients for higher education are not statistically significant in any country.

The results in table 4.4 show expected signs for the age groups variables. Women in younger age groups are more likely to have had a birth in the last three years relative to the control group (women aged 15 to 19). The coefficients for age group 20 to 24 and age group 25 to 29 are positive and statistically significant for the three countries, with the exception of age group 25 to 29 in Honduras that is not statistically significant. Women in older age groups 30 to 34, 35 to 39, 40 to 44, and 45 to 49 are less likely to have had a birth in the last three years relative to the youngest age group. The coefficients for these older age groups are negative and statistically significant at the 1% levels for the three countries, with the exception of age group 35 to 39 in Tanzania that is not statistically significant. The other exception is also on Tanzania where the coefficient for the age group 30 to 34 is positive and statistically significant at the 1% level. This is an

Table 4.4

Probit model without IV: Dependent variable - birth in the last 3 years (PB3)[24]

	Honduras		Nepal		Tanzania	
Var	Coeff	Marginal Effect	Coeff	Marginal Effect	Coeff	Marginal Effect
Const	-0.9961		0.2603		-1.2439	
	(0.0614)		(0.0775)		(0.0706)	
NS	0.0019	0.0007	0.0033**	0.0012	0.0002	0.0001
	(0.0010)		(0.0013)		(0.0003)	
WI	-0.1877***	-0.0635	-0.1535***	-0.0540	-0.0674***	-0.0268
	(0.0154)		(0.0164)		(0.0153)	
Edup	-0.1724***	-0.0597	-0.1582***	-0.0540	-0.0619	-0.0246
	(0.0459)		(0.0540)		(0.0403)	
Edus	-0.2628***	-0.0837	0.0192	0.0068	-0.1943**	-0.0762
	(0.0659)		(0.0606)		(0.0847)	
Eduh	-0.0774	-0.0256	0.1911	0.0700	-0.3390	-0.1303
	(0.1827)		(0.1718)		(0.2310)	
Age2024	0.4455***	0.1605	0.7132***	0.2686	0.9072***	0.3436
	(0.0472)		(0.0715)		(0.0636)	
Age2529	0.0764	0.0262	0.1653**	0.0595	0.6813***	0.2643
	(0.0519)		(0.0711)		(0.0686)	
Age3034	-0.2221***	-0.0715	-0.5264***	-0.1651	0.3940***	0.1560
	(0.0552)		(0.0763)		(0.0706)	
Age3539	-0.5012***	-0.1482	-0.8506***	-0.2439	0.0863	0.0344
	(0.0592)		(0.0797)		(0.0745)	
Age4044	-0.9314***	-0.2358	-1.6002***	-0.3556	-0.5309***	-0.2001
	(0.0644)		(0.0972)		(0.0799)	
Age4549	-1.8047***	-0.3202	-2.1417***	-0.3838	-1.3685***	-0.4191
	(0.0899)		(0.1325)		(0.0992)	
Knows	-0.0564	-0.0188	-0.0206	-0.0072	0.1180***	0.0470
	(0.0581)		(0.0503)		(0.0425)	
Sonp	0.0580	0.0198	0.0870**	0.0307	-0.0188	-0.0075
	(0.0361)		(0.0406)		(0.0434)	
Emar	1.5367***	0.3819			1.3649***	0.4542
	(0.0518)				(0.0642)	
Cmort	0.1886***	0.0662	0.3043***	0.1100	0.2268***	0.0902
	(0.0431)		(0.0475)		(0.0427)	
Cuse	0.0218	0.0074	-0.1604	-0.0542	-0.1169	-0.0461
	(0.0506)		(0.0834)		(0.1260)	
Number of obs		10,929		6,007		6,599
Wald chi2(16)		2,358.31		1,423.19		1,856.19
Prob > chi2		0.0000		0.0000		0.0000
Pseudo R2		0.2191		0.2413		0.2507
L.pseudolikeld		-5,462.92		-2992.62		-3,426.57

***, ** represents significance at 1% and 5% respectively

[24] Note the variable Emar is dropped for Nepal because it predicts failure perfectly. STATA software drops the variable because its coefficient would have an infinite coefficient. STATA does this for logistic, Probit, and IVPROBIT. Therefore, the variable is dropped for Nepal in all subsequent analyses that involve single equation Probit and IVPROBIT models in this study.

indication that women in Tanzania continues to bear children even at older age relative to Honduras and Nepal.

The coefficient for knowledge of ovulatory cycle variable is only positive and statistically significant at the 1% level for Tanzania. The coefficients for Honduras and Nepal are not statistically significant. The coefficient for son preferences is only positive and statistically significant for Nepal at the 5% level and no statistical significance is found for Honduras and Tanzania. The coefficients for ever married variable are positive and statistically significant at the 1% level for Honduras and Tanzania. This variable was purged when the model was run for Nepal because the model predicted perfect failure. The coefficients for child mortality are all positive and statistically significant at the 1% levels for the three countries. The coefficients for the contraceptive use before a birth of a first child variable are not and statistically significant in the three countries.

Table 4.5 presents Probit results for the single-equation model of whether or not a woman had at least one birth in the last five years preceding the surveys. The results for whether or not a woman had at least one birth in the last five years model in table 4.5 largely mirror that of whether or not a woman had at least one birth in the last three years model. The coefficient for natural resource scarcity is positive and statistically significant at the 5% level for Nepal only. Similar findings were observed for whether or not at least one birth occurred in the last three years model. As it was for the birth in the last three years model, the coefficients for wealth index are negative and statistically significant at the 1% level for the three countries.

The coefficients for education levels in the birth in the last five years model are similar to the birth in the last three years model.

Table 4.5

Probit without IV: Dependent variable - birth in the last 5 years (PB5)

	Honduras		Nepal		Tanzania	
Var	Coeff	Marginal Effect	Coeff	Marginal Effect	Coeff	Marginal Effect
Const	-1.0217		0.3131		-1.3532	
	(0.0620)		(0.0774)		(0.0746)	
NS	0.0020	0.0008	0.0031**	0.0012	0.0001	0.0001
	(0.0010)		(0.0013)		(0.0003)	
WI	-0.2039***	-0.0801	-0.1621***	-0.0647	-0.0787***	-0.0302
	(0.0153)		(0.0162)		(0.0163)	
Edup	-0.1602***	-0.0633	-0.1582***	-0.0629	0.0259	0.0100
	(0.0466)		(0.0550)		(0.0430)	
Edus	-0.2634***	-0.1011	0.0214	0.0085	-0.1785**	-0.0697
	(0.0661)		(0.0627)		(0.0873)	
Eduh	-0.1851	-0.0712	0.0465	0.0185	-0.1378	-0.0537
	(0.1766)		(0.1768)		(0.2153)	
Age2024	0.8521***	0.3288	1.2027***	0.4265	1.2055***	0.3735
	(0.0471)		(0.0762)		(0.0652)	
Age2529	0.5235***	0.2065	0.7627***	0.2903	1.1375***	0.3550
	(0.0523)		(0.0733)		(0.0728)	
Age3034	0.1211**	0.0479	-0.0065	-0.0026	0.7524***	0.2543
	(0.0547)		(0.0752)		(0.0739)	
Age3539	-0.2592***	-0.0993	-0.5470***	-0.2111	0.4069***	0.1466
	(0.0582)		(0.0778)		(0.0764)	
Age4044	-0.7394***	-0.2590	-1.1044***	-0.3867	-0.2101***	-0.0821
	(0.0618)		(0.0864)		(0.0788)	
Age4549	-1.5183***	-0.4199	-1.6677***	-0.4981	-0.9746***	-0.3711
	(0.0740)		(0.1050)		(0.0897)	
Knows	-0.0162	-0.0064	0.0273	0.0109	0.1196***	0.0454
	(0.0574)		(0.0502)		(0.0458)	
Sonp	0.0896**	0.0354	0.0928**	0.0370	0.0780	0.0297
	(0.0371)		(0.0399)		(0.0464)	
Emar	1.7628***	0.5366			1.5200***	0.5459
	(0.0495)				(0.0640)	
Cmort	0.2938***	0.1165	0.3454***	0.1369	0.3288***	0.1231
	(0.0436)		(0.0457)		(0.0461)	
Cuse	-0.0677	-0.0265	-0.3052***	-0.1199	-0.1750	-0.0684
	(0.0531)		(0.0872)		(0.1336)	
Number of obs		10,929		6,007		6,599
Wald chi2(16)		3,290.71		1,731.80		2,222.52
Prob > chi2		0.0000		0.0000		0.0000
Pseudo R2		0.3007		0.2720		0.3372
L.pseudolikeld		-5,278.45		-3031.37		-2,946.87

***, ** represents significance at 1% and 5% respectively

However, the coefficients for age groups 25 to 29 and 30 to 34 variables are now positive and statistically significant for Honduras. The coefficient for age group 25 to 29 is not statistically significant for the birth the last three years model for Honduras. In addition, the coefficient for age 30 to 34 is statistically significant for the birth in the last three years model but it is negative. The coefficient for age group 30 to 34 variable for Nepal is not statistically significant. This coefficient is negative and statistically significant for the birth in the last three years model. The coefficient for age group 35 to 39 for Tanzania is positive and statistically significant at the 1% level. This coefficient is not statistically significant for the birth in the last three years model. In addition, the coefficient for son preferences variable that is not statistically significant for Honduras for the birth in the last three years model, is positive and statistically significant at the 5% level for the birth in the last five years model.

Testing for Endogeneity of Natural Resource Scarcity

The three methods of testing for endogeneity of the natural resource scarcity described in Chapter Three are applied here. The first method is the Wald test that is obtained by running IVPROBIT. The Wald tests results are given at the bottom of Tables 4.24 and 4.25. Table 4.24 shows that the p-values are 0.0013, 0.0404, and 0.7312 for Honduras, Nepal, and Tanzania respectively. Table 4.25 shows that the p-values are 0.0855, 0.0769, and 0.7475 for Honduras, Nepal, and Tanzania respectively. In both tables the p-values for Honduras and Nepal are below 0.1 suggesting that the Wald test of exogeneity rejects the null hypothesis (hypothesis 1 on page 52) that natural resource

scarcity is exogenous. However, as the results show, the null hypothesis is not rejected for Tanzania suggesting that natural resource scarcity is exogenous.

The second method which follows the standard practice suggested by Bollen, Guilkey, and Mroz (1995) is used to determine whether the predicted values from the reduced form equation when inserted in the structural equation produces a statistically significant coefficient. For the discussion of this approach see the second paragraph on page 80. The results of this test are shown in Tables 4.6 through 4.14. The results for the first steps which are regressions of the reduced form equations are shown in Tables 4.6, 4.9, and 4.12 for Honduras, Nepal, and Tanzania. The results for second steps that use the predicted value (Res) from the first steps are shown in Tables 4.7 and 4.8, 4.10 and 4.11, and 4.13 and 4.14 for Honduras, Nepal, and Tanzania respectively.[25] The coefficients for the predicted (Res) values for Honduras in both models (PB3 and PB5) are not statistically significant different from 0 (see p-values on Tables 4.7 and 4.8 for the variable Res). The results suggest that natural resource scarcity variable is exogenous. However, the results for Nepal and Tanzania show that the coefficients of the predicted values are statistically significant from 0. The results imply that the variable natural resource scarcity is indeed endogenous. For Nepal, the predicted value is statistically significant at 1% levels for both PB3 and PB5 models (see Tables 4.10 and 4.11). For Tanzania, the predicted value is statistically significant at 5% and 10% levels for PB3 and PB5 models respectively (see Table 4.13 and 4.14).

[25] Note that the results for the second steps are shown in two tables for each country because each country has two models; a birth in the last three years (PB3) preceding the surveys and a birth in the last five years (PB5) preceding the surveys.

Table 4.6

Results for first step test of exogeneity for Honduras

Dependent variable: Natural resource scarcity (NS)

NS	Coef.	Std. Err.	t	P>|t|
WI	-1.2250	0.1279	-9.58	0.000
Edup	-1.0049	0.4085	-2.46	0.014
Edus	-1.1528	0.5585	-2.06	0.039
Eduh	-1.4607	1.4585	-1.00	0.317
Age2024	-0.0519	0.4034	-0.13	0.898
Age2529	-0.3162	0.4482	-0.71	0.481
Age3034	0.3887	0.4777	0.81	0.416
Age3539	0.2918	0.5093	0.57	0.567
Age4044	0.6412	0.5372	1.19	0.233
Age4549	-1.1299	0.5780	-1.95	0.051
Knows	-0.0188	0.4977	-0.04	0.970
Sonp	0.0607	0.3168	0.19	0.848
Emar	-0.0485	0.3609	-0.13	0.893
Cmort	0.0907	0.3823	0.24	0.812
Cuse	-0.2634	0.4349	-0.61	0.545
Cons	7.4266	0.5121	14.50	0.000

Table 4.7

Results for second step of exogeneity: for the model for Honduras

Dependent variable - birth in the last 3 years (PB3)

PB3	Coef.	Std. Err.	z	P>|z|
Res	0.0530	0.1216	0.44	0.663
NS	0.0019	0.0011	1.82	0.068
WI	-0.1228	0.1526	-0.80	0.421
Edup	-0.1192	0.1192	-1.00	0.318
Edus	-0.2017	0.1395	-1.45	0.148
Age2024	0.4482	0.0477	9.40	0.000
Age2529	0.0931	0.0646	1.44	0.149
Age3034	-0.2427	0.0704	-3.45	0.001
Age3539	-0.5167	0.0662	-7.81	0.000
Age4044	-0.9654	0.1005	-9.61	0.000
Age4549	-1.7448	0.1633	-10.69	0.000
Knows	-0.0554	0.0577	-0.96	0.337
Sonp	0.0548	0.0366	1.50	0.135
Emar	1.5392	0.0461	33.36	0.000
Cmort	0.1838	0.0444	4.14	0.000
Cuse	0.0357	0.0581	0.62	0.538
Cons	-1.3895	0.8985	-1.55	0.122

Table 4.8

Results for second step of exogeneity for the model for Honduras

Dependent variable - birth in the last 5 years (PB5)

PB5	Coef.	Std. Err.	z	P>|z|
Res	0.1267	0.1156	1.10	0.273
NS	0.0020	0.0011	1.78	0.076
WI	-0.0487	0.1453	-0.33	0.738
Edup	-0.0329	0.1130	-0.29	0.771
Edus	-0.1174	0.1322	-0.89	0.375
Age2024	0.8586	0.0492	17.47	0.000
Age2529	0.5635	0.0642	8.78	0.000
Age3034	0.0718	0.0691	1.04	0.299
Age3539	-0.2962	0.0647	-4.58	0.000
Age4044	-0.8206	0.0959	-8.56	0.000
Age4549	-1.3751	0.1495	-9.20	0.000
Knows	-0.0138	0.0577	-0.24	0.811
Sonp	0.0819	0.0371	2.21	0.027
Emar	1.7690	0.0443	39.94	0.000
Cmort	0.2823	0.0446	6.34	0.000
Cuse	-0.0344	0.0581	-0.59	0.554
Cons	-1.9626	0.8531	-2.30	0.021

Table 4.9

Results for first step test of exogeneity for Nepal

Dependent variable: Natural resource scarcity (NS)

NS	Coef.	Std. Err.	t	P>|t|
WI	-3.6280	0.1352	-26.83	0.000
Edup	0.9718	0.4904	1.98	0.048
Edus	0.9831	0.5360	1.83	0.067
Eduh	1.8473	1.2464	1.48	0.138
Age2024	0.2069	0.6205	0.33	0.739
Age2529	-0.0197	0.6764	-0.03	0.977
Age3034	0.2751	0.7325	0.38	0.707
Age3539	0.8043	0.7523	1.07	0.285
Age4044	0.6073	0.7889	0.77	0.441
Age4549	0.8226	0.8404	0.98	0.328
Knows	0.2978	0.4412	0.68	0.500
Sonp	-1.5823	0.3726	-4.25	0.000
Emar	0.2901	0.6181	0.47	0.639
Cmort	0.4718	0.4412	1.07	0.285
Cuse	-2.0402	0.8678	-2.35	0.019
Cons	18.4805	0.6031	30.64	0.000

Table 4.10

Results for second step of exogeneity for the model for Nepal

Dependent variable - birth in the last 3 years (PB3)

PB3	Coef.	Std. Err.	z	P>|z|
Res	0.0423	0.0045	9.38	0.000
NS	0.0033	0.0013	2.47	0.014
Edup	-0.1993	0.0536	-3.72	0.000
Edus	-0.0224	0.0600	-0.37	0.709
Eduh	0.1129	0.1719	0.66	0.511
Age2024	0.7045	0.0698	10.09	0.000
Age2529	0.1661	0.0699	2.38	0.017
Age3034	-0.5380	0.0755	-7.12	0.000
Age3539	-0.8845	0.0794	-11.14	0.000
Age4044	-1.6259	0.0957	-16.98	0.000
Age4549	-2.1765	0.1303	-16.70	0.000
Knows	-0.0332	0.0504	-0.66	0.511
Sonp	0.1539	0.0407	3.78	0.000
Cmort	0.2844	0.0475	5.98	0.000
Cuse	-0.0741	0.0822	-0.90	0.367
Cons	-0.5337	0.0809	-6.59	0.000

Table 4.11

Results for second step of exogeneity for the model for Nepal

Dependent variable - birth in the last 5 years (PB5)

PB5	Coef.	Std. Err.	z	P>|z|
Res	0.0447	0.0044	10.07	0.000
NS	0.0031	0.0013	2.31	0.021
Edup	-0.2016	0.0542	-3.72	0.000
Edus	-0.0226	0.0616	-0.37	0.714
Eduh	-0.0361	0.1746	-0.21	0.836
Age2024	1.1934	0.0743	16.07	0.000
Age2529	0.7635	0.0720	10.61	0.000
Age3034	-0.0187	0.0740	-0.25	0.800
Age3539	-0.5829	0.0771	-7.56	0.000
Age4044	-1.1316	0.0853	-13.26	0.000
Age4549	-1.7045	0.1026	-16.61	0.000
Knows	0.0140	0.0498	0.28	0.778
Sonp	0.1635	0.0401	4.08	0.000
Cmort	0.3243	0.0465	6.98	0.000
Cuse	-0.2140	0.0848	-2.52	0.012
Cons	-0.5255	0.0809	-6.49	0.000

Table 4.12

Results for first step test of exogeneity for Tanzania

Dependent variable: Natural resource scarcity (NS)

NS	Coef.	Std. Err.	t	P>|t|
WI	-6.8525	0.6112	-11.21	0.000
Edup	-2.6322	1.6335	-1.61	0.107
Edus	-17.840	3.4124	-5.23	0.000
Eduh	-4.4875	9.9090	-0.45	0.651
Age2024	-3.6085	2.6050	-1.39	0.166
Age2529	-4.2328	2.8423	-1.49	0.136
Age3034	-5.1322	2.9880	-1.72	0.086
Age3539	-5.2884	3.2069	-1.65	0.099
Age4044	-5.3075	3.3647	-1.58	0.115
Age4549	-6.6764	3.5307	-1.89	0.059
Knows	5.4923	1.7218	3.19	0.001
Sonp	2.6452	1.7401	1.52	0.129
Emar	4.8047	2.4732	1.94	0.052
Cmort	-1.8005	1.7223	-1.05	0.296
Cuse	2.7828	4.6477	0.60	0.549
Cons	60.7627	2.5500	23.83	0.000

Table 4.13

Results for second step of exogeneity for the model for Tanzania

Dependent variable - birth in the last 3 years (PB3)

PB3	Coef.	Std. Err.	z	P>|z|
Res	0.0109	0.0049	2.21	0.027
NS	0.0002	0.0003	0.77	0.439
WI	0.0073	0.0403	0.18	0.857
Edup	-0.0333	0.0374	-0.89	0.374
Edus	-0.2902	0.2421	-1.20	0.231
Age2024	0.9465	0.0676	14.01	0.000
Age2529	0.7274	0.0726	10.02	0.000
Age3034	0.4500	0.0759	5.93	0.000
Age3539	0.1439	0.0803	1.79	0.073
Age4044	-0.4731	0.0845	-5.60	0.000
Age4549	-1.2958	0.1012	-12.80	0.000
Knows	0.0582	0.0492	1.18	0.237
Sonp	-0.0476	0.0448	-1.06	0.287
Emar	1.3126	0.0696	18.86	0.000
Cmort	0.2465	0.0422	5.84	0.000
Cuse	-0.1472	0.1132	-1.30	0.193
Cons	-1.9059	0.2991	-6.37	0.000

Table 4.14

Results for second step of exogeneity for the model for Tanzania

Dependent variable - birth in the last 5 years (PB5)

PB5	Coef.	Std. Err.	z	P>|z|
Res	0.0100	0.0051	1.95	0.052
NS	0.0001	0.0003	0.35	0.726
WI	-0.0102	0.0422	-0.24	0.810
Edup	0.0523	0.0397	1.32	0.188
Eduh	-0.0929	0.2427	-0.38	0.702
Age2024	1.2416	0.0709	17.51	0.000
Age2529	1.1798	0.0779	15.14	0.000
Age3034	0.8037	0.0791	10.16	0.000
Age3539	0.4599	0.0827	5.56	0.000
Age4044	-0.1570	0.0845	-1.86	0.063
Age4549	-0.9078	0.0931	-9.75	0.000
Knows	0.0646	0.0524	1.23	0.217
Sonp	0.0515	0.0483	1.07	0.286
Emar	1.4720	0.0701	20.99	0.000
Cmort	0.3468	0.0460	7.54	0.000
Cuse	-0.2028	0.1174	-1.73	0.084
Cons	-1.9613	0.3118	-6.29	0.000

The third method is that of comparing the coefficients for the natural resource scarcity variable of the Probit and IVPROBIT models.[26] The results in Tables 4.4, 4.5, 4.24, and 4.25 provide some indication that natural resource scarcity is endogenous for both Honduras and Nepal. The coefficients of natural resource scarcity are not statistically significant when endogeneity problem is ignored for Honduras. However, when the problem is addressed, the coefficients become positive and statistically significant. In addition, the results show a large difference in the magnitude of the NS coefficient between Probit and IVPROBIT for Honduras and Nepal. These results imply that natural resource scarcity is endogenous for Honduras. Probit and IVPROBIT for PB3 models for Nepal show that the variable NS was statistically significant in the Probit model but the significance level increased in the IVPROBIT model. However, for PB5 model, the significance level did not change. In addition, for both PB3 and PB5 models, there is a large difference in the magnitude of the NS coefficient between Probit and IVPROBIT for Nepal. This is also an indication that natural resource scarcity is endogenous for Nepal. For Tanzania, the variable NS was not statistically significant in both Probit and IVPROBIT for both PB3 and PB5 models. In addition, there is no large difference in magnitude of the NS coefficient. This implies that natural resource scarcity is exogenous for Tanzania.

The results of the three methods of endogeneity of the natural resource scarcity largely indicate that the variable is endogenous. This particular finding warrants the need to find an IV that can be used to address the problem. The following section attempts to address the problem by examining the relevance of the chosen IV.

[26] A detail of the IVPROBIT results is provided later under "Empirical Results of the IVPROBIT Equation Model" section. Here Tables 4.24 and 4.25 are used for the sake of determining the endogeneity of the natural resource scarcity.

Addressing Endogeneity of Natural Resource Scarcity and IV Relevance

As proposed in Chapter Three, this study uses improved source of drinking water (*Improved*) as an identifying IV. The three methods of judging the relevance of identifying IV described in Chapter Three are applied here. The first method follows the standard practice of assessing the IV's strength from its performance in first stage regressions (Bound, Jaeger, & Baker, 1995). It is suggested that if an F statistic from the first stage regression (reduced form equation 3.2) is not less than 10, then the IV is judged as relevant (Staiger & Stock, 1997). The results of the first stage regressions are presented in Tables 4.15, 4.16, and 4.17 for Honduras, Nepal, and Tanzania respectively. As the Tables show, F statistics are 93.3, 90.12, and 18.5 for Honduras, Nepal, and Tanzania respectively. By using this method, the proposed IV is judged relevant.

The second method of assessing the strength of IV examines the results from the first stage regressions to determine whether the IV is correlated with the endogenous explanatory variable. The results for this method are also shown in Tables 4.15, 4.16, and 4.17 for Honduras, Nepal, and Tanzania respectively. The coefficients of IV (Improved) in the three countries are negative and statistically significant at the 1% level (see the p-values on the coefficient Improved). The results suggest that the IV is negatively related to the natural resource scarcity (NS). Intuitively, it makes sense that household with improved source of drinking water are less likely to experience water scarcity than otherwise. This method confirms that the suggested IV is relevant and reasonable to identify the endogenous explanatory variable.

Table 4.15

Results for First-stage results for Natural Resource Scarcity for Honduras

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-9.9846	0.2767	-36.08	0.000
WI	-0.1700	0.1224	-1.39	0.165
Edup	-0.5704	0.3797	-1.50	0.133
Edus	-0.5107	0.5176	-0.99	0.324
Eduh	-1.0629	1.3426	-0.79	0.429
Age2024	0.0733	0.3740	0.20	0.845
Age2529	-0.2017	0.4161	-0.48	0.628
Age3034	0.3527	0.4429	0.80	0.426
Age3539	0.2850	0.4709	0.61	0.545
Age4044	0.6862	0.4982	1.38	0.168
Age4549	-0.8583	0.5352	-1.60	0.109
Knows	0.0813	0.4594	0.18	0.859
Sonp	0.0545	0.2941	0.19	0.853
Emar	-0.1400	0.3336	-0.42	0.675
Cmort	0.1493	0.3552	0.42	0.674
Cuse	-0.2907	0.4046	-0.72	0.472
Cons	12.1955	0.4950	24.64	0.000

F test for instrument = 93.30

Table 4.16

Results for First-stage results for Natural Resource Scarcity for Nepal

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-10.4467	0.4358	-23.97	0.000
WI	-2.4492	0.1507	-16.26	0.000
Edup	0.9399	0.5138	1.83	0.067
Edus	0.5275	0.5923	0.89	0.373
Eduh	0.0926	1.6859	0.05	0.956
Age2024	-0.8698	0.7217	-1.21	0.228
Age2529	-0.6225	0.7327	-0.85	0.396
Age3034	-0.5327	0.7712	-0.69	0.490
Age3539	0.1808	0.7876	0.23	0.818
Age4044	0.1969	0.8229	0.24	0.811
Age4549	0.1695	0.8664	0.20	0.845
Knows	0.5138	0.4652	1.10	0.269
Sonp	-1.4177	0.3682	-3.85	0.000
Cmort	0.5490	0.4165	1.32	0.187
Cuse	-2.0366	0.8316	-2.45	0.014
Cons	24.3085	0.7581	32.07	0.000

F test for instrument = 90.12

Table 4.17

Results for First-stage results for Natural Resource Scarcity for Tanzania

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-12.3380	1.4850	-8.31	0.000
WI	-5.6159	0.6263	-8.97	0.000
Edup	-2.3001	1.6266	-1.41	0.157
Edus	-15.6211	3.4068	-4.59	0.000
Eduh	-4.4763	9.8608	-0.45	0.650
Age2024	-3.0613	2.5935	-1.18	0.238
Age2529	-3.4310	2.8308	-1.21	0.226
Age3034	-4.2330	2.9755	-1.42	0.155
Age3539	-4.5031	3.1927	-1.41	0.158
Age4044	-4.2694	3.3508	-1.27	0.203
Age4549	-5.6941	3.5156	-1.62	0.105
Knows	5.2253	1.7139	3.05	0.002
Sonp	2.7931	1.7323	1.61	0.107
Emar	4.2324	2.4623	1.72	0.086
Cmort	-2.0903	1.7146	-1.22	0.223
Cuse	3.3416	4.6256	0.72	0.470
Cons	62.1455	2.5439	24.43	0.000

F test for instrument = 18.54

The third method is the two-step procedures suggested by Davis and Kim (2002). As discussed in Chapter 3, this method follows two steps. The first step is the first stage regressions of which the results are shown in Tables 4.18, 4.20, and 4.22 for Honduras, Nepal, and Tanzania respectively. The results of the second step which regress the predicted values (NS predict) from the first stage regression on all the explanatory variables including the endogenous variable (NS) are shown in Tables 4.19, 4.21, and 4.23 for Honduras, Nepal, and Tanzania respectively.

Assessing the IV relevance using the two steps method suggested by Davis and Kim (2002) requires the use of eigenvalues as discussed in Chapter 3. In the three

countries, the eigenvalues are greater than the LR. For Honduras, the eigenvalue for the likelihood ratio test is 0.1094, the parameter estimate on NS. At the 5% level, the critical value for the test statistic is 26.296, so given 0.1094>0.002 [the value 0.002 is obtained from the likelihood ratio test equation: 1 – exp(-26.296/10,615)], the null hypothesis of no IV relevance is rejected for Honduras. For Nepal, the eigenvalue for the likelihood ratio test is 0.0803, the parameter estimate on NS. At the 5% level, the critical value for the test statistic is 24.996, so given 0.0803>0.003 [the value 0.003 is obtained from the likelihood ratio test equation: 1 – exp(-24.996/7,418)], the null hypothesis of no IV relevance is rejected for Nepal. For Tanzania, the eigenvalue for the likelihood ratio test is 0.0104, the parameter estimate on NS. At the 5% level, the critical value for the test statistic is 26.296, so given 0.0104>0.004 [the value 0.004 is obtained from the likelihood ratio test equation: 1 – exp(-26.296/6,595)], the null hypothesis of no IV relevance is rejected for Tanzania.

The results of the three methods unanimously confirm that the IV is relevant. The analyses of tests of endogeneity and assessment of the IV relevance given in the preceding subsections warrant the use of IVPROBIT.

Table 4.18

Results for Honduras: First step (Davis & Kim, 2002)

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-9.9846	0.2767	-36.08	0.000
WI	-0.1700	0.1224	-1.39	0.165
Edup	-0.5704	0.3797	-1.50	0.133
Edus	-0.5107	0.5176	-0.99	0.324
Eduh	-1.0629	1.3426	-0.79	0.429
Age2024	0.0733	0.3740	0.20	0.845
Age2529	-0.2017	0.4161	-0.48	0.628
Age3034	0.3527	0.4429	0.80	0.426
Age3539	0.2850	0.4709	0.61	0.545
Age4044	0.6862	0.4982	1.38	0.168
Age4549	-0.8583	0.5352	-1.60	0.109
Knows	0.0813	0.4594	0.18	0.859
Sonp	0.0545	0.2941	0.19	0.853
Emar	-0.1400	0.3336	-0.42	0.675
Cmort	0.1493	0.3552	0.42	0.674
Cuse	-0.2907	0.4046	-0.72	0.472
Cons	12.1955	0.4950	24.64	0.000

Table 4.19

Results for Honduras: Second step (Davis & Kim, 2002)

Dependent variable: Predicted values of natural resource scarcity

NS(predict)	Coef.	Std. Err.	t	P>|t|
NS	0.1094	0.0030	36.08	0.000
WI	-1.1636	0.0393	-29.59	0.000
Edup	-0.7170	0.1256	-5.71	0.000
Edus	-0.8115	0.1712	-4.74	0.000
Eduh	-0.8184	0.4440	-1.84	0.065
Age2024	0.0322	0.1237	0.26	0.795
Age2529	-0.1478	0.1376	-1.07	0.283
Age3034	0.3729	0.1465	2.55	0.011
Age3539	0.5013	0.1557	3.22	0.001
Age4044	0.5782	0.1648	3.51	0.000
Age4549	-0.7448	0.1770	-4.21	0.000
Knows	0.0551	0.1519	0.36	0.717
Sonp	0.0796	0.0973	0.82	0.413
Emar	-0.2391	0.1103	-2.17	0.030
Cmort	0.0739	0.1175	0.63	0.529
Cuse	-0.3614	0.1338	-2.70	0.007
Cons	6.3972	0.1586	40.33	0.000

Table 4.20

Results for Nepal: First step (Davis & Kim, 2002)

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-10.1906	0.4007	-25.43	0.000
WI	-2.4750	0.1376	-17.99	0.000
Edup	0.7090	0.4703	1.51	0.132
Edus	0.6509	0.5139	1.27	0.205
Eduh	0.4860	1.1954	0.41	0.684
Age2024	-0.4228	0.5953	-0.71	0.478
Age2529	-0.2829	0.6483	-0.44	0.663
Age3034	-0.1576	0.7022	-0.22	0.822
Age3539	0.4966	0.7209	0.69	0.491
Age4044	0.4471	0.7560	0.59	0.554
Age4549	0.4931	0.8054	0.61	0.540
Knows	0.2933	0.4227	0.69	0.488
Sonp	-1.4138	0.3570	-3.96	0.000
Emar	0.2796	0.5926	0.47	0.637
Cmort	0.5377	0.4227	1.27	0.203
Cuse	-1.8346	0.8312	-2.21	0.027
Cons	23.6257	0.6129	38.54	0.000

Table 4.21

Results for Nepal: Second step (Davis & Kim, 2002)

Dependent variable: Predicted values of natural resource scarcity

NS(predict)	Coef.	Std. Err.	t	P>|t|
NS	0.0804	0.0032	25.43	0.000
WI	-3.3550	0.0385	-87.10	0.000
Edup	0.9004	0.1333	6.75	0.000
Edus	0.9712	0.1457	6.67	0.000
Eduh	1.7894	0.3386	5.28	0.000
Age2024	0.1729	0.1686	1.03	0.305
Age2529	-0.0363	0.1838	-0.20	0.843
Age3034	0.2567	0.1990	1.29	0.197
Age3539	0.7449	0.2044	3.64	0.000
Age4044	0.5615	0.2144	2.62	0.009
Age4549	0.7337	0.2283	3.21	0.001
Knows	0.2916	0.1198	2.43	0.015
Sonp	-1.4320	0.1013	-14.13	0.000
Emar	0.3388	0.1680	2.02	0.044
Cmort	0.4273	0.1198	3.57	0.000
Cuse	-1.8808	0.2358	-7.98	0.000
Cons	16.9496	0.1739	97.47	0.000

Table 4.22

Results for Tanzania: First step (Davis & Kim, 2002)

Dependent variable: Natural resource scarcity

NS	Coef.	Std. Err.	t	P>|t|
Improved	-12.338	1.4850	-8.31	0.000
WI	-5.6159	0.6263	-8.97	0.000
Edup	-2.3001	1.6266	-1.41	0.157
Edus	-15.6211	3.4068	-4.59	0.000
Eduh	-4.4763	9.8608	-0.45	0.650
Age2024	-3.0613	2.5935	-1.18	0.238
Age2529	-3.4310	2.8308	-1.21	0.226
Age3034	-4.2330	2.9755	-1.42	0.155
Age3539	-4.5031	3.1927	-1.41	0.158
Age4044	-4.2694	3.3508	-1.27	0.203
Age4549	-5.6941	3.5156	-1.62	0.105
Knows	5.2253	1.7139	3.05	0.002
Sonp	2.7931	1.7323	1.61	0.107
Emar	4.2324	2.4623	1.72	0.086
Cmort	-2.0903	1.7146	-1.22	0.223
Cuse	3.3416	4.6256	0.72	0.470
Cons	62.1455	2.5439	24.43	0.000

Table 4.23

Results for Tanzania: Second step (Davis & Kim, 2002)

Dependent variable: Predicted values of natural resource scarcity

NS(predict)	Coef.	Std. Err.	t	P>|t|
NS	0.0104	0.0013	8.31	0.000
WI	-6.7715	0.0626	-108.15	0.000
Edup	-2.6026	0.1657	-15.70	0.000
Edus	-17.6760	0.3468	-50.97	0.000
Eduh	-4.4647	1.0049	-4.44	0.000
Age2024	-3.5270	0.2643	-13.35	0.000
Age2529	-4.1805	0.2884	-14.50	0.000
Age3034	-5.0949	0.3031	-16.81	0.000
Age3539	-5.2512	0.3253	-16.14	0.000
Age4044	-5.2690	0.3413	-15.44	0.000
Age4549	-6.6250	0.3582	-18.50	0.000
Knows	5.4139	0.1748	30.98	0.000
Sonp	2.6022	0.1766	14.74	0.000
Emar	4.7789	0.2509	19.05	0.000
Cmort	-1.7787	0.1747	-10.18	0.000
Cuse	2.7289	0.4713	5.79	0.000
Cons	60.1057	0.2696	222.96	0.000

Empirical Results of the IVPROBIT Equation Models

The findings of the single equation models appear to differ with those of IVPROBIT in terms of statistical significance for the coefficients of natural resource scarcity. In addition, when examining the level of statistical significance and magnitude of the parameter estimates for the NS variable corrected for endogeneity, findings are quite striking. Table 4.24 presents Probit results for the IVPROBIT model of the birth in the last three years preceding the surveys, reporting coefficients, robust standard errors, and marginal effects. For Honduras, whereas the coefficient of the variable NS is not statistically significant in the single equation model, in the IVPROBIT model the coefficient is positive and statistically significant at the 1% level. For Nepal, whereas the

coefficient of NS variable in the single equation model is positive and statistically significant at the 5% level, in the IVPROBIT model, the level of statistical significance increased to 1% level while maintaining its positive sign. For Tanzania, the coefficient of the NS variable is still not statistically significant even after controlling for endogeneity.

Focusing on the WI variable and other explanatory variables, it is observed that coefficients estimates are very similar for single equation and IVPROBIT models for the three countries. In all the countries, the sign on each of these variables is the same across the two models, and differences in magnitude are quite small. Moreover, in all the countries, the set of statistically significant variables is essentially the same for the single equation model and the IVPROBIT model.

Table 4.24

Probit with IV: Dependent variable - birth in the last 3 years (PB3)

	Honduras		Nepal		Tanzania	
Var	Coeff	Marginal Effect	Coeff	Marginal Effect	Coeff	Marginal Effect
Const	-1.0491		0.0845		-1.1781	
	(0.0646)		(0.1144)		(0.2064)	
NS	0.0125***	0.0042	0.0121***	0.0043	-0.0008	-0.0003
	(0.0033)		(0.0044)		(0.0030)	
WI	-0.1717***	-0.0580	-0.1189***	-0.0419	-0.0748***	-0.0297
	(0.0164)		(0.0236)		(0.0250)	
Edup	-0.1804***	-0.0624	-0.1653***	-0.0565	-0.0644	-0.0256
	(0.0466)		(0.0539)		(0.0408)	
Edus	-0.2628***	-0.0835	0.0087	0.0031	-0.2112**	-0.0827
	(0.0666)		(0.0605)		(0.0991)	
Eduh	-0.0746	-0.0246	0.1669	0.0610	-0.3411	-0.1310
	(0.1821)		(0.1709)		(0.2298)	
Age2024	0.4294***	0.1542	0.7127***	0.2687	0.9007***	0.3415
	(0.0479)		(0.0717)		(0.0666)	
Age2529	0.0816	0.0280	0.1710**	0.0618	0.6746***	0.2619
	(0.0525)		(0.0710)		(0.0715)	
Age3034	-0.2217***	-0.0711	-0.5181***	-0.1634	0.3884***	0.1538
	(0.0558)		(0.0764)		(0.0733)	
Age3539	-0.4817***	-0.1429	-0.8450***	-0.2437	0.0811	0.0323
	(0.0597)		(0.0796)		(0.0764)	
Age4044	-0.9237***	-0.2335	-1.5888***	-0.3560	-0.5352***	-0.2015
	(0.0654)		(0.0980)		(0.0807)	
Age4549	-1.7771***	-0.3173	-2.1234***	-0.3845	-1.3727***	-0.4196
	(0.0913)		(0.1325)		(0.0994)	
Knows	-0.0547	-0.0182	-0.0254	-0.0089	0.1242***	0.0494
	(0.0582)		(0.0501)		(0.0453)	
Sonp	0.0666	0.0228	0.1000**	0.0355	-0.0162	-0.0065
	(0.0366)		(0.0409)		(0.0441)	
Emar	1.5193***	0.3791			1.3667***	0.4545
	(0.0524)				(0.0643)	
Cmort	0.1827***	0.0639	0.2966***	0.1074	0.2246***	0.0893
	(0.0438)		(0.0476)		(0.0433)	
Cuse	0.0313	0.0106	-0.1384	-0.0472	-0.1131	-0.0446
	(0.0513)		(0.0840)		(0.1261)	
Number of obs		10,615		6,003		6,595
Wald chi2(16)		2,334.45		1,455.70		1,861.85
Prob > chi2		0.0000		0.0000		0.0000
L.pseudolikeld		-46,258.6		-27,048.408		-39,401.202
Wald test of exogeneity:						
chi2(1)		10.35		4.20		0.12
Prob > chi2		0.0013		0.0404		0.7312

***, ** represents significance at 1% and 5% respectively

Table 4.25 presents Probit results for the IVPROBIT model of a birth in the last five years preceding the surveys, reporting coefficients, robust standard errors, and marginal effects. For Honduras, whereas the coefficient of the variable NS is not statistically significant in the single equation model, in the IVPROBIT model the coefficient is positive and statistically significant at the 5% level. For Nepal, in the IVPROBIT model, the coefficient of NS variable is positive and statistically significant at the 5% level. The level of statistical significance is similar to what was observed in the single equation model but the magnitude of the coefficient increased in the IVPROBIT model. For Tanzania, the coefficient of the NS variable is still not statistically significant even after controlling for endogeneity. As it was for the birth in the last three years model preceding the survey, the magnitude of the NS coefficients increased for both Honduras and Nepal after controlling for endogeneity. A possible explanation for lack of statistical significance of the natural resource scarcity coefficient for Tanzania may be due to the fact that time to get to the source of drinking water is not a good proxy. This particular finding warrants further analysis that may involve using different measures of natural resource scarcity.

Focusing on the WI variable and other explanatory variables, it is observed that coefficients estimates are very similar for single equation and IVPROBIT models for the three countries. In all the countries, the sign on each of these variables is the same across the two models. Moreover, in all the countries, the set of statistically significant variables is essentially the same for the single equation model and the IVPROBIT model.

Comparatively, after addressing endogeneity of natural resource scarcity, the birth in the last three years model does better than the birth in the last five years model. Tables

4.24 and 4.25 show that using whether or not a woman had at least one birth in the last three years as the dependent variable, the level of statistical significance of the NS coefficient is at the 1% for both Honduras and Nepal where the coefficient is found to be statistically significant. This particular finding underscores the importance of using a more recent measure of fertility that precede the event, in this case the natural resource scarcity. This is contrary to what some of the existing studies that have used cumulative measure of fertility such as total number of children ever born.

Table 4.25

Probit with IV: Dependent variable - birth in the last 5 years (PB5)

	Honduras		Nepal		Tanzania	
Var	Coeff	Marginal Effect	Coeff	Marginal Effect	Coeff	Marginal Effect
Const	-1.0510		0.1592		-1.2878	
	(0.0664)		(0.1144)		(0.2199)	
NS	0.0079**	0.0031	0.0109**	0.0043	-0.0009	-0.0003
	(0.0035)		(0.0044)		(0.0032)	
WI	-0.1978***	-0.0776	-0.1320***	-0.0527	-0.0859***	-0.0330
	(0.0162)		(0.0233)		(0.0264)	
Edup	-0.1635***	-0.0644	-0.1643***	-0.0653	0.0232	0.0089
	(0.0475)		(0.0550)		(0.0437)	
Edus	-0.2571***	-0.0984	0.0122	0.0049	-0.1958	-0.0766
	(0.0669)		(0.0627)		(0.1030)	
Eduh	-0.1660	-0.0638	0.0267	0.0106	-0.1412	-0.0551
	(0.1774)		(0.1762)		(0.2152)	
Age2024	0.8417***	0.3253	1.2000***	0.4255	1.1988***	0.3723
	(0.0478)		(0.0765)		(0.0694)	
Age2529	0.5218***	0.2058	0.7656***	0.2912	1.1304***	0.3537
	(0.0531)		(0.0733)		(0.0770)	
Age3034	0.1216**	0.0480	-0.0020	-0.0008	0.7461***	0.2527
	(0.0555)		(0.0752)		(0.0779)	
Age3539	-0.2399***	-0.0918	-0.5447***	-0.2104	0.4012***	0.1448
	(0.0590)		(0.0776)		(0.0793)	
Age4044	-0.7424***	-0.2585	-1.0980***	-0.3852	-0.2149***	-0.0840
	(0.0629)		(0.0866)		(0.0801)	
Age4549	-1.5039***	-0.4146	-1.6569***	-0.4968	-0.9795***	-0.3727
	(0.0753)		(0.1048)		(0.0904)	
Knows	-0.0237	-0.0093	0.0237	0.0094	0.1253**	0.0475
	(0.0577)		(0.0502)		(0.0488)	
Sonp	0.0867**	0.0341	0.1037**	0.0413	0.0806	0.0307
	(0.0377)		(0.0404)		(0.0468)	
Emar	1.7557***	0.5335			1.5218***	0.5463
	(0.0501)				(0.0640)	
Cmort	0.2866***	0.1136	0.3393***	0.1345	0.3264***	0.1223
	(0.0443)		(0.0457)		(0.0471)	
Cuse	-0.0599	-0.0234	-0.2851***	-0.1122	-0.1715	-0.0670
	(0.0540)		(0.0881)		(0.1339)	
Number of obs		10,615		6,003		6,595
Wald chi2(16)		3,204.06		1,760.19		2,226.64
Prob > chi2		0.0000		0.0000		0.0000
L.pseudolikeld		-46,093.7		-27,086.9		-38,922.2
Wald test of exogeneity:						
chi2(1)		2.96		3.13		0.10
Prob > chi2		0.0855		0.0769		0.7475

***, ** represents significance at 1% and 5% respectively

CHAPTER 5

SUMMARY AND DISCUSSION

This dissertation used DHS data for Honduras, Nepal, and Tanzania to examine the impact of natural resource scarcity and poverty on fertility. The analyses were done for rural samples only for each country. This chapter is divided into four sections: (1) review and summary of empirical findings; (2) discussion of results; (3) policy recommendations; and (4) study limitations and recommendations for further research.

Review and Summary of Empirical Findings

Probit estimation technique was used. A binary variable for a woman's birth in the last three years and the last five years preceding the DHS surveys were two dependent variables used in the Probit models. For the Probit models, two estimation strategies were employed. That is, single equation models and IVPROBIT models. The findings of the single equation models appear to differ with the findings of IVPROBIT in terms of the statistical significance and the magnitude of the coefficients for natural resource scarcity.

The first estimation strategy was a single equation Probit models of a birth in the last three and a birth in the last five years were estimated as a function of natural resource scarcity, poverty and other socioeconomic variables. This model assumes that natural resource scarcity as measured by the time taken to get to the source of drinking water is

an exogenous variable. This approach parallels the existing studies that have examined the vicious circle theory without addressing endogeneity problem. For Nepal, the coefficients for natural resource scarcity were positive and statistically significant at the 5% level in both the birth in the last three years and the birth in the last five years models. For Honduras and Tanzania, the coefficients for natural resource scarcity were not statistically significant in both the birth in the last three years and the birth in the last five years models.

The second estimation strategy involved IVPROBIT technique which relaxes the assumption that time taken to get to the source of drinking water is an exogenous variable. This strategy involves two stages. In the first stage, natural resource scarcity was modeled as a function of socioeconomic variables and one identifying instrument. The identifying instrument used is improvement in drinking water quality. In the second stage, the predicted natural resource scarcity variable from the first stage regression was used to replace the observed natural resource scarcity. This maneuvering is done automatically by version 10 of STATA software. Findings from the IVPROBIT estimation also reveal interesting outcomes. For Honduras, the coefficients for the natural resource scarcity were positive and statistically significant for a birth in the last three years and a birth in the last five years models. Note that, the Wald test of exogeneity rejected the null hypothesis that natural resource scarcity was exogenous. This is a very important finding because by addressing the endogeneity problem, the coefficients of natural resource scarcity became statistically significant for Honduras. This means that failure to address endogeneity could result in rejecting the impact of natural resource scarcity in Honduras.

For Nepal, the coefficient for the natural resource scarcity was positive and statistically significant for the birth in the last three years and the birth in the last five years models. Note that, the Wald test of exogeneity rejected the null hypothesis that natural resource scarcity was exogenous. Note that the magnitude of the coefficient increased in both models after addressing endogeneity problem. In addition, the level of statistical significance increased the birth in the last three years model.

For Tanzania, the coefficient for natural resource scarcity was not statistically significant at all before or after addressing the endogeneity problem. Note that the Wald test of exogeneity could not reject the null hypothesis that natural resource scarcity was exogenous. These results suggest that natural resource scarcity is not an important factor influencing fertility in Tanzania.

The empirical results for both models, with and without addressing endogeneity problem consistently and robustly show the coefficients for family wealth index were negative and statistically significant in the three countries. This finding implies that income is negatively related to fertility which means that poverty perpetuates increases in fertility. The finding reaffirms the vicious circle theory in terms of the relationship between poverty and fertility.

Apart from natural resource scarcity and poverty, this study examined the role of other socioeconomic factors on fertility. The two most prominent variables were women's education and child mortality. Women' education was very important determinant in reducing fertility. For Honduras, women's primary and secondary education levels were important in reducing fertility in all models examined. In Nepal, woman's primary education was very important in reducing fertility in all models

examined. Whereas in Tanzania, only woman's secondary education was very important in reducing fertility in all models examined, the exception is the birth in the last five years model after addressing endogeneity. However, in all countries and all the models examined by this study, the coefficients for women's higher education were not statistically significant. This may be attributed to the fact that in all countries examined in this study, very few women attained higher level education as Table 3.2 above shows.

Child mortality was very important in increasing the probability of births across all the models examined in this study. This particular finding reaffirms the existing knowledge that infant and child mortality are significant determinant in influencing fertility in developing countries.

In sum, with the exception of Tanzania, this study supports the vicious circle theory that population growth, natural resource scarcity and poverty are interlinked at least for Honduras and Nepal. The study further reveals that the theory is valid for rural areas of the developing countries as suggested by one of the theory's pioneer (Dasgupta, 2000).

Discussion of the Results of Natural Resource Scarcity

This section compares and discusses the results of this study with those of the existing studies. The emphasis is on this discussion on the impact of natural resource scarcity on fertility. None of the existing studies deliberately analyzed the impact of poverty on fertility, but wherever applicable, the discussion will include its impact as well. Since none of the existing studies, with the exception of Bhattacharya, (2007) addressed endogeneity problem, it is prudent to compare the results of the single equation

of this study with those of the existing studies. The results in this study that addressed endogeneity problem are discussed in the previous section above.

As mentioned in Chapter Three, out of the eight previous studies that examined the vicious circle only three studies used dependent variables which are recent measures of fertility similar to this study (Loughran and Pritchett, 1997; Aggarwal, Netanyahu, & Romano, 2001; & Filmer & Pritchett 2002). The following paragraphs provide discussion of the single equation technique results of this study in comparison with these three studies.

Loughran and Pritchett (1997) results show that both firewood and water scarcity as measures of natural resource scarcity have negative coefficients when the dependent variable is a birth in the last five years. These findings that do not address endogeneity suggest that increases in natural resource scarcity lowers the probability of births in the last five years. The results of a birth in the last five years model for this study show the opposite. The present study's findings of a birth in the last five years model show a positive sign for the coefficient of natural resource scarcity for Honduras and Nepal. The findings suggest that natural resource scarcity increases the probability of a birth in the last five years. The results of this study and those of Loughran and Pritchett are similar in terms of the impact of wealth on fertility. The two studies agree that poverty leads to higher levels of fertility which is consistent to one of the arguments of the vicious circle theory. Loughran and Pritchett did not report the results of a birth in the last three years model in their papers.

Aggarwal, Netanyahu, and Romano (2001) results show that both water and wood scarcity as measures of natural resource scarcity have positive coefficients but only wood

scarcity was statistically significant when the dependent variable is a birth in the last five years. They found similar results when the dependent variable is a birth in the last ten years. These findings that do not address endogeneity suggest that increases in natural resource scarcity increases a probability of a birth in the last five years and a probability of a birth in the last ten years. However, it needs to be emphasized that only wood scarcity was found to be statistically significant at the 10% level for a probability of a birth in the last five years. The lack of significance for the similar variable (wood) when the dependent variable is a birth in the last ten years may be another indication that a recent measure of fertility may be preferable than a cumulative one. The results of this study and those of Aggarwal, Netanyahu, and Romano are also similar in terms of the impact of wealth on fertility. The two studies agree that poverty leads to higher levels of fertility. In short, the results of Aggarwal, Netanyahu, and Romano are essentially similar with this study. Both of these two studies essentially support the vicious circle theory.

Filmer and Pritchett (2002) results for their entire rural sample show that households in clusters with greater problems with firewood supply or households who live in clusters that are further away from firewood source have a higher probability of having had a birth in the last five years. Their findings are largely similar to the findings of this study in that they are both consistent with a vicious circle hypothesis.

The remaining five studies that examined the vicious circle theory (Cleaver & Schreiber, 1994a; Sutherland, Carr & Curtis, 2004; Biddlecom, Axinn, & Barber, 2005; Ghimire & Mohai, 2005; Bhattacharya, 2007) have used different measures of fertility which are not similar to this study. The remaining discussion of this section discusses the results of some of these studies in comparison with this study.

Sutherland, Carr and Curtis (2004) study used number of living children as a dependent variable which is a cumulative measure of fertility that the current study avoided for the reason aforementioned in Chapter Three. For natural resource variables they used farm size and tenure security, ownership of cattle, time to collect water in minutes, and collecting fuelwood. Similar to this study, Sutherland, Carr and Curtis results show that the coefficient of time to collect water in minutes is positive. However, unlike the current study, the coefficient was not statistically significant in the Sutherland, Carr and Curtis study. In addition, Sutherland, Carr and Curtis results show that other natural resources variables coefficient such as owning cattle is positive and statistically significant, consistent with vicious circle theory.

Biddlecom, Axinn, and Barber (2005) have examined the vicious circle theory by using two dependent variables: family size desires of men and women and whether or not women had pregnancy in the three years following when the environmental and household measures were made. The second dependent variable (the probability of women getting pregnant in three years after the environmental measures were made may be considered as a recent measure of fertility that this current study advocates. By using this recent measure of fertility, Biddlecom, Axinn, and Barber results show that women from households that relied on public lands for fuel wood collection were more likely to have had a pregnancy in three years after the environmental measures were made. In addition, using the recent measure of fertility, their results show that women from the household where the time to collect fuel wood had increased by at least one hour were also more likely to have a pregnancy in the following three years. These results by Biddlecom, Axinn, and Barber are similar with the findings of this study because they are

both consistent with the vicious circle theory. The results of Biddlecom, Axinn, and Barber from using the cumulative measure of fertility also support the vicious circle theory.

Ghimire and Mohai (2005) used monthly hazard of using contraceptives as a dependent variable. In their study they found that when people think that agricultural productivity has decreased tend to use contraceptives. This finding implies that when members of the households in Nepal perceive that there is natural resource scarcity, they take such measures as contraceptive use to limit fertility. This particular finding is inconsistent with this study and the vicious circle theory.

Bhattacharya (2007) study findings are similar with this study. Both Bhattacharya and this study address endogeneity problem. However, Bhattacharya used macro-level data as opposed to micro-level data that this study used.

Policy Recommendations

Understanding of the impact of natural resource scarcity and poverty on fertility, and hence population growth rates is important in programming and formulating policies. This study helps to provide insights on the impact of natural resource scarcity and poverty on fertility. The findings suggest that sustainable use of natural resources is not only good for environment but also helps reduce unnecessary population growth. Equally important is the alleviation of poverty in reducing fertility and protecting environment. Both policy makers and international community aimed to reduce higher levels of fertility in developing countries should not only confine themselves to such factors as unmet need for contraceptives. They should incorporate other factors such as natural resource

availability and household wealth in their family planning programs. For example, instead of just concentrating on the distribution of contraceptives, the governments in developing countries should also attempt to ease the burden of collecting natural resources. This can be done by improving access to natural resources such as water as well as providing substitutes for other natural resources such as affordable electricity and efficient stoves for fuel wood.

In addition, the importance of investing in education cannot be overemphasized as revealed by the study findings. In this study and elsewhere, it has been shown that education is an important determinant of fertility. Therefore, the governments in developing countries need to target and increase investment in education at all levels if reduced fertility is a desirable outcome. Moreover, infant and child mortality need to be reduced if not eliminated completely because they still remain important factors in influencing fertility (see the coefficients of Cmort on Tables 4.4, 4.5, 4.24, and 4.25).

The impact of natural resource scarcity and poverty on fertility may be place specific. As shown in this study natural resource scarcity and poverty are having impact of increasing fertility in Honduras and Nepal only. In Tanzania even though poverty has been shown to have impact of increasing fertility, the natural resource scarcity variable did not have any impact. This could be that time taken to fetch drinking water not being a good proxy for natural scarcity in Tanzania. This is an important remainder to both policy makers and donor communities that no single policy should be applied universally unless proven otherwise. The problems of population growth, natural resource scarcity, and poverty need to be examined locally and find practical solutions that suit local conditions.

Study Limitations and Recommendations for Further Research

This study examined the impact of natural resource scarcity and poverty on fertility, and hence population growth rates. The study used cross sectional data which may limit the analysis. The limitation of the cross sectional data may arise due to the fact that the nature of the analyzed problem may not be well captured by using a single year data. The use of longitudinal data may be very appropriate for this kind of study for future studies. However, given the size of the number of observations in this study, longitudinal data may prove to be very costly. In addition, time series data tend to have other problems normally not associated with cross sectional data.

Due to data limitation, this study used only one measure of natural resource scarcity. There is a need for future studies to examine different natural resource and environmental variables to see how different or indifferent they impact fertility. For example future studies may use other measures of natural resource scarcity such as time taken to collect fuel wood, changes in groundwater table levels, and the use of satellite images to measure vegetation.

In addition, the future studies should tests for endogeneity and address the problem if present. As shown in Tables 4.24 and 4.25, in Honduras, the coefficients for natural resources scarcity became statistically significant only after addressing endogeneity problem. In addition, the level of statistical significance and magnitudes of the NS coefficients increased for Nepal after controlling for endogeneity. This implies that IVPROBIT models are superior to the traditional approach which do not address potential endogeneity problem.

This study like many other previous studies used time to get to the source of drinking water as a proxy of natural resource scarcity. While the use of this proxy is warranted, it assumes that different people have same speed while walking to sources of drinking water. This assumption may not necessarily be true because time taken to get to sources of drinking water may depend on various factors such age and sex. However, this problem may be addressed by the use of IVPROBIT technique as this study does.

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