A LONGITUDINAL ANALYSIS OF AGGREGATE FERTILITY DECLINE AS A PRODUCT OF INCREASING CONTRACEPTIVE PREVALENCE

A Dissertation

by

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ABSTRACT

The human population has experienced tremendous growth over the past 300 hundred years. It took from the start of human history up to the 1800 before the world reached 1 billion in population; in but 210 years another six billion people were added to the population. This exponential growth has been well documented since the time of Thomas Malthus at the turn of the 19th century and continuing with his modern day counterparts in the 1960's, particularly Paul Ehrlich. Interestingly, a simultaneous population trend emerged in the 1960's, namely, fertility decline. However, many academics, as well as the public in general, have been largely fixated on high fertility and overpopulation while in reality fertility continues to plummet in most regions of the world.

This dissertation addresses the fertility decline reported in 178 countries between 1960 and 2011. I draw on data from the World Bank Data Bank; my research focuses on the role of contraceptive prevalence in facilitating the vast fertility decline observed over this time period. I estimate multilevel quadratic growth curve models to analyze the effect of contraceptive prevalence on total fertility rates among countries. My results document the substantial fertility decline over this time period and indicate that contraceptive prevalence is a significant predictor of fertility decline even after controlling for known correlates of fertility decline such as development, urbanization, economic growth, and declining mortality.

This dissertation also includes a discussion of missing observations and the unique complications that missing observations present in a longitudinal framework. Furthermore, I also discuss the logic of multilevel modeling and how multilevel models may be employed in longitudinal research. Finally, I include a discussion of theoretical implications stemming from this dissertation. The focus of these implications is centered on the need for a paradigmatic shift in how we approach the study of fertility in favor of more effective fertility paradigms such as the "Low Fertility Trap Hypothesis." I argue that a paradigm shift in research orientation is essential as a growing number of countries face the stark reality of population aging, which has occurred as a result of declining and sustained low fertility.

DEDICATION

To the five most important people in my life, my wife who supported me in so many ways over these five years, and all of my children who filled my days with unending joy!

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If this process has taught me anything it is that my success is largely a product of a concerted effort on the part of many people in my life. First, I would like to acknowledge and thank my committee chair, Dr. Dudley L. Poston, Jr. for teaching me to love demography, providing me with wisdom and guidance, and providing me with some of the most amazing experiences over my graduate career. Secondly, I would like to thank my committee members, Dr. Mark Fossett, Dr. W. Alex McIntosh, and Dr. Oi-Man Kwok. Both Dr. Mark Fossett and Dr. W. Alex McIntosh have assisted me throughout my career and I am ever humbled by their knowledge and appreciative of their service. I would like to especially thank Dr. Oi-Man Kwok for all of his technical assistance in helping me navigate very complicated material.

Finally, I know that my success as a professional would not be possible without the support I have received from home. I would like to thank my parents and in-laws for all of their selfless help in supporting us and caring for our children. I would also like to thank my children who always found a way to make the bad days better and the good days great. Lastly, and most importantly, thanks to my wife for all the years of her love and devotion through good times and bad, through joy and suffering, and through all of life's triumphs and failures. I could not have retained my sanity throughout this process without her love and guidance.

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CHAPTER I

INTRODUCTION

At approximately 8:15 AM on August 6, 1945 the world changed forever. After falling for only 44 seconds, the atomic bomb nicknamed "Little Boy" detonated over Hiroshima leveling most of the city. This was a tragic end to what seemed like an endless war. Following the bombing of Hiroshima, warfare, politics, and international relations would never again be the same. Over time humanity has fashioned great technological developments from penicillin to electricity, all of which have their respective places in history. Few developments, however, can match the radical and rapid change that ensued after the dawn of the nuclear age. The effects of the first nuclear bombs are still being felt by those in the immediate area generations later and by nations the world over. From the cold war to modern day conflicts with Iran, the nuclear age looms as a constant threat to humanity. The nuclear age impacts the individual as well as the nation. But for all its power and wonder, the nuclear technological innovation was not alone in its ability to dramatically shape the future. It was not long after World War II that another development made its debut that would have similar long term global effects, namely, modern contraception.

Sixty years ago demographers would never have imagined that even a handful of countries would fall below the replacement level fertility, that is, a total fertility rate (TFR) of 2.1. Many demographers then would likely have downplayed the prediction that by 2012 just over half (117 out of 224) of the countries analyzed in the CIA World

Factbook in 2012 would fall below replacement fertility levels (Central Intelligence Agency, 2013). Such a radical change in fertility patterns was impossible according to the Malthusian perspective that has plagued the field of demography for the past century.

In 1964 Donald J. Bogue's presidential address to the Population Association of America focused on the anticipated fertility control movement worldwide and the fact that it was just a matter of time before fertility rates would drop precipitously. His assertion that "the plague of high fertility is no more insuperable than was malaria or other infectious diseases that are now all but forgotten" was met by disbelief among many demographers and even derision (Bogue, 1964:453). Yet, in hindsight, Bogue was more a prophet than a charlatan.

The 1960s and the early 1970s were much less influenced by Bogue's scholarship and much more by the authors of several high profile books, namely, Osborn's, *This Crowded World* (1960), Ehrlich's best seller, *The Population Bomb* (1968), and *Famine 1975* (1967) by Paddock and Paddock; these treatises, sometimes referred to as neo-Malthusian, "were designed to be alarmist in tone," and questioned whether slow growth or no growth was ever possible (Bouvier and Bertrand, 1999:64).

The alarmist view may be traced back to the work of Malthus, who correctly recognized that if left unchecked that populations would grow geometrically while food production would increase arithmetically (Malthus, 1798). Initially this trend would not be problematic so long as food stores outpaced population size. However, eventually population growth would overtake food production leaving societies with food shortages, famines, and starvation on a massive scale. Malthus was one of the first to recommend controls on population growth for the sake of the greater good. He suggested that there were two "checks" on population growth, positive checks and preventative checks. The positive checks came in the form of drought, famine, and war. These checks were difficult to predict and even harder to control. Malthus suggested that preventative checks provided the brighter future. Preventative checks involved delaying marriage and what Malthus referred to as moral restraint, meaning controlling ones sexual desire. At the time of Malthus, most couples were only exposed to intercourse, and therefore the risk of pregnancy, in the course of marriage. Little extramarital fertility occurred. In this context, increasing the age at marriage had serious implications for the overall fertility rate.

Ultimately, Malthus' projections never came to fruition. For one thing, he did not account for the industrial revolution. Within a single generation food production changed substantially such that a single farmer could now produce what took hundreds of men only a few years earlier. Secondly, he failed to envision the role of family planning *within* marriage. Nevertheless, Malthus had left his imprint on demographic history. His predictions may not have come to pass, but his fear of overpopulation was here to stay.

Researchers, officials, and concerned individuals the world over picked up where Malthus left off. Leaders in the twentieth century population control movement such as Margaret Sanger would use any means available to help curb population growth. Unfortunately, the early days of this overpopulation movement became intertwined with more egregious concerns such as eugenics and at times pursued contraceptive methods that endangered women (Connelly, 2008). Nevertheless, many in positions of power still viewed the efforts as warranted as concerns over population growth mounted.

The more recent flavor of this movement was well captured in the already noted landmark bestseller *The Population Bomb* by Paul Ehrlich (1968). Ehrlich's prophecy was much more extreme than Malthus' original concern in that Ehrlich posited that we were already too late. Even if extreme measures were taken to control population growth, the current rates in developing countries had already done their damage. Too many people were already alive and the bomb, so to speak, was ticking. Similar to Malthus, Ehrlich's forecast came up empty. However, Ehrlich succeeded where Malthus failed. Ehrlich was able to push the concern of overpopulation into the public sector, increasing awareness and attention on the part of individuals and governments alike.

Many contemporary demographers were certain that overpopulation was and is still a serious threat even in the face of mounting evidence to the contrary. Even the United Nations Population Division refused to acknowledge the slowing in global population growth that began in the late 1960's through 2002 (Wattenberg, 2005). In hindsight, Ehrlich's work had a somewhat prophetic, all be it, ironic title. There was in fact a "population bomb" that would change the world in a similar way that "Little Boy" had only a few decades earlier. During the 1960's the development, implementation, and distribution en masse of modern contraceptives would achieve the unthinkable. For the first time in human history, countries would witness total fertility rates plummeting at a pace once thought impossible. This reality led one author to describe the situation as "never have birth and fertility rates fallen so far, so fast, so low, for so long, in so many places, so surprisingly" (Wattenberg, 2005:5).

Consider that the global total fertility rate in the early 1950's was 4.97 according to the World Population Prospects: The 2012 Revisions (2013) published by the United Nations. By 2010, the total fertility rate for all countries of the world had fallen to 2.53. By 2010, if a woman were to spend her entire reproductive life exposed to the current age specific fertility rates we would expect her to have about 2.5 children, or 2,500 children per thousand women. The decline from nearly 5 children per women to only 2.5 is astounding in itself.

However, the global decline masks two distinct trends among very different parts of the world. First, combining all the countries of the world hides a much steeper decline in the less developed countries. For example, if we limit the scope of the above time period to only include less developed countries then the total fertility falls from a high of 6.08 in the early 1950's to 2.69 by 2010. Moreover, this rapid fertility decline is very different from the decline experienced by the more developed countries of the world over the same time period. Starting in the early 1950's the more developed countries had an average total fertility rate of 2.83, which fell to a low of 1.66 in 2010.

Clearly, fertility decline is not a new issue in the field of demography. Indeed, demographers dating back to the 1930's were aware of countries with total fertility rates below the replacement level of 2.1 (Keyfitz and Flieger, 1968; Kohler, Billari and Ortega, 2002). Yet this subreplacement fertility was short lived as births increased in the late 1940's up through the 1960's pretty much across the globe. Nevertheless, following the mass production of modern and effective contraceptives, fertility rates around the globe began a precipitous decline. To some extent, the fertility decline began before the introduction of modern contraceptives; indeed the rudimentary attempts of controlling fertility reach back for thousands of years (Noonan, 1966). However, modern contraceptives have accelerated the pace of the fertility decline.

What I will argue throughout this dissertation is that contraceptives have created a historic demographic shift by accelerating fertility decline and sustaining low fertility regimes all over the world. This dramatic shift in fertility rates at a national level is very similar to that which occurred in politics following the introduction of nuclear warfare. International relations changed after World War II such that virtually every international dialog was undergirded by the constant threat of a nuclear holocaust, unprecedented destruction, and the annihilation of the human race (Herz, 1959). Similarly, contraceptives have the ability to radically alter the demographic profile of humanity. The new low fertility era, driven by contraceptive technology, has already begun to shape the next several generations impacting societies for years to come. Obstinately low fertility has existed for over half a century with little indication of substantial revival any time soon and substantial shifts in age structures have already begun in countries around the world leading to the graying of society. Yet, as the world trembles in fear of the next nuclear strike, politicians, non-profits, and physicians alike continue to peddle contraceptives at an unprecedented rate.

However, the potency of the nuclear age has yet to actualize into reality, or as Herz (1959) states:

> While it cannot be denied that the situation created by the nuclear threat is not only radically new but also extremely foreboding, we must keep in mind that possibility is not certainty, that we can attempt to cope with a threat in order to avoid its realization, and, last, that the nuclear situation is only one among several factors which all have an impact on the present and may influence the shape of the future (24).

Likewise, the threat of population implosion as a consequence of widespread contraceptive use is but one possibility among many. Nonetheless, I will argue in this dissertation that the longitudinal relationship between contraceptive prevalence and declining fertility is one that warrants our attention.

Demography is full of explanatory frameworks and various descriptions of why countries begin and complete the fertility transition from a total fertility rate (TFR) of around 6 or 7 children per women over her reproductive lifetime to the magical replacement rate of 2.1. Many authors have theorized why this transition occurs, but no single paradigm explains the transition across time and space. Demographic transition theory, wealth flows, human ecology, political economic, ideational theories, and proximate determinants theory have all made important strides in illuminating the causes behind fertility transitions, but no single theory has sufficed. Moreover, many of these perspectives fail to explain the emergence and persistence of below replacement rate fertility. This lack of explanation has left demography continually grasping for new ideas, but finding few that provide an adequate cumulative explanation.

Moreover, demography as with virtually every other discipline, is stained by entrenched ideologies which at times cross over into the political sphere creating dangerous allegiances with the potential to taint research. As a case in point, demography has been clinging to the demographic transition theory for decades even in the face of serious flaws; one is its inability to account for change across time and in various cultures; yet this ideology still undergirds a vast amount of global development initiatives (Mason, Skolnick and Sugarman, 1998; Wattenberg, 2005). The time has come in demography to acknowledge the success of the established fertility paradigms while seeking to develop equally elegant theories of fertility decline in keeping with the impact of unprecedented contraceptive use.

We are living in the most exciting demographic times. Never before has the world seen such vast changes in all three of the demographic processes of fertility, mortality and migration. Yet, it is possible that our predictions and underlying theories of the fertility transition have missed some of the major elements. Not only were many researchers and organizations reluctant to acknowledge the change in growth patterns as was the case with the UNPD, but their eventual recognition of the shift was padded by predictions that fertility trends would revert to overall population growth by the mid to late 21st century.

This dissertation will proceed as follows. Chapter II is a review of the literature organized by three key themes. The first portion of the literature review briefly recounts the history of population growth and fertility decline. Next, I review in detail several of the dominant theories and analytical frameworks pertaining to fertility decline. Lastly, in Chapter II, I review the literature covering the emergence and persistence of low fertility regimes. In the last section I also include a discussion of the Low Fertility Trap Hypothesis as well as a discussion of how this literature has characterized the relationship between contraception and fertility decline.

In Chapter III, I discuss the data and methodology I use in this dissertation. Additionally, I explain how the logic of traditional multilevel models may be applied to a longitudinal analysis. Next, in Chapter IV, I provide a detailed descriptive analysis of the data in general as well as of patterns of contraceptive prevalence at the national level. Traditionally, the focus of analyses is directed towards the dependent variable, which in this dissertation is the total fertility rate. However, the purpose of my analysis is to examine the relationship between the total fertility rate and contraceptive prevalence over time. The existing literature includes several descriptions concerning changes in overall fertility but the literature is severely lacking in any general account of patterns of contraceptive prevalence. This chapter seeks to fill that void.

Then, in Chapter V, I estimate and report the results of the longitudinal multilevel models assessing the longitudinal effect of changing contraceptive prevalence on the total fertility rate at a national level controlling for both time varying and country level variables. Finally, in Chapter VI, I summarize the findings from the descriptive analysis as well as the multilevel models. This chapter also includes a discussion of the potential future effects contraception may have on low and declining fertility.

CHAPTER II

REVIEW OF THE LITERATURE

The following chapter is divided into three main sections with each section subdivided into multiple sections. The first section briefly reviews the history of population growth. Historic trends in population growth clearly contribute to the current size of the human population. Moreover, rapid population growth, as discussed below, continues to exert a powerful influence on the demographic discourse surrounding population growth. Thus, the growth in the human population throughout history still impacts the way demographers view contemporary demographic issues.

The second main section in this chapter addresses several of the prominent theories of fertility decline. Many of these theories, including the demographic transition theory, have shaped the discipline of demography and the general understanding of population growth. However, virtually all of the existing theories of fertility decline are incomplete and incapable of fully explaining the continual fertility decline witnessed around the world today. Therefore, this section reviews each theory highlighting the strengths and limitations of each perspective.

Finally, the third section of this chapter discusses the emergence and persistence of low fertility regimes. The section is organized around the dimensions of low fertility as developed by Lutz, Basten, and Striessnig (2013). Each dimension of low fertility corresponds to a social, economic, or demographic trend that has led to the development and persistence of the sustained low fertility now witnessed in many parts of the world.

The six dimensions includes, trends in ideal family size, trends in education and the labor force, macro-level changes that impact the cost of childbearing, the changing nature and stability of partnership, shifts in population composition, and changing biomedical conditions.

Also in the last section, I introduce the Low Fertility Trap Hypothesis (LFTH) developed by Lutz, Skirkbekk, and Testa (2006). I argue that the low fertility trap hypothesis is perhaps the best approach to understanding fertility decline and I detail how this perspective overcomes many of the shortcomings found in the more common theories of fertility decline. Finally, I conclude the last section of this chapter by discussing the relationship between contraception and low fertility and how this relationship fits into the low fertility trap hypothesis. The existing literature on contraception largely focuses on the ability of contraceptives to reduce population growth, nearly to the exclusion of research evaluating the role of contraceptives in contributing the more recent patterns of sustained low fertility.

A Brief Review of Population Change*

Much of the history of the human race has been a tale of growth in the face of great adversity. In fact, prior to the 1800's, growth in the human population was slow and tedious. Around 8,000 B.C. there were only around six million human inhabitants on the earth.

* Figure 2.2 and Figure 2.3 were taken from the *World Population Prospects: The 2012 Revisions*, by the United Nations Department of Economic and Social Affairs, © 2013 United Nations. Reprinted with the permission of the United Nations.

By the time of Christ, the world population had only grown to about 250 million people. It took another 1,600 years for the population to double. It is not until 1850 that the human population reached the 1 billion mark. At this point in history an ideological shift occurred in regards to population growth. Prior to the 1800's the primary concern over population growth focused on the survival of the human race. Famines, natural disasters, and plagues wreaked havoc on the human population. Furthermore, the lack of access to clean water coupled with limited knowledge of basic hygiene and medicine suppressed life expectancies and dramatically inflated mortality rates. Following the industrial revolution, however, the pace of population growth increased rapidly leading to concerns regarding overpopulation for the first time in history. These early demographic concerns were not without warrant.

Bear in mind that humanity reached one billion people in 1850. The second billion people was added to the population by 1927, in just less than eighty years. Around three billion people inhabited the earth by 1960, four billion by 1974, five billion by 1987, six billion by 1999, and seven billion people estimated in October of 2011. The world didn't reach the first billion people for thousands of years; then less than two hundred years later it had added another 6 billion to the population. The rapid growth of the human population over the past 10,000 years is undeniable. In fact, estimates of the doubling time, or the time necessary for a given population to double in size with constant birth and death rates, decreased rapidly from 150 years between the 18th century and the start of the 20th century to only 65 years between 1900 and 1965 (Gelbard, Haub and Kent, 1999).

Some of the earliest demographers, including Thomas Malthus, correctly identified the potential problem of rampant population growth. Malthus authored his most famous work *An Essay on the Principle of Population* in 1798. In the course of his analysis Malthus (1798) noted:

> Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will show the immensity of the first power in comparison of the second. By that law of our nature which makes food necessary to the life of man, the effects of these two unequal powers must be kept equal. This implies a strong and constantly operating check on population from the difficulty of subsistence. This difficulty must fall somewhere and must necessarily be severely felt by a large portion of mankind. (5)

According to Malthus, the growth in the human population would clearly outpace that of food production. Therefore, humanity was doomed towards famine, misery, and vice if the population was not kept in check. For Malthus, there were two types of checks, positive and preventative checks. Positive checks were those events that would lead to an increase in the mortality rate, thereby reducing the size of the population through excess deaths. These events include war, famine, and pestilence. However, Malthus also suggested that populations could be controlled through the use of preventative checks.

Preventative checks address family formation and the regulation of childbearing. In Malthus' day virtually all childbearing took place within marriage. Therefore, by limiting the number of marriages, or at least delaying the transition into marriage, one could ostensibly limit the number of children entering the population. From an individual perspective, as well as that of public policy, the preventative check is far superior to positive checks since "it is better that [population] should be checked from a foresight of the difficulties attending a family and the fear of dependent poverty than that it should be encouraged, only to be repressed afterwards by want and sickness" (Malthus, 1798:28). Malthus was correct in identifying the alarming population growth rate. However, for all of his brilliant insights, Malthus failed to foresee the radical impact that the industrial revolution would have on agriculture and food production. He failed to predict that very soon after his publication food production would increase geometrically and keep pace with population growth. Furthermore, Malthus did not foresee the technological revolution that would enable couples to effectively regulate births within marriage through contraception.

Nonetheless, the work of Malthus represents a crucial turning point in the history of population growth. Prior to Malthus, virtually all of humanity was consumed by fears of extinction. One disease or crop failure had the potential to eliminate entire cities in very short order. Furthermore, this period of human history was plagued by incredibly high mortality rates across the life course and perhaps most notably at the younger ages. Parents, then, were compelled to produce a large number of offspring to ensure that a few of them would survive, thus guaranteeing the survival of the family and the species.

Yet, as humanity's technological responsiveness and adaption to the environment advanced, the threat of extinction as a result of excess mortality gave way to fears of annihilation at the hands of excess fertility. Since the time of Thomas Malthus more attention has focused on limiting the number of children. Thanks to falling mortality rates, families no longer need seven or more children in order to ensure that a few survive into adulthood. As Malthus noted, the presence of excess children creates a new threatening situation particularly when there are more children than sustenance. Yet, although Malthus' original concerns never came to pass, his legacy remains strongly intact. From this point in history onward, researchers and politicians alike became fixated on rapid population growth and fears of overpopulation.

Yet, in the midst of this ideological turmoil a disturbing new trend begins to take shape. Many countries of the world began experiencing fertility decline to historically low levels. The progression from high fertility to low fertility is commonly referred to as the fertility transition. In the course of this dissertation I will focus on the total fertility rate (TFR), which is generally a synthetic, period, measure of fertility. The TFR represents the average number of children that will be born to a woman over her reproductive lifespan assuming that she is exposed to the current age-specific fertility rates over that period of time. In other words, a TFR of 7 suggests that women in that location over the course of their lifetime will on average give birth to 7 children. The ideal fertility rate is commonly set at a level of 2.1. A TFR of 2.1 suggest that women will have on average 2 children over the course of their reproductive lifetime, or 2,100 children per thousand women. This is considered the replacement fertility rate since each woman produces enough children to replace herself and her male counterpart. Moreover, 2,100 children are necessary since not all children born will reach adulthood.

Furthermore, void of any social interference there are roughly 105 boys born for every 100 girls owing to the fact that males have a higher mortality rate than females, ensuring that an equal number of males and females reach sexual maturity. Therefore, Fertility rates that fall below a TFR of 2.1 are considered "low fertility" and anything below a TFR of 1.3 is referred to as "lowest-low fertility" (Billari and Kohler, 2004;

Kohler et al., 2002). Armed with this terminology, the dramatic nature of the fertility transition becomes more evident.

The global fertility decline began largely in the more developed regions of the world, namely, Europe, Northern America, Australia/New Zealand and Japan. This early fertility transition began in the 19th century and progressed very slowly, such that by the middle of the 20th century European countries averaged a TFR of 2.67 with countries such as Japan close behind with a TFR of 3.0 (United Nations, 2013). Within the European countries, however, total fertility rates in the early 1950's ranged from a high of 6.1 in Albania, to a low of 1.98 reported in Luxembourg. Nonetheless, 27 of the 40 European countries in the period of 1950-1955 reported a TFR less than 3. Thus, high European TFR's in the 1950's were exceptions to the rule and not characteristic of the nearly 68 percent of countries that were approaching the replacement rate of 2.1 by the middle of the 20th century.

The fertility transition in less developed countries, comprised of all regions of Africa, Asia (except Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia, was much different compared to that of developed countries. The transition in less developed parts of the world began much later. As such, the TFR for less developed countries in 1950 was 6.08. Similar to the patterns we see today, the highest levels of fertility were recorded in Sub-Saharan Africa with Rwanda reporting a TFR of 8. The lowest TFR of the 155 developing countries in 1950 was 2.73 in Uruguay. As was the case in Europe, the range of TFR's in the less developed countries around 1950 is very misleading. At the time, approximately 60 percent of those 155 less developed countries had TFR's of 6 or higher, and close to 20 percent had TFR's that were greater than 7.

Figure 2.1 Total Fertility Rate by Region of the World

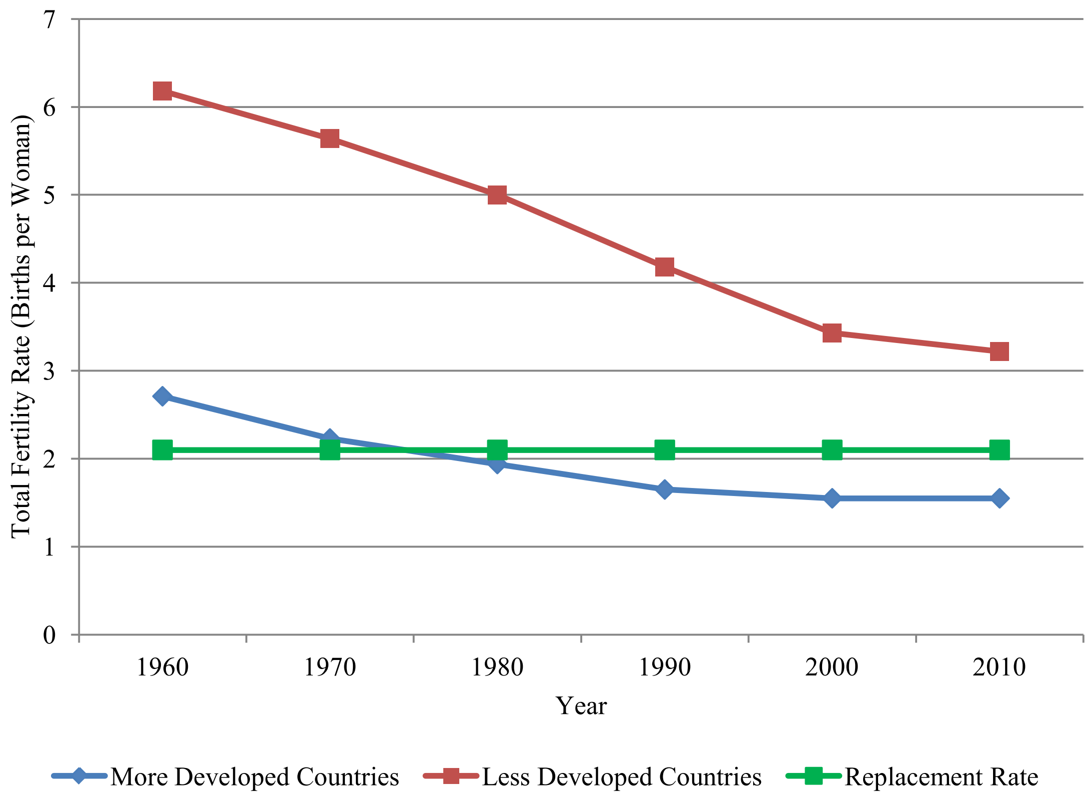
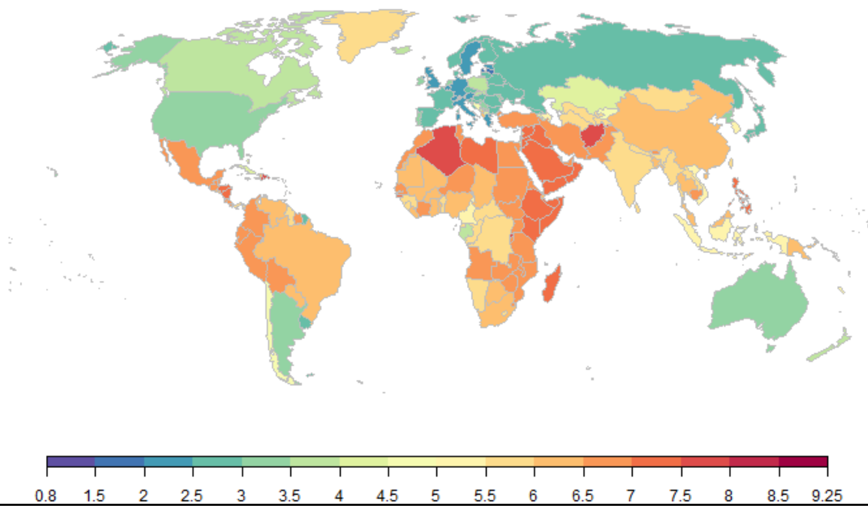


Figure 2.1 shows the dramatic difference in total fertility rates between the more developed and less developed parts of the world. By 1950 the more developed countries were well into the fertility transition. Furthermore, by the start of the 21st century, the more developed countries have already moved into below replacement fertility. The TFR in the less developed countries, however, actually increased slightly until the 1960's before starting a rapid decent towards replacement fertility.

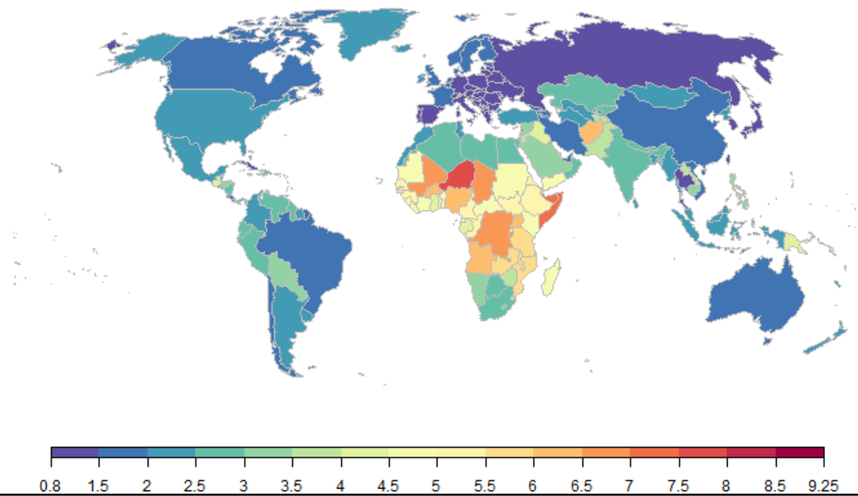
Figure 2.2 Total Fertility Estimates 1950-1955



Source: United Nations Department of Economic Social Affairs: Population Division. 2013. W*orld Population Prospects: The 2012 Revision*

Geographical representations of the worldwide fertility transition are also very informative. Figure 2.2 displays the total fertility rate by country based on estimates for the period of 1950-1955. Once again, high fertility is concentrated in particular parts of the world including Africa, Asia, as well as Central America, and large parts of South America. However, as demonstrated in Figure 2.3, the 2005-2010 estimates represent a starkly different scenario. First, by 2010, the concentrations of high fertility are dramatically reduced in number and heavily concentrated in Sub-Saharan Africa. Second, a new pattern emerges in that vast regions of the globe are now at replacement or below replacement level fertility.

Figure 2.3 Total Fertility Estimates 2005-2010



Source: United Nations Department of Economic Social Affairs: Population Division. 2013. W*orld Population Prospects: The 2012 Revision*

Comparing the fertility transition of the more developed countries to that of the less developed countries reveals two interesting facts. First, the onset of fertility decline occurs at different points in time across the globe. Initially, these findings were believed to be a result of economic development, as discussed below. Secondly, the pace of fertility decline is strikingly faster in less developed countries compared to more developed countries. The question that remains is why we see such radical differences. Furthermore, the global comparisons between the more developed and less developed countries disguises more subtle patterns that occur within each group.

Finally, none of these patterns are new to demographers since for nearly a century demographers have theorized why fertility declines. In the next section I will discuss several of the key theories of fertility in demography and associated disciplines.

Theories of Fertility Decline

This section will review six of the most common explanations of fertility decline, namely, demographic transition theory, wealth flows theory, political economic theory, human ecological theory, the proximate determinants framework, and diffusion theory. Each of these theoretical approaches contributes to our understanding of fertility decline, but each remains deficient in one respect or another.

Demographic Transition Theory

The most notable explanation of how populations grew so quickly is known as the Demographic transition theory (DTT). Demographic transition theory has its origins in the work of Warren Thompson (1929). However, Notestein (1945, 1953) and Davis (1945, 1963) are commonly credited with DTT's more recent formulations. Interestingly, the reception of DTT in the 1930's was poor indeed and garnered very little support in the demographic community (Szreter, 1993). It was not until the political concerns of the post World War II era that many researchers got behind the theory.

In its simplest form, demographic transition theory posits that populations move through the fertility transition in four general stages. In the first stage populations are characterized by high levels of fertility and mortality. This stage is often referred to as pre-transitional or pre-industrial. At this point populations are subject to disease, famine, war, and natural disasters that threaten the survival of the species. Thus, the high mortality rates are compensated for by high fertility. Very little growth takes place in the pre-transitional stage since mortality and fertility levels remain at similar levels.

In stage 2, the stage of high growth potential, the population experiences a dramatic decline in mortality. In many societies this decline in mortality is directly related to improvements in living conditions, increased access to clean water, and advances in basic medical care. However, as mortality rates fall, fertility rates remain at still very high levels. Bear in mind that for generations parents have reproduced under the assumption that several of their offspring will not survive into adulthood. Therefore, declines in mortality are not immediately apparent to all adults in the reproductive ages. As a result, parents continue the pattern of high fertility until the connection is made that large numbers of children are not necessary to ensure the survival of the family. Stage 2, therefore, results in rapid population growth as couples continue to reach high order parities and the majority of children survive into adulthood.

Stage 3 of the demographic transition theory is depicted by significant declines in fertility rates. Complicated causal mechanism begin to reduce fertility levels in the wake of declines in mortality (Poston and Bouvier, 2010). Substantial changes as a result of industrialization, urbanization, and shifting family dynamics help reduce the fertility rate (Davis, 1963; Hirschman, 1994; Knodel and Van de Walle, 1979). Furthermore, new standards of education for children, changes in educational and labor force opportunities for women also encouraged lower fertility. Davis (1963) provides an excellent example of these interrelated forces at work in Japan. The age at marriage in Japan during the third stage of the demographic transition increased, which effectively reduced fertility rates. In Japan, the dowry paid by the bride's parents was quite high and as industrialization created a surplus of jobs in the factories parents began to send daughters to work in the factories. This accomplished two results. First, parents collected extra income from the daughters' salaries. Secondly, parents were able to put off the expense of the dowry. This interplay of family dynamics, shifting labor force opportunities, and the rise in age at first marriage all contributed to fertility decline.

Finally, in the last stage of the demographic transition, fertility and mortality rates once again balance out at stable levels. Other authors have referred to this final stage in the demographic transition as the stage of "incipient decline" because it is "not really possible to determine how low fertility will really go" (Poston and Bouvier, 2010:272). Presumably, once a given population reaches this stage in the demographic transition the fertility rate and mortality rate will level off with only slight variations. These variations then account for any incidence of natural increase or natural decrease, which are not expected to be prolonged.

The demographic transition theory has long served as the core explanation of how populations transitioned from high fertility and high mortality societies to the low fertility, low mortality societies that are more common today. The account provided by DTT is straightforward and a seemingly good fit for a number of countries. France is one of the first countries to complete the demographic transition beginning in the early 1800's and requiring nearly 150 years to complete the transition (Van de Walle, 1974). Many other western nations followed a similar pattern by completing the demographic transition in 150 to 200 years. Thus, at a millennial and centennial time scale DTT offers a very elegant account of fertility decline (Mason, 1997). Additionally, the beauty of demographic transition theory is that it is general enough to allow for a multitude of causal variables (Hirschman, 1994). For these reasons, DTT has been a mainstay in the demographic literature for nearly a century.

However, there are several damning criticisms of demographic transition theory. Analyses conducted in the European Fertility Project demonstrated that the fertility transitions in European countries began and proceeded under a variety of conditions that do not fit neatly into the demographic transition model (Coale and Watkins, 1986; Knodel and Van de Walle, 1979). For example, Knodel and Van de Walle (1979: 224) found that "although the fertility decline began in England only after considerable urbanization and industrialization had taken place, it occurred at about the same time in Hungary, which was at a substantially lower level of development as measured by conventional socioeconomic indexes." Furthermore, substantial variation in literacy levels, infant and adult mortality levels, and social contexts at the outset of the fertility decline among western European nations challenges many of the fundamental elements of DTT (Freedman, 1979; Knodel and Van de Walle, 1979).

Yet, despite its many failures, demographic transition remains at the forefront of fertility research. In other words:

> It is a remarkable paradox that although there has been an accumulation of modern and early modern historical evidence that would seem to have comprehensively discredited the accuracy and validity of demographic transition as either a theory or a general historical description, this model of demographic change remains a central preoccupation in contemporary population studies (Szreter, 1993:660).

The paradox of DTT is particularly perplexing since the failures of the theory are in fact very well documented (Szreter, 1993). However, tracing the development of DTT reveals a disturbing shift to a focus on policy implications of presumably scientific research. Policy science has been a part of demographic research from the beginning (Hodgson, 1983). However, it is essential to partial the focus and consequences of two distinct approaches to demographic research:

> From Malthus's day to the present, the study of population dynamics has attracted those wishing to understand and those wishing to influence. These two activities are quite different in nature. The demographer as social scientist seeks knowledge about conditions. His stance requires no commitment to change. He is interested in "what is" and strives to apprehend reality. The demographer as policy scientist seeks to alter current conditions in a specific direction. His stance is necessarily one committed to change. He is interested in "what can be" and strives to produce a desired state (Hodgson, 1983:1).

Hodgson (1983) goes on to note that policy oriented demographers have dominated the field over the course of the mid-20th century, particularly with regard to fertility research. The key danger in a policy orientation is the potential willingness to overlook failures in a theoretical perspective in favor of the tangible policy implications provided by such a theory (Hodgson, 1983, 1988; Szreter, 1993).

In many respects, this is the fundamental danger of demographic transition theory. DTT's utility as a policy framework for identifying and categorizing countries into simple factions enables policy analysts and government officials to develop strategies that target the demographics of each group aimed at achieving the desired demographic outcomes. The last fifty years have been full of demographic goals and targets that speak directly to the policy oriented approach to understanding fertility decline. As history has demonstrated, such demographic targets and goals often lead to serious humanitarian disasters including mandatory sterilization campaigns, severe repercussions for unpermitted reproduction, and strings attached to basic humanitarian aid packages (Connelly, 2008).

Despite its advantages as an explanatory framework, demographic transition theory ought to be contextualized as such in the demographic discourse. Not only do the key tenets of DTT fail to hold up to modern and historical analysis, but the policy orientation embedded in the Notestein (1944) and Davis (1945) formulations posits serious concerns as to the validity of the theory today. Furthermore, the limited instances in which DTT accurately describes the transition from high to low fertility regimes have all but faded into history. Contemporary societies making that same transition, or on the brink of transitioning, will likely experience a transition at a far more rapid pace and perhaps for different reasons.

Finally, DTT fails to account for the dramatic decline in fertility witnessed following the fourth stage. Presumably, countries that enter the fourth stage of the transition will experience a balanced fertility rate in respect to the low mortality rates, thereby achieving a stable population. Yet the overwhelming numbers of countries that complete the demographic transition continue to see fertility rates decline. This has become known as the "second demographic transition" (Van De Kaa, 1987). In 2003 Van De Kaa stated:

> Advanced industrial societies face a new imbalance between the components of natural population growth. Fertility has declined well below replacement level. Life expectancies at advanced ages have risen substantially. The combination of the two leads to a rapidly ageing population. Negative rates of natural population growth are already observed in numerous countries. National projections show that this phenomenon will spread. There are no indications this state of affairs is temporary: hence the conclusion that a second demographic transition is in progress (2003:872).

The second demographic transition is characterized by substantial shifts in "values related to family life and children, and [is] marked by the weakening of the 'traditional' family as an institution" (Sobotka, 2008:172). The changes in traditional family values give rise to large increases in the proportion of populations cohabiting. Previous research has described this shift in values as:

> …a matter of postponing or eschewing parenthood altogether because of more pressing competing goals such as prolonging education, achieving more stable income positions, increased consumerism associated with self-expressive orientations, finding a suitable companion and realizing a more fulfilled partnership, keeping an open future, and the like. (Lesthaeghe and Neidert, 2006:669)

Furthermore, another defining characteristic of the second demographic transition is the continual decline of fertility rates as a consequence of widespread contraceptive use (Van De Kaa, 1987). Clear evidence of the second demographic transition is found in countries all across Europe, North America, and parts of Asia (Lesthaeghe and Neidert, 2006; Sobotka, 2008; Van De Kaa, 1987).

Wealth Flows Theory

Another popular theoretical explanation of the fertility transition was developed by Caldwell (1976, 1982) and is commonly referred to as the wealth flows model of fertility. Caldwell (1976) stated that fertility behavior throughout the demographic transition was not only "rational but economically rational" (1976:322). The issue of rationality is key since many scholars, following the suppositions of DTT, characterized pre-transitional societies as irrational (Caldwell, 1976). Caldwell (1976), however, stipulated that "societies are economically rational" (1976:326). This economic rationality leads to fertility decisions based on the flows of emotion, wealth, and services from one generation to the next. From this perspective fertility will decline as families become “emotionally nucleated” such that they are “less concerned with ancestors and extended family relatives than they are with their children, their children's future, and even the future of their children's children” (Caldwell, 1976:352). The argument is more succinctly stated in future research:

> The fundamental thesis is that fertility behavior in both pre-transitional and post-transitional societies is economically rational within the context of socially determined economic goals and within bounds largely set by biological and psychological factors. Two types of society can be distinguished: one of stable high fertility, where there would be no net economic gain accruing to the family (or to those dominant within it) from lower fertility levels, and the other in which economic rationality alone would dictate zero reproduction. The former is characterized by “net wealth flows” from younger to older generations, and the latter by flows in the opposite direction. These flows are defined to embrace all economic benefits both present and anticipated aver a lifetime. (Caldwell, 1982:157)

Much like the tenets of demographic transition theory, wealth flows theory is straightforward and plausible. However, other researchers have noted several instances in which countries have completed the fertility transition with virtually no change in family interaction (Freedman, 1979). Freedman (1979) showed that the fertility decline in Taiwan did not follow the tenets of wealth flows theory:

> Development and modernization did continue at a spectacular pace. But, the massive adoption of contraception and the rapid fall in fertility occurred while the family retained many traditional forms and attitudes. For example, in 1973, over 80 percent of Taiwanese older parents lived with a married son if they had one. Married sons who don't live with the husband's parents send them money. A large majority of young Taiwanese couples say they expect to live with a married son and to receive financial support from him in their old age…There are almost universal aspirations for high education for children and for a high standard of living for both children and parents. There is also a perception of the rising costs of education and higher standards of consumption. But, all of this appears to operate along with traditional familial values-changing slowly-but still very different from ours. (1979:7)

Freedman (1979) continued his remarks as follows:

> The Taiwanese apparently want to maintain intergenerational extended kinship ties in households equipped with TV and all the latest electronic gadgets. They have rationally decided that this is feasible with fewer children in whom greater investment is made. The costs are similar to those in the West, but the perceived benefits are quite different. Large-scale adoption of birth control and smaller families need not necessarily be preceded by the development of Western nuclear families. (1979:7)

Thus, while family nucleation may help explain changes in fertility in parts of Africa, where John Caldwell conducted much of his research, the same cannot be said for large parts of Asia (Freedman, 1979). Furthermore, others have noted that a focus on the nuclear family existed for centuries prior to fertility decline (Mason, 1997). Wealth flows theory successfully focuses the fertility literature on issues that fall outside the realm of demographic transition theory. Yet, wealth flows theory succumbs to a similar fate, in that the theory fails to account for fertility decline in a large number of cultural settings found in Asia and Europe.

Political Economic & Human Ecological Theories of Fertility

Similar to the efforts of John Caldwell's wealth flows theory, both political economic and human ecological theories of fertility seek to extend demographic transition theory. Political economic theories of fertility are interdisciplinary in nature and operate at a micro and macro level (Greenhalgh, 1990). Political economic approaches to analyzing fertility change function at multiple levels necessitating both quantitative and qualitative analysis (Greenhalgh, 2008). For example:

> A political economic demographer is more likely to work from the top down, beginning with an understanding of the historically developed global forces-the world market, the international state system, and so on-that shape local

> demographic regimes, next identifying the ways these impinge on regional, national, and local institutional environments, and finally tracing their effects on individual fertility behavior (Greenhalgh, 1990:87)

The political economic perspective functions as an "analytical framework" that address fertility at all levels of analysis.

Ecological perspectives of fertility focus on the relationship between the complexity of sustenance organization and levels of fertility. According to this perspective, the complexity of sustenance organization is negatively related to the total fertility rate (Poston and Frisbie, 2005). The rationale behind this approach suggests that "a high fertility pattern is dysfunctional for an increasingly complex sustenance organization because so much of the sustenance produced must be consumed directly by the population" (Poston and Frisbie, 2005:606). Furthermore, depleting resources at the disposal of the society limits the society's "flexibility for adapting to environmental, technological, and other kinds of changes and fluctuations" (Poston and Frisbie, 2005:606). Therefore, as the complexity of sustenance organization increases, fertility should decline thereby freeing up more resources to be invested in other ways. Several studies have found evidence for this negative relationship between the complexity of sustenance organization and fertility (Kasarda, 1971; London, 1987; London and Hadden, 1989; Poston and Frisbie, 2005).

Proximate Determinants of Fertility

The proximate determinants of fertility is a fertility paradigm that first began with the work of Davis and Blake (1956). In their initial analysis Davis and Blake (1956) suggested that all factors influencing fertility must operate through one of 11 intermediaries. This novel approach to understanding fertility changed the way many demographers measured and studied fertility. However, the approach developed by Davis and Blake (1956) proved to be cumbersome particularly with respect to quantifying some of the 11 variables.

However, the initial framework was revised by Bongaarts (1971) and Bongaarts and Potter (1983). In 1971, Bongaarts adjusted the framework to include eight variables grouped into three broad categories as follows:

I. Exposure factors
  1. Proportion married
II. Deliberate marital fertility control factors
  2. Contraception
  3. Induced abortion
III. Natural marital fertility factors
  4. Lactational infecundibility
  5. Frequency of intercourse
  6. Sterility
  7. Spontaneous intrauterine mortality
  8. Duration of the fertile period

Based on these eight determinants of fertility Bongaarts stated that:

> Fertility variations can always be traced to variations in one or more of the intermediate variables, the scope for variation differs among the variables as does their degree of influence in different societies and over time within societies (Bongaarts, 1978:108).

In other words, the effect of each of these proximate determinants is not universal or equal. The fertility rate in societies with access to effective contraceptives and high rates of contraceptive prevalence will be less impacted by the frequency of intercourse assuming that contraceptives are used at each moment of intercourse. Moreover, in later research Bongaarts (1982) demonstrated that the first four proximate determinants explained 96 percent of the variation in fertility levels. The remaining variables failed to vary much over the 45 countries in the analysis and contributed little to changes in fertility. Based on this knowledge, Bongaarts (1978) developed a simple equation to predict the total fertility rate using several indices he developed, that ranged in their values between 0 and 1, based on the first four proximate determinants as follows:

$$\text{TFR} = C_m \times C_c \times C_a \times C_i \times TF$$

Where:

C_m = the index of marriage, which equals 1 when all women of reproductive ages are in a marital union and 0 when all such women are not in a marital union

C_c = the index of contraception, which equals 1 when no contraceptives are used within marital and consensual unions and 0 when all fecund women are using effective contraception

C_a = the index of abortion, which equals 1when there are no occurrences of induced abortion in a given population and 0 when every pregnancy ends in an induced abortion

C_i= the postpartum infecundibility index, which equals 1 when no women are experiencing lactational amenorrhea as a result of breastfeeding and 0 when no women experience postpartum infecundibility

TF = the total fecundity expected in the absence of all deterrents to fertility

The utility of this framework has been well documented by Knodel and colleagues (1987) in their research on the fertility transition in Thailand. They were able to demonstrate how changes in contraceptive prevalence were chiefly responsible for the fertility transition. Marriage rates, abortion, and breastfeeding did not change radically between 1960 when the total fertility rate in Thailand was 6.3 and 1980 when the TFR fell to just above 2. But the proportion of married women using effective contraception tripled over the two decades. The proximate determinants model provides us with a way to quantitatively examine fertility patterns and pinpoint the causal mechanisms behind the change.

There have been some recent revisions of the original paradigm set out by Bongaarts. Most notably, Stover (1998) addressed the problem of Bongaarts using the proportion of married women in the population. One of the main assumptions of the proximate determinants paradigm is that childbirth is assumed to always occur within marriage. That does not always hold in countries today. For example, in 2007 just over 40 percent of births were to unmarried women in the United States. So in 1998 Stover addressed this issue by reconstructing the marriage index to represent the proportion of women actually engaged in sexual intercourse. His revision enables the exposure index (marriage index) to more accurately gauge the mechanism that impact fertility. However, Stover found that very few countries had the necessary data to accommodate his revision and his results were not much different from the original estimates set out by Bongaarts.

Diffusion Theories of Fertility

Theories of diffusion, or diffusion of innovation, have a longstanding history in the social sciences (Beal and Bohlen, 1955; Coleman, Katz and Menzel, 1957; Coleman, Katz and Menzel, 1966; Granovetter, 1978; Rogers, 1962, 1973). Originally, much of the diffusion literature focused on the extent to which rural farmers adopted new farming techniques and materials (Ryan and Gross, 1943). However, the approach gained ground in the 1970's in the field of demography following publications by Rogers (1973), Knodel (1977), and Knodel and Van de Walle (1979). Furthermore, a number of more recent empirical analyses ascribing to the diffusion perspective have gained some popularity among demographers (Behrman, Kohler and Watkins, 2002; Casterline, 2001; Rosero-Bixby and Casterline, 1993; Watkins, 1991).

Unlike the structural and economic theories of fertility decline discussed above, diffusion theories of fertility focus on the spread of the motivations for and techniques of fertility limitations. Casterline (2001) broadly defines diffusion theory by stating the following:

> The crux of innovation diffusion theory is an argument that has two closely linked, yet distinguishable, key elements that correspond to the two terms in the phrase "innovation diffusion": fertility decline is the consequence of the increased prevalence of attitudes and behaviors that were previously very rare or absent in the population (i.e., they are innovative), and their increased prevalence is the consequence of the spread of these attitudes and behaviors from some segments in the population to others (i.e., a diffusion process) (2001:6).

As stated here, diffusion theories investigate to what extent fertility limitation is indeed new or innovative, as well as how the diffusion process occurs. Diffusion theories can be further subdivided into "blended" versions versus "pure" versions (Cleland, 2001). According to Cleland (2001):

> Blended versions are essentially a fusion of classical demand theories and elements of the diffusion model. The fundamental cause of fertility decline is reduced demand for children (and/or increased supply through improved child survival) that stems from modernization in its various forms. Once the structural

> conditions are right, fertility decline is inevitable but its timing may be lagged. The onset of decline can be advanced by skillful government deployment of mass media and change agents or delayed by inappropriate official efforts to promote contraception. Diffusion processes subsequently condition the speed and mechanisms of change (2001:45).

Blended versions of diffusion theory, therefore, place an emphasis on structural and economic forces as causal mechanisms in the fertility transition. In other words, in the context of fertility declines, structural mechanisms such as development are the "engine" of demographic change and "diffusion is the lubricant" (Cleland, 2001:45). Pure versions of diffusion, on the other hand, take on a much different character. Cleland (2001) goes on to define pure diffusion theories stating that a:

> …pure version of innovation-diffusion explanations of fertility decline accords a much more central explanatory role to marital birth control as an innovation. It is an exogenous theory of change whereas the blended version is essentially an endogenous theory. Not only are modern methods of contraception recent inventions, but the very idea of deliberate pregnancy regulation within marriage has been absent in most societies for most of human history. This absence of pregnancy regulation for so much of human history remains a puzzle because, as our knowledge of historical demography increases, it is becoming clear that all societies have developed ways of suppressing average fertility and family size to remarkably low levels.

Pure versions of diffusion theories suggest that the dispersion of the knowledge of contraceptives as well as the devices and techniques are in fact the causal mechanism of fertility decline. The causal focus on contraceptive knowledge and availability of devices is far more controversial although it is important to note that Cleland (2001) has suggested that blended and pure versions are not necessarily exclusive and the two share many similar assumptions:

> The pure version of innovation-diffusion explanations rests on key assumptions and leads to a large number of empirical expectations, some of which can be

addressed by evidence. Many are also relevant to the blended version. These are listed below.

- Fertility regulation within marriage is an innovation.
- The idea of fertility regulation within marriage and many of the methods to achieve this initially evoke feelings of uncertainty, ambivalence, and fear.
- The evidence concerning the timing of fertility transitions across societies is more consistent with expectations derived from the innovation-diffusion framework than with those derived from economic theories.
- Once a certain threshold of cumulative adoption is reached, contraception spreads rapidly throughout socially and linguistically homogeneous systems, regardless of the position of groups within the economic structure.
- Contraception, and related topics, is the subject of interpersonal communication.
- The decision of individuals to adopt contraception and the methods they choose are influenced by their perceptions of behavior of others within their communication networks.
- Declines in desired family size accompany or follow the diffusion of contraception rather than precede it.
- Contraception supersedes earlier methods of managing family size and composition (Cleland, 2001:47).

This strand of pure diffusion of innovation theories has also been referred to as "ideational theories" of fertility decline (Cleland and Wilson, 1987). According to Casterline (2001), ideational theories "explicitly reject the notion that fertility decline can be explained by changes in structural conditions" (2001:10). This isolationist approach is perhaps why the pure ideational theories of fertility decline have remained at the fringe of fertility research.

Nonetheless, diffusion theories are not without merit. Much of the findings from the European Fertility Project appear to coincide with a diffusion approach. The fertility transition in Europe appear, in many places, to have followed the tenets laid out in diffusion theories since fertility declined in adjacent regions even though those regions were at various stages of development (Knodel and Van de Walle, 1979).

Evidence in parts of Asia also gives credence to the diffusion perspective. In their analysis of the fertility decline in Thailand, Knodel, Aphichat and Nibhon (1987) found both quantitative and qualitative evidence to support the key role of this diffusion of knowledge concerning contraceptives.

However, diffusion theories, more generally, and in the extremist or pure versions, have failed to overcome some damning limitations. First, several of the key principles are, at best, debatable. For example, the notion of contraception as a true innovation is problematic. Some researchers have argued that the parents possessed a contraceptive or strategizing mentality "in terms of the gender composition of offspring, the spacing between children, the timing of births, or whether another child is desired at a particular point in time" even though this was not always oriented towards determining the total number of children (Mason, 1997:448). Furthermore, reproductive control in historical societies often occurred post-natal through strategies to deal with an undesired number of children (Mason, 1997). These strategies included adoption, sending children to live with relatives, and extremes such as child abandonment or infanticide. The idea of controlling the number of children is certainly not new. Moreover, ample evidence of crude contraceptive use and knowledge stretches far back in human history as will be discussed in more detail in the following section (Himes, 1936; McLaren, 1990; Noonan, 1966; Poston and Bouvier, 2010).

The rebuttal to this lack of innovation on the parts of diffusion advocates is less than convincing. Supporting the diffusion perspective, Cleland refers to the work of Pollak and Watkins (1993) in his statement that "the innovatory element of pregnancy regulation within marriage may not take the form of new information about the biology of procreation but a more moral one of thinking (and then doing) the hitherto unthinkable" (2001:48). According to this rebuttal, fertility control must be within the calculus of conscious choice (Coale, 1973). In other words, the idea of preventing births or accommodating unwanted births may not be new, but the moral acceptance of these behaviors, primarily pre-natal contraceptive practices, is in fact an innovation. However, as noted earlier this line of reasoning is weak and unconvincing. This moral acceptance seems less like an innovation and more emblematic of a return to the norms and values regarding sexual behavior found in older civilizations. Thus, what appears as innovative in the 19th and 20th centuries is really a cyclical return to behaviors that were accepted in centuries past, all be it now armed with more effective means of contraception.

A second critique of diffusion theories, in particular the pure or ideational theories of innovation, objects to the role of ideas in two respects. First, favoring "ideational explanations of ideas about contraception is arbitrary and unnecessary" since "there is every reason to give equal or greater weight to ideas that influence the demand for children, namely, ideas about the costs and benefits of children, the roles of women and children, and so forth" (Casterline, 2001:13). Simply stated, why the idea of fertility control is so much more important than the equally compelling ideas driving a desire for fewer children is unfounded. Second, the belief that ideas are somehow isolated from economic and social structures is antithetical to the vast majority of social science (Casterline, 2001). As Casterline has noted:

> It is common in this [ideational] literature to perceive ideas and material conditions as alternative, even competing, causes of fertility change, a definition of the terms of the debate that demands that ideas can be separated from material conditions. Most social science theory does not accommodate such a relationship between ideas and material conditions: Palloni (2001) makes this point by drawing on mainstream sociological theory, and Carter (2001) recounts the rejection by anthropology early in the twentieth century of the notion of autonomous cultural diffusion, supplanted by functionalist theory that emphasized the capacity of societies to invent their own idiosyncratic solutions to common human problems. Most social scientists recognize that ideas are grounded in social and economic institutions (2001:11).

Therefore, the foundation of ideational theory, namely, the diffusion of innovative ideas concerning family limitation independent of economic and structural forces, is incongruent with most of the social science literature.

In sum, all of the theories of fertility decline discussed above have contributed in varying ways to our current understanding of the historic transition from high fertility regimes to low fertility regimes in vast regions of the globe. Yet, as demonstrated, each perspective has serious limitations in explaining the transition in all places at all times. More troubling is the reality that none of the perspectives reviewed above provide reasonable insights about the advent and the mechanisms of lowest low fertility societies, with the exception of the van de Kaa's "second" demographic transition theory. Furthermore, even those approaches that do provide some insights into the continual fertility decline witnessed in many countries fail to satisfactorily provide sound expectations for the future.

In the next section, I will briefly review the literature on sustained low fertility including a description of the demographic and social trends in low fertility societies, the timing and onset of low fertility, a discussion of the low fertility trap hypothesis, and the role of effective contraceptives in creating and sustaining low fertility regimes. As noted above, the existing theoretical perspectives fail to fully account for the continual fertility decline observed in many parts of the world. Therefore, it is important to explore newer paradigms that have the potential to make sense of the current fertility patterns.

Dimensions of Low Fertility Regimes

Recall that as of 2012, 117 out of 224 of the countries analyzed in the CIA World Factbook reported a total fertility rate of less than 2.1. Low fertility is now a demographic reality for many countries around the globe. As noted above fertility rates that fall below a TFR of 2.1 are considered “low fertility” and anything below a TFR of 1.3 is referred to as “lowest-low fertility” (Billari and Kohler, 2004; Kohler et al., 2002). Furthermore, the theories of fertility decline discussed in the previous section are valuable explanations of the fertility transition that occurred in the 20th century in many parts of the world. However, most of them , including demographic transition theory, have “nothing to say about the future of fertility” (Lutz et al., 2013:207). Even the concept of a second demographic transition says little about what will happen to fertility levels in the future (Lutz et al., 2013). For this reason, in this section I will examine three key areas of research. First, I will review the demographic and social trends that characterize low fertility societies. Second, I will examine the low fertility trap hypothesis. Finally, I will review the contributions of contraception to the development and persistence of low fertility societies.

Demographic and Social Trends in Low Fertility Societies

According to Lutz and colleagues (2013) there are six social and demographic trends that characterize low fertility populations, namely, 1. Trends in ideal family size, 2. Trends in education and the labor force, 3. Macro-level changes that impact the cost of childbearing, 4. The changing nature and stability of partnership, 5. Shifts in population composition, and 6. Changing biomedical conditions. There are many ways to organize a discussion of low fertility; this one, proposed by Lutz and colleagues (2013), is perhaps the most logical to date. These six dimensions of low fertility societies serve two functions. First, as these trends become dominant in a given population, fertility will decline. Second, as long as these patterns remain in place, fertility will remain at low levels and even continue to decline. Thus, these six dimensions help to both create and sustain low fertility regimes. Each dimension is discussed in detail below.

1. Ideal Family Size and Completed Fertility. The first dimension of low fertility populations is the incongruence that exists between desired fertility and completed fertility rates. It is well established now that many low fertility societies desire having more children than they will actually have (Bongaarts, 2001; Goldstein, Lutz and Testa, 2003; Hagewen and Morgan, 2005). There are several potential explanations as to why this difference between desired and completed fertility exists. Bongaarts (2002) has noted that the desire for two or more children is still common in many more developed countries. According to Bongaarts (2002), the deficit between desired and completed fertility is simply a consequence of the tempo effect. In other words, women still report wanting at least two children. Those same women, however, typically postpone childbirth until later in life. The delay in childbirth creates a lag between the first record of intentions and the actual birthing of children. Bongaarts (2002) therefore argues that once the tempo effect has passed, the deficit between desired fertility and completed fertility will decline and perhaps disappear. Furthermore, as the deficit between desired and completed fertility passes away, the total fertility rate will move towards replacement levels.

Demeny (2003) makes a similar argument. However, he suggests that the deficit could continue indefinitely. Rather than attribute the difference between desired fertility and completed fertility to a tempo effect, Demeny (2003) suggests that the deficit occurs in response to competing preferences. For example, women may really want two children, but as they age their preferences may evolve and shift such that competing preferences become more important. It is possible that as a woman advances through the various stages of her career, the cost of having additional children increases thereby shifting her preference to continuing to progress in her career over having additional children. Ultimately, the competing preferences win out over higher parities. Yet, the imbalance between desired fertility and completed fertility remains so long as women at younger ages continue claiming they want at least two children.

Goldstein and colleagues (2003) present an alternative view compared to the previous two perspectives. According to their research, desired family size in Europe has actually declined. These declines have reduced the deficit between desired family size and completed fertility. More importantly, reductions in desired fertility suggest that fertility preferences are not just competing with alternative preferences, i.e., are a function of the tempo effect, but are in actuality indicative of a new low fertility reality. In other words, as people come of age in a low fertility society, their fertility preferences are biased downwards. Low fertility, in turn, influences individuals to desire fewer children. From this perspective, low fertility reinforces low fertility preferences and creates a negative self-perpetuating cycle sustaining low fertility.

In my mind, the approach developed by Goldstein and colleagues (2003) is the most plausible of the three perspectives discussed above. The other two perspectives have severe limitations. The reliance of Bongaarts on the tempo effect as an explanation of the discrepancy between desired fertility and completed fertility fails to provide an adequate explanation for the nearly 30 countries in which fertility fell below 1.5 and have been unable to rebound (Lutz and Skirbekk, 2005). If the difference were solely attributable to the tempo effect, then we would expect many of these countries to see an increase in fertility rates as the mean age at first birth begins to stabilize.

The argument developed by Demney (2003), which focuses on competing preferences, is incompatible with new evidence that in parts of the world there is a real change in desired family size (Goldstein et al., 2003). These changes suggest that women from an early age now desire a smaller number of children. Furthermore, in a multilevel analysis with controls for a number of economic and social predictors of fertility, Testa and Grilli (2006) found that desired fertility was much lower among young adults whose parents had few births. This research is important for two reasons. First, it demonstrates that desired fertility from very early stages is declining and not just a consequence of competing perspectives as women age, as suggested by Demney (2003). Secondly, these findings further support the perspective presented by Goldstein and colleagues (2003) that young adults raised in low fertility regimes adopt those norms as their own ideal family size.

2. Trends in education and the labor force. The second dimension of low fertility populations involves substantial shifts in mass education and labor force opportunities. With respect to education, there is little dispute that increased education, particularly for women, has a negative effect on fertility. Researchers for decades have identified education as a key determinant of fertility decline (Cleland and Rodriguez, 1988; Cochrane, 1979; Notestein, 1953). In fact, the empirical relationship between education and fertility is "one of the most consistent findings in the literature" (Hirschman, 1994:222).

Caldwell (1980) described several dimensions in which education decreases fertility. For example, mass education limits the ability of the child to work in or outside the home. He showed that education not only limits the amount of time children have during the day to work, but that it changes the way that children are perceived and the way they perceive themselves. Once children enter the education system parents feel a need to provide more for the children in terms of clothing, food, and time. Parents and uneducated siblings are less likely to expect school children to participate in daily chores, thus allowing school children to focus all of their energy on educational tasks. Caldwell (1982) also suggests that education plays a large role in reversing the flow of wealth from children to parents, thus limiting the need for a large number of children because education increases the cost of each child. Interestingly, Caldwell (1980) also notes that the advent of a mass education system is the key, and this is not simply because of increasing literacy rates. Literacy taught in the home does little to change the family dynamic necessary to affect fertility.

More recently, Martin (1995) has noted that the relationship between education and fertility is perhaps more complicated than previously thought:

> The analysis undertaken for this study suggests that women's education does not have identical repercussions in every society, but is conditioned by socioeconomic development, social structure, and cultural context, as well as by a society's stage in the fertility transition. In general, the impact of individual schooling on reproductive behavior is weak in poor, mostly illiterate societies, grows stronger as societies improve their overall education and advance in their fertility transition, and becomes less prominent once a relatively low level of fertility has been reached (Martin, 1995:199).

Admittedly, variables rarely, if ever, exist in isolation. It should come as no surprise then that the effect of education on fertility rates does not exist in a vacuum. Instead, the effect of education on fertility is dependent on the country’s stage of development and current level of fertility. Based on this approach I would expect that education should become less of a factor in countries with low fertility. Nonetheless, the education system continues to serve as an important agent of socialization in terms of fertility behaviors and as such will continue to impact fertility to some extent.

Finally, education is often related to changes in the labor market. As societies develop, more educational opportunities become available and high paying jobs demand more technical skills. To be competitive in this market, everyone, women included, must invest more in their education. Then, once in the job market, people must invest time and energy to their career. This investment, first in education and then in a career, encourages women to postpone childbirth (Kasarda, 1971). As women become integrated into the labor force and they see an increase in their wages, the opportunity costs of bearing children also increase creating a negative effect on fertility (Becker, 1981). The relationship between labor force participation and declining fertility is widely accepted and well documented in the literature (Boling, 2008; Oppenheimer, 1994).

3. Macro-level changes that impact the cost of childbearing. According to Lutz and colleagues (2013), there are a number of macro-level conditions that also serve to influence the cost of childbearing; these include government policies favoring or dissuading fertility, access to childcare facilities, and housing opportunities. Most of these government policies can be broadly categorized into two types: policies of fertility limitation, and pronatalist policies.

Fertility limitation policies grew largely out of the Malthusian fear of overpopulation, which intensified in the late 1960's and throughout the 1970's. By 1976, 40 of 156 countries covering a broad spectrum of development had policies limiting fertility (Tsui, 2001). Only 20 years later the number of countries with policies aimed at lowering fertility rose to 80 (Tsui, 2001). Thus, much of the development in fertility policy took place in the latter half of the 20th century. India is one of the first countries to institute a fertility policy to facilitate a decline in fertility; this occurred in 1952. India was followed by Pakistan, the Republic of Korea, China, and Fiji during the period from 1960 to 1962; most of the developing countries developing policies did so in the late 1960's and early 1970's (Tsui, 2001).

The most well known fertility limitation policies were developed in China beginning in the early 1970's, and culminating in 1979 with what became known as the One Child Policy. The movement has its origins in State Directive number 51, issued in 1971, known as *Wan Xi Shao*, which literally means longer, later, fewer, meaning that couples should have "later marriages, longer intervals between children, and fewer children" (Poston and Bouvier, 2010:257). In 1979 the Chinese government instituted the One Child Policy. Interestingly, the main architect of the policy, Song Jian, had virtually no demographic training but had worked in the missile defense industry in China. Song was heavily influenced by the ideology stemming from the Club of Rome and backed by technological advantages such as state of the art statistical models and graphs that ultimately won over many politicians (Greenhalgh, 2008). Despite the opposition of other groups within the Chinese government, the One Child Policy went into effect.

Initially the policy simply encouraged compliance through positive sanctions. For example, in Beijing "incentives included a bonus of approximately 60 Yuan annually until the child turned fourteen years-old and they also provided preferential treatment in education, health, housing, and job assignment" (Currier, 2008:369).Yet, when it became apparent that such positive sanctions were not having the intended effect, the Chinese government turned to stricter and more Draconian sanctions. These included "severe fines, ration restrictions, and the denial of registration for higher order births (with implications for health, education, housing" as well as "mandatory IUD insertions, regular birth control and menstrual checks, forced abortions, and, in the case of repetitive violations, forced sterilization" (Currier, 2008:369). The results of this policy vary somewhat by location. Fertility rates fell quite rapidly in the more developed regions of China but remained somewhat high in more agrarian rural communities. In the agricultural dependent communities, the One Child Policy morphed into a de facto two child policy recognizing the need for more help on the family farm (Currier, 2008).

Two crucial trends surfaced in the wake of the One Child Policy. First, in China an unprecedented rise in the sex ratio at birth has led to an incredibly high sex ratio imbalance such that in the very near future vast proportions of Chinese men will be unable to find a wife (Poston, 2005). The combination of severe family limitation and strong cultural preference for sons has created a demographic crisis in China. The second trend that emerges following the Chinese experience relates to changes in how the international community approached demographic targets and goals as well as the role of women in fertility limitation. The Chinese example, in particular the more stringent negative sanctions, presents a pretty clear case of humanitarian violations. In the years that followed the initiation and implementation of the One Child Policy, culminating in 1994 at the International Conference on Population and Development in Cairo, a new international agenda emerged focusing on the more modest efforts to promote fertility decline without the use of unrealistic demographic targets.

Furthermore, developments at the Cairo conference turned out to be a significant turning point in the history of fertility limitation policy in that this was the first time in which many policies included concerns over women's complete reproductive help moving away from severe penalties that often unfairly targeted women (Connelly, 2008).

As noted above, many other countries also developed similar fertility limitation policies, but few rivaled the Chinese in respect to the severe measures enforcing the policy. Ironically, many countries today still have remnants of fertility limitation policies in place, although most countries today scarcely need be concerned with high fertility. On the contrary, numerous more developed nations today are scrambling to generate pronatalist policies that will hopefully have a positive influence on fertility rates.

Pronatalist policies, by definition, are policies directed toward increasing fertility rates. Hugo (2000) categorizes pronatalist policies into two groups differentiating direct policies from indirect policies. According to Hugo:

> Direct pronatalist policies involve direct attempts to influence fertility by offering incentives to those who have children and disincentives to those who choose to have no children. These types of policies involve cash payments for each child, privileged access to state housing, medical or education services, taxation incentives or disincentives related to children, etc. Indirect pronatalist policies involve interventions which seek to change the environment in which couples make decisions about the number of children they intend to have. These are sometimes referred to as 'family-friendly' policies (2000:188).

The effort to differentiate policies is noble but unconvincing and unnecessary. Pronatalist policies, direct or indirect, encourage higher fertility. Sometimes those policies involve cash payments or tax breaks to parents or tax hikes on childless households. Other policies try to level the playing field for women moving in and out of the labor force as a result of childbearing by alleviating the motherhood penalty and associated tasks of rearing children that continue to fall disproportionately on women (Budig and England, 2001; McLanahan and Percheski, 2008). Either way, the end result is the same, i.e., to negate the opportunity costs and physical costs of raising children. Therefore, the only reason to differentiate direct from indirect pronatalist policies is if one produced better results than the other. Thus far there is no evidence to suggest that either of these policy approaches has been very successful (Hugo, 2000).

For example, Japan has instituted a number of plans in the last decade or so known as the Angel Plan (Boling, 2008). The Japanese approach includes a combination of direct and indirect efforts including monthly stipends per child for the first 12 years of life, 14 weeks of maternity leave paid at 60 percent of salary, an optional 1 year parental leave at 40 percent of current salary, assistance with childcare expenses, access to early childhood education, several tax benefits, as well as other benefits paid out by private employers (Boling, 2008). Furthermore, the majority of these benefits are available to part time employees (Boling, 2008). Despite these extraordinary efforts, the fertility rate in Japan remains very low at 1.34 (United Nations, 2013).

Other countries have encountered limited success with pronatalist policies. France, for example has more generous policies in place compared to those in Japan (Boling, 2008). The total fertility rate in France fell to a low of 1.72 in the early 1990's and has since rebounded to 1.95 in 2010 (United Nations, 2013). This suggests that, to some extent, pronatalist policies have had a positive effect on total fertility rates in France (Toulemon, Pailhé and Rossier, 2008). However, the slight increase could be attributed to other sources. For instance, immigration has a known positive effect in many of the developed western nations when the sending country reports a higher fertility rate than that of the host country (Coleman, 2006). France, in particular, is home to a large number of Muslim immigrants who have maintained a much higher fertility rate of 3.2 (Coleman, 2006). Therefore, it is difficult to attribute much of the gains in the French TFR to pronatalist policy. It is more likely that the bulk of the gains to the TFR in France are due more to the high fertility subgroups, i.e., the Muslims, now residing in France.

Finally, the vast majority of family friendly policies have failed to produce major results; most are modest in nature (Lutz and Skirbekk, 2005). Furthermore, most countries with TFRs of 1.5 or less seem to have difficulty in raising their TFRs, suggesting that their pronatalist policies are relatively insignificant (McDonald, 2006). Moreover, evidence suggests that even in the countries of Northern Europe, often held as the gold standard of family friendly policies, pronatalist policies have at best slowed the fertility decline, with few if any countries showing any long-term increases (Grant et al., 2004).

4. The changing nature and stability of partnership. The next dimension of low fertility regimes focuses on trends in union formation and stability, both of which contribute to sustained low fertility. Clearly, union formation and the stability of long term relationships have changed over the last fifty years, and though "the most common family form is still one male and one female who embark upon a long-term commitment" many current trends now challenge the norm (Lutz et al., 2013:210). The effect of union formation and stability on fertility operates through three key mechanisms including cohabitation, increases in the mean age at marriage, and voluntary childlessness.

The growing popularity of cohabitation as an alternative or precursor to standard marital relationships plays a crucial role in declining fertility rates. A fundamental characteristic of the move towards low fertility regimes, commonly referred to as the second demographic transition (see my discussion earlier in this chapter), involves a "shift from the golden age of marriage to the dawn of cohabitation" (Van De Kaa, 1987:11). In the United States cohabitation is one of the fastest growing trends in union formation (Cherlin, 2010). This pattern is found throughout the western world, although, cohabitation in Western Europe and Canada tends to be of a longer duration (Cherlin, 2010). In either case, cohabitation is indicative of a shift in emphasis. Historically, one of the fundamental roles of marriage or partnership was the bearing and rearing of children. However, the rise of cohabitation signals the end of the "era of the king-child with parents" and the beginning of the era of the "king-pair with *a child*" (Emphasis Added:Van De Kaa, 1987:11). In other words, changes in family formation are emblematic of more substantive changes in family ideals such that couples are more interested today in increasing union satisfaction and less concerned with childbearing. Moreover, Van De Kaa's (1987) wording is particularly keen in that he identifies the shift in family size from children in marriage to *a child* in cohabitation.

Interestingly cohabitation, in and of itself, is not necessarily emblematic of changes in the desired number of children because cohabiting couples do not necessarily desire fewer children (Sobotka, 2008). Furthermore, cohabiting unions increasingly account for a greater proportion of births. In the United States alone, 40.8 percent of births were to unmarried mothers in 2010 (Hamilton, Martin and Ventura, 2011). Yet, the unstable nature of cohabitation lowers fertility since couples routinely fail to achieve desired fertility levels prior to union dissolution (Manning, 2004; Manning, Smock and Majumdar, 2004; Wineberg, 1990). Moreover, while conceiving a child during cohabitation increases relationship stability, nonmarital births significantly decrease relationship stability relative to childbearing within marriage.

However, not every country has witnessed increasing rates of cohabitation. In many of the more socioeconomically advanced countries of Asia, rates of cohabitation have remained relatively low (Sobotka, 2008). Thus, while many Asian countries have also witnessed an increase in the number of women remaining single as is the case in the United States and Europe, Asian women are not transitioning into cohabiting, or marriage-like, relationships but are choosing to remain single (Jones, 2007). Instead, women in many parts of Asia such as Japan, Korea, and Taiwan are postponing the transition into marriage and parenthood. Thus, there is little evidence of cohabitation in Asia, but the mean age at marriage and subsequently the mean age at first parity is increasing.

The postponement of childbearing is not, however, unique to Asian countries. Virtually, every country that has slipped below replacement level fertility has also witnessed a parallel increase in the mean age at marriage (Sobotka, 2004). The postponement of childbearing until later ages tends to increase the likelihood that women will be unable to achieve their original desired family size since the probability of conception begins to decline as early as age 30 with substantial reductions by age 35 (Lutz et al., 2013). Moreover, the postponement in childbearing, known as the tempo effect, is cited as artificially suppressing fertility rates; hence, once the trend towards postponement has subsided fertility rates, should again rise to near replacement levels (Bongaarts, 2002; Morgan, 2003; Sobotka, 2004). However, much of the evidence to date suggest that in a best case scenario, total fertility rates may rise by a modest 0.1 or 0.2 in some countries (Goldstein, Sobotka and Jasilioniene, 2009). Additionally, in many countries the fertility rate will likely remain at a low rate and potentially continue to decline (Billari and Kohler, 2004; Lutz et al., 2006).

A final disturbing pattern that has accompanied changes in union formation and stability is the growing prevalence of women voluntarily remaining childless. The proportion of women remaining childless has grown in the United States such that in 1976 about 11 percent of women between the ages of 35 and 39 were childless compared to 20 percent of women in the same age group by 2002 (Abma and Martinez, 2006). Similarly, approximately 10 percent to 20 percent of women in Europe are currently childless (Rowland, 2007). These statistics, however, are a bit misleading since the broad category of childless women include women who are temporarily childless (i.e. who intend to have a child later on), involuntarily childless, as well as women that are voluntarily childless. The proportion of women who are voluntarily childless is much lower, on the order of around 9 percent in the United States (Abma and Martinez, 2006).

Women who remain voluntary childless are often more educated, hold more prestigious occupations, generate higher incomes, and hold less traditional family values compared to their childbearing counterparts (Abma and Martinez, 2006; Livingston and Cohn, 2010). Based on these characteristics it is believed that voluntarily childless women choose to forego motherhood due to the high opportunity costs that childbirth entails. Regardless of motivation, increases in the levels of voluntary childlessness will certainly be related negatively to overall fertility levels.

5. Shifts in population composition. Another dimension of low fertility regimes involves the variation in key demographic characteristics of population subgroups. The most obvious factor is the variance in fertility among a country's migrant stock. In Europe, for example, "specific ethnic or religious subgroups of the population have fertility rates that are twice the national average" (Lutz et al., 2013:210). In 2010 the United States had an overall total fertility rate of 1.93 (Martin et al., 2012). Yet, closer inspection of various subgroups reveals a fair amount of variation in fertility. American Indians and Alaskan Natives, Asian and Pacific Islanders, and non-Hispanic whites report the lowest levels of fertility with TFR's of 1.40, 1.69, and 1.79 respectively. U.S. subgroups with higher TFR's include non-Hispanic Blacks with a TFR of 1.97 and Hispanics with a TFR of 2.35 (Martin et al., 2012). Therefore, in the United States in 2010 there was a difference of nearly one child between the subgroup with the highest and lowest TFRs. Although, American Indians and Alaskan Natives exhibit the lowest TFR their share of the population (1.2%) is not substantial enough to dramatically influence the nation's TFR. On the other hand, in 2010 Hispanics accounted for 16.3 percent of the U.S. population making them the largest minority group and thereby more capable of influencing the fertility of the entire country (Ennis, Ríos-Vargas and

Albert, 2011). Therefore, as the size of migrant stocks with particularly high fertility rates increases in countries around the world, the respective fertility rates of the countries are also likely to increase. Similar trends are evident in France with the growth in the Muslim population (see my earlier discussion).

Initially, trends in migration occurring in the more developed countries tend to have a positive effect with regard to combating low fertility. However, such an assumption may be, at the very least, overenthusiastic. There are three opposing trends that often limit the contribution of population subgroups to bolstering slowing fertility rates. First, as population subgroups assimilate into the culture of the host country, the subgroup fertility tends to decline. For example, just a little over 10 years ago the total fertility rate of Hispanics in the United States was estimated at 2.73 and in a decade has fallen to 2.35 (Martin et al., 2012). Assuming these trends continue, in a matter of 15 to 20 years Hispanic fertility will likely catch up to non-Hispanic white fertility. Moreover, it is quite common for fertility among immigrants to increase immediately after their immigration so as to compensate for births that were postponed due to travel (Ford, 1990). Yet, once groups begin to assimilate and take on many of the values of the host culture, including preferred family size, fertility begins to decline (Ford, 1990).

The second limitation of the ability of the population subgroups to increase low fertility involves the political apprehension expressed by many host countries. Countries such as the United States and the United Kingdom have developed an interesting stance with regard to immigration. For the most part, more relaxed and flexible policies on immigration are favored among the social and political elites, but these policies often fail to gain favor with the general public (Coleman, 2006). Furthermore, in many regions of Asia, including Japan, Korea, and China, immigration flows are more modest in response to more restrictive immigration policies. Nonetheless, the level of migrants required to substantively overturn declining fertility rates is of such a large magnitude that it is improbable in most cases and impossible in others (Coleman, 2006). The United Nations has developed the concept of "replacement migration" to show empirically exactly the magnitude of immigration to a country that would be needed to maintain a specified level of population. The numbers of immigrants needed to move host countries in most all circumstances are astounding.

Third, assuming that large scale migration was suddenly possible in the majority of low fertility nations, the incoming migrants comprising these population subgroups would have to maintain current high levels of fertility. Frequently, this has not been the case. The migration flow from Mexico to the United States offers one such example. As noted above, the TFR of Hispanics in the United States has been steadily declining in step with virtually every other main racial or ethnic subgroup in the United States. It is likely that this decline in fertility is partially in response to assimilation. However, it is also essential to note that the total fertility rate of Mexico has plummeted over the past forty years. In 1970 Mexico had a TFR of 6.72; it fell to 2.32 by 2010 (World Bank, 2013b). This rapid decline in fertility of any given country of origin will typically impact the fertility of the subgroup in the host country. Furthermore, the majority of countries around the world are currently experiencing declines in fertility. Therefore, even if low fertility countries enact liberal immigration policies, the declining fertility of the sending countries will not substantially offset the low fertility already in place in the host nations.

6. Changing biomedical conditions. The last of the six dimensions of low fertility regimes discussed by Lutz and his colleagues (2013) addresses the changing levels of involuntary childlessness, declining fecundity at older ages, and declining sperm counts. For the sake of clarity, I will define involuntary childlessness as synonymous with impaired fecundity, which is defined as "the inability of cohabiting as well as married couples to have a baby for any reason other than a sterilizing operation and includes the inability to carry a baby to term or the lack of a pregnancy after three years or longer of trying to conceive" (Chandra et al., 2005:22). Involuntary childlessness can occur for a variety of reasons. One of the strongest predictors of involuntary childlessness is the woman's age simply because as she ages, the likelihood of conceiving decreases dramatically (Shanley and Asch, 2009). Women are born with a finite number of eggs that age and decline in viability over a life time. Specifically, the female's eggs develop from primordial follicles, which are present in her ovaries while the female is "in utero." Typically, the female fetus will develop around 7 million follicles by the end of the second trimester (Wood, 1994). The follicles then begin a process of depletion and decline in number with her age (McKibben and Poston, 2003). Thus, as women age the chance of remaining involuntarily childless increases. Other known causes of involuntary childlessness include blocked fallopian tubes as a consequence of pelvic inflammatory disease, Chlamydia, or Gonorrhea, and exposure to environmental or workplace toxins (Shanley and Asch, 2009). Data from the National Survey of Family

Growth estimate that roughly 12% of women in the United States suffer from impaired fecundity, which is a significant increase from 8.4% in 1982 (Chandra, Copen and Stephen, 2013). This pattern of increasing involuntary childlessness, or impaired fecundity, is also common in other parts of the world, particularly in Europe (Lechner, Bolman and van Dalen, 2007; Letherby, 2002; Rowland, 2007).

These trends are further complicated by the increasing age at marriage and the postponement of childbearing. As noted above, a women's reproductive lifespan is finite beginning with menarche and generally ending in menopause. Therefore, as women continue to postpone childbearing, many will find it difficult to achieve their initial desired family size simply because fecundity is highly correlated with age. Moreover, the sharp increase in assisted reproductive technologies (ARTs) suggests that men and women are increasingly finding it difficult to procreate on their own (Lutz et al., 2013). Recent estimates propose that roughly 7 percent of births to Danish parents occurred through unnatural means (Skakkebaek et al., 2006). Yet, impaired infecundity at older ages is not the only biological shift limiting fertility. Men, too, are experiencing biological changes that will likely result in lower fertility rates.

Though it has not garnered much attention in the sociological or demographic literature, changing patterns in semen quality and quantity documented in the medical literature in many parts of the world suggest that a new generation of men may find it difficult to produce offspring (Lutz et al., 2013). Investigations of semen quality among Danish men have found that 30 percent of men in that population are considered to have subfertile semen and as many as 10 percent as having infertile semen (Jørgensen et al., 2001). These findings have led some researchers to conclude that today approximately 20 percent of men in Denmark will be incapable of reproducing without the assistance of costly assisted reproductive technologies (Jensen et al., 2004; Jensen et al., 2007). Furthermore, it appears that much of the loss of male fecundity is due to a condition known as Testicular Dysgenesis Syndrome (TDS) (Skakkebaek et al., 2006). TDS and subsequent male infecundity are "caused by a number of factors, including postnatal infections, accidents, chemotherapy, genetic aberrations causing meiotic arrest and many others" including genetic and environmental factors (Skakkebaek et al., 2006:6). Other risk factors that are currently being explored include endocrine disrupters, or chemical compounds known to interfere with the endocrine system (Skakkebaek et al., 2006). Often times these chemicals are used in industrial processes and manufacturing plants. Still, other factors include the relationship between male infecundity and obesity as well as infecundity and sedentary occupations (Jensen et al., 2004; Skakkebaek et al., 2006).

Regardless of cause, evidence suggests an increase in male infecundity in many parts of the world. This trend, coupled with rising rates of female infecundity, will help create and sustain low fertility regimes. Assisted reproductive technologies (ARTs) may be able to offset changes in fecundity, but the effect size is debatable. ART's are certainly far from reliable in terms of conceiving a child and enabling that child to be carried to full term. Moreover, the cost of ART's is astounding and rarely covered under medical insurance policies. Drugs that stimulate ovulation can cost between $1,000 and $5,000 per cycle with estimates of the cost of procedures such as in vitro fertilization

(IVF) ranging from $10,000 to $15,000 per cycle (Shanley and Asch, 2009). Thus, the cost of ART is prohibitive for most people.

In sum, these six dimensions of low fertility together influence fertility in a negative direction and help to sustain low fertility regimes. However, they do not necessarily constitute a theoretical perspective. Each dimension is correlated with fertility, and there is evidence of each dimension's negative effect on fertility. Nonetheless, taken independently these dimensions lack the causal and predictive qualities generally associated with a strong theory. However, Lutz and Skirbekk (2005) have remedied that problem with their introduction of the Low Fertility Trap Hypothesis (LFTH), which I will now discuss.

The Low Fertility Trap Hypothesis

The Low Fertility Trap Hypothesis was first introduced by Lutz and Skirbekk (2005) and more clearly defined by Lutz, Skirbekk, and Testa (2006). The basic premise of LFTH is simple. There are basically two types of low fertility countries, those that stay above a TFR of 1.5 and those that fall below 1.5 and have yet to escape. Based on this observation the authors hypothesized that countries that fall below the level of 1.5 indeed are trapped "if a trap is defined as an unpleasant situation (governments would rather see higher fertility) into which one enters unintentionally and which it is very difficult to get out of" (Lutz et al., 2006:173). The low fertility trap is triggered by three different mechanisms: demographic, social, and economic.

The demographic mechanism largely focuses on the interplay between the age structure of the population and the number of births. This relationship is best summed up by the concept of population momentum in that the number of women of childbearing ages directly impacts the number of births in the population. In the context of low fertility, as women of childbearing ages have fewer children, there will be fewer women of childbearing ages in the future to produce the same number of births. As this cycle repeats populations develop a skewed age structure with more women concentrated at older ages and fewer potential mothers to replace them. Thus, the effect of declining fertility rates will continue to decrease the total number of births of a population long after fertility rates have stabilized or even improved; this is so because low fertility has altered the age structure of the population.

The second mechanism, which the authors refer to as "sociological reasoning," corresponds to fluctuations in ideal family size and levels of achieved fertility (Lutz et al., 2006:175). As noted above, research shows that in many countries today ideal family size tends to be higher than actual achieved fertility levels, and, moreover, ideal family size appears to be declining (Goldstein et al., 2003). The LFTH assumes that declines in ideal family size were actually triggered by low fertility levels of the preceding years. In other words:

> It is assumed that through the processes of socialization and social learning, the social norms and in particular the family size ideals of the young generation are influenced by what people experience around themselves in term of families with young children. The fewer the children belonging to the environment that young people experience, the lower the number of children that will be part of their normative system in terms of what is a desirable life (Lutz et al., 2006:176).

Growing up in a lower fertility society, therefore, creates a feedback loop in which young adults internalize a new low fertility norm. Moreover, as with the demographic mechanism, the social mechanism becomes self-perpetuating as new generations encounter even lower fertility norms such that:

> Once the number of children (siblings, friends, children seen in other families, media) experienced during the process of socialization falls below a certain level, one's own ideal family size would become lower, which in course may result in a further decline in actual family size and still lower ideals in the subsequent generation (Lutz et al., 2006:179).

The social mechanism of the LFTH is then best understood as the feedback loop between low fertility norms and declining ideal family size so as to further decrease actual fertility.

The third and final mechanism of the LFTH deals with the economic determinants of fertility. The “economic rationale” borrows heavily from Richard Easterlin’s (1980) relative income hypothesis (Lutz et al., 2006:176), a part of which states that ” it is not the absolute (expected) income that matters, but rather income relative to aspirations that are largely formed in one's youth, and greatly dependent on the standard of living in the parental home” (Lutz et al., 2006:176). According to this perspective, young adults attempt to rationally balance expected income against a desired lifestyle. The enormous financial investment need to bear and raise children is often viewed as a barrier to the desired lifestyle given the rather stringent and fixed income of most young adults today. In fact, “a more pessimistic economic outlook for today's younger generations, which is widely documented in opinion surveys” coupled with the reality that “aspirations for material consumption are probably higher today than they ever were before" suggest that the economic calculations will further discourage upcoming generations from childbearing at any substantial rate (Lutz et al., 2006:176-7).

In sum, the Low Fertility Trap Hypothesis suggests that the three mechanisms, demographic, social, and economic, will continue to negatively influence the number of births in low fertility countries. This self-perpetuating cycle will make it difficult if not impossible to reverse the trends in low fertility. Countries will then effectively find themselves trapped in a low fertility regime.

Moreover, Lutz and colleagues (2006) astutely observed that the problem facing many countries today is quite different compared to the problems perceived by countries only five or six decades ago in that:

> while it is a relatively clear argument that couples who do not have access to acceptable forms of contraception have more children than they want, and that making such services available will result in closing the gap, it is less clear what should be made available to couples that have fewer children than they say they want (Lutz et al., 2006:177).

Thus, the problem facing policymakers today is how to address the situation of couples who consistently fail to achieve their stated desired fertility goals. The clear solution to overpopulation in past years was to increase contraceptive prevalence, thereby reducing the total number of births. Yet, the solution to today's demographic problem is far more complicated. The questions now becomes how do we encourage couples to have more children.

Based on the logic of the Low Fertility Trap Hypothesis, it is possible for countries to enter a continual downward spiral with a fertility rate decreasing to zero.

However, one critique of the LFTH suggests that evolutionary biology has hardwired all species to seek adequate levels of reproduction for the survival of the species. Therefore, void of any severe environmental factors such as a severe famine or plague, it is claimed that human fertility will never fall low enough to threaten the viability of the species. Two facts, however, stand in opposition to such an approach. First, such a criticism has a difficult time accounting for the constant increases observed in childlessness. Based on the preceding logic childlessness would certainly challenge the general viability of the species. Secondly, and perhaps more importantly, the link between sexual activity and the perpetuation of the species has been effectively severed through contraception. According to Lutz and colleagues:

> From an evolutionary perspective, these are seemingly reasonable assumptions because a species without a drive to reproduce would not have survived to this day. But there is a strong counterargument, namely, that through the introduction of modern contraception, the evolutionary link between the sex drive and procreation has been broken and now reproduction is merely a function of individual preferences and culturally determined norms (2006:172).

Therefore, the internal biological drive to reproduce has been overshadowed by modern effective means of contraception and the prevailing low fertility norms. The Low Fertility Trap Hypothesis fails to formally acknowledge the role of contraceptives any further than the above statement. The lack of attention to the role of contraception is not fully damning but perhaps better characterized as a substantial oversight. Thus, LFTH like many of the other theories of fertility decline discussed earlier ignores the substantial contribution of contraceptives to the development and entrenchment of low fertility regimes. In the next section, I review the literature on contraception, particularly that literature evaluating the contributions of contraceptives to patterns of low fertility.

Contraception & Low Fertility

The complete history of the development of contraception is beyond the scope of this review. A number of books have very adequately recounted the full history of contraception including *The Medical History of Contraception* by Norman Himes (1936), *Contraception: A History of Its Treatment by the Catholic Theologians and Canonists* by John T. Noonan (1966), *A History of Contraception* by Angus McLaren (1990), and *Contraception: A History* by Robert Jütte (2008). I provide now a brief account of the development of contraception.

The idea of preventing pregnancy and birth is by no means new. In fact, “man’s attempts to control the increase in his numbers reach so far back into the dim past that it is impossible to discern their real origin” (Himes, 1936:3). The earliest recordings of contraceptive and abortive methods are found in Egyptian papyri dating back to between 1900 and 1100 B.C. (Noonan, 1966). However, for most of human history the existing methods of contraception were highly ineffective, with the exception of induced abortion and withdrawal (Poston and Bouvier, 2010). It was not until the 18th century that the first more effective means of contraception was introduced, namely condoms (Himes, 1936). The most effective forms of contraception were not developed until the end of the 19th century and well into the 20th century. Thus, while contraceptives have existed for thousands of years, effective contraception is relatively new. Not surprisingly, much of the fertility decline witnessed over the past one hundred years coincides with the development and production of some of the most effect means of controlling fertility.

Generally, methods of contraceptives are divided into the two categories, modern and traditional. Traditional contraceptives include devices and techniques that are generally less effective such as coitus interruptus (withdrawal), prolonged breastfeeding, long term abstinence, and the older forms of fertility awareness-based methods (FABMs) such as the rhythm method. Modern contraceptives, on the other hand, are considered to be far more effective and include methods such as hormonal contraceptives (the pill, injectables, patches, and so forth), intrauterine devices (IUDs), the male condom, spermicides, sterilization procedures, as well as contemporary FABMs (natural family planning) including the Standard Days Method, Sympto-Thermal Method (STM), Billings Ovulation Method, Creighton Fertility Care System, and the Marquette Model System. The difference between traditional and modern methods of contraceptives is not simply a function of when the method was introduced; it is based more on the method's effectiveness at preventing unwanted pregnancies.

The effectiveness of contraceptives, with most methods, largely depends on proper usage. Therefore, the literature on contraceptive efficacy differentiates between theoretical or perfect use and actual or typical use. A woman who uses a particular method perfectly is said to use that method "consistently according to a specified set of rules" (Trussell, 2004:91). Alternatively, typical use commonly refers to "how effective methods are for the average person who does not always use methods correctly or consistently" (Trussell, 2004:89). Both of these definitions are intentionally vague so as to accommodate all the various types of contraceptive methods. For example, consider the difference between the pill, an injectable such as Depo-Provera, and coitus interruptus. The pill typically requires the woman to take the prescribed dose each day and roughly at the same time of day to reach maximum effectiveness. Deviation from the schedule limits, or perhaps even diminishes all together, the method's effectiveness (Glasier and Gebbie, 2008). Depo-Provera, an injectable, on the other hand only requires the woman to receive a single shot every 12 weeks (Glasier and Gebbie, 2008). Both of the above methods require less attention and skill than withdrawal, which relies on "discipline on the part of the male and is practiced most successfully by men able to recognize the imminence of orgasm and withdraw quickly prior to ejaculation" (Glasier and Gebbie, 2008:171). Thus, the definition of perfect use and typical use varies widely from one method to next. Furthermore, the most effective methods of contraception have a smaller difference between typical and perfect use.

In terms of actual rates of effectiveness, modern methods typically outperform traditional methods and women using no contraceptive method. For example, research suggests that on average 85 percent of women using no form of contraception will experience an unintended pregnancy in the first year (Trussell, 2011). More traditional methods of contraception such as withdrawal and older forms of FABMs under the context of typical use will result in between 22 percent to 24 percent of women experiencing and unintended pregnancy in the first year (Trussell, 2011). Modern methods of contraception are generally more effective than traditional methods though some methods such as spermicides (28 percent failure) and male condoms (18 percent) have a typical use similar to, if not worse than, traditional methods. However, when we limit modern methods to hormonal methods (pill=9%; Depo Provera=6%), IUDs

(Mirana=0.2%), and sterilization (male=0.15%; female=0.5%) the effectiveness vastly improves (Trussell, 2011).

Surprisingly, even traditional methods of contraception substantially reduce the number of unintended pregnancies experienced over the course of the first year. Withdrawal, for example, with a typical use effectiveness rate of 22 percent has the ability to dramatically influence aggregate fertility rates. It has been well documented in the literature that France began and nearly completed its fertility transition with the use of coitus interruptus (Van de Walle, 1974). However, the inefficiency of traditional methods dramatically slowed the pace of fertility decline. It took France over one hundred years to reach a stable fertility rate. Countries such as Thailand and Mexico began their fertility decline much more recently and proceeded at an unprecedented rate largely as a function of modern effective contraceptives. Both countries were able to reduce total fertility levels from a high of over 6 children per woman down to nearly 2 children per woman in a little over 30 years. Nonetheless, any discussion of the tremendous impact of contraceptive prevalence on rapid fertility declines at an aggregate level is largely absent from the literature. In this dissertation I will attempt to address this void.

Moreover, the literature on contraception has virtually and unilaterally focused on increasing contraceptive prevalence, i.e., getting contraceptives into the hands of more users. Generally, this literature is framed as the campaign to decrease the unmet need for contraception (Bongaarts, 1991; Bongaarts and Bruce, 1995; Bongaarts and Elof, 2002; Casterline and Sinding, 2000; Cleland et al., 2006; Coale, 1984). The concept of unmet need stretches back into the 1960's with the development of the Knowledge, Attitudes, and Practice (KAP) studies on contraception (Casterline and Sinding, 2000). Based on the findings of those studies, the KAP-gap, also known as the unmet need, show a woman in "the condition of wanting to avoid or postpone childbearing but not using any method of contraception" (Casterline and Sinding, 2000:691). The concept, however, was heavily disputed in the 1990's (Casterline and Sinding, 2000).

Critics of "unmet contraceptive need" argue that the concept commonly includes women who may be currently pregnant, not sexually active, or have no intent to use contraception. For example, data from Sub-Saharan Africa reveal that only 37 percent of women categorized as in need of contraceptives intended to actually use contraceptives, while some 85 percent of women in that category knew about modern contraceptives (Pritchett, 1994). Moreover, "in Uganda 27 percent of women are said to have "unmet need," but only 5 percent of married fecund women want no more children and are not using contraception" (Pritchett, 1994:34). Despite these problems and inconsistencies the concept of unmet need still motivates the vast majority of contraceptive research as demonstrated by numerous articles such as the 2006 article by Cleland and colleagues titled "Family Planning: The Unfinished Agenda."

The literature, therefore, lacks a focus on the precise effect of rapidly increasing contraception prevalence in many parts of the world on the aggregate decline in total fertility rates. Additionally, there are several limitations in the articles that have examined the issue. The most pressing problem is the apparent lack of data. In one particular study, part of the analysis was limited to only 17 countries with 2 points in time (Pritchett, 1994). Elsewhere researchers were able to utilize just over 40 countries but with observations only ranging over an 8 year period (Robey, Rutstein and Morris, 1993). In both articles the lack of data is further complicated by a narrow focus. Each of the articles only analyzes data on developing nations with no attention given to more developed countries. I argue that this is emblematic of the ideological focus on increasing contraceptive use in the wake of the overpopulation scares of the 1960's and 1970's. Once again, a purpose of my dissertation is to articulate the effect of contraception on reducing high fertility rates in several parts of the world.

However, there is a substantial literature evaluating the success of family planning programming in developing nations (Coale, 1978; Davis, 1967; Freedman, Whelpton and Campbell, 1959; Jain, 1989; Rosenzweig and Wolpin, 1986; Whelpton, Campbell and Patterson, 1966). The literature largely focuses on the debate between two competing perspectives, both of which were present in force at the international population conference in Bucharest in 1974. These competing perspectives have been aptly described by their respective catch phrases of "Take care of the people and population will take care of itself" and "Development is the best contraceptive" (Coale, 1978:420). The battle that began some 40 years ago continues today. There is ample evidence that fertility planning programs do increase contraceptive prevalence and therefore reduce overall fertility (Robey et al., 1993). Yet, a recent systematic review of family planning programs found that only half of the family planning studies conducted between 1995 and 2008 that included some measure of fertility reduction associated with family planning found any significant effect. Once again, it is important to emphasize that the literature on contraception seems to be consumed with this push to reduce the overall fertility around the world. Virtually no research to date has addressed the potential effect of contraception to drive fertility rates well below the replacement rate of 2.1 or to sustain the lowest-low fertility rates found in most of the more developed nations today.

It is time for a paradigmatic shift in the manner in which we study the relationship between contraception and fertility. For generations demographers have struggled to solve the impending overpopulation crisis. In this context, research on contraceptives focused exclusively on developing programs to increase the knowledge, availability, and use of contraceptives. As noted in the introduction, such an ideological approach to the issue needlessly constrains our understanding of contraception and fertility decline. For the past one hundred years the question has been how do we get more women to use contraception and stop having children? Today, however, the question for most regions of the world should be how do we get women to stop contracepting and start having children so as to avoid the low fertility trap?

In the following chapters I try to evaluate the contributions of contraceptive prevalence to the global decline in total fertility rates. My analysis includes countries across the stages of development and with data stretching back the late 1960's through today. I will also attempt to avoid the ideological trap present in much of the current literature on the topic; I will evaluate the merits of contraception in relation to fertility decline and its potential to contribute to the low fertility trap. For decades politicians, advocates, and researchers alike have pushed for increased contraceptive use as part of a general development plan and as an attempt to avoid overpopulation. Yet, the policies and agendas largely in place today may, in fact, be contributing to the rapid emergence of low fertility regimes and all the potential hazards that accompany that demographic phenomenon.

CHAPTER III

DATA, METHODS, & HYPOTHESES

In this chapter I introduce the data I plan to use in this dissertation and describe each of the variables. Then, I discuss the problem of missing data and strategies to address this issue in a longitudinal framework. Next, I summarize the statistical methods I will employ focusing in particular on how the logic of multilevel modeling is applied in a longitudinal context. Finally, I set forth the key hypotheses of this analysis.

Data

The data for my dissertation analyses come from the World Bank Data Bank. More specifically, I am relying on data from the World Development Indicators database of the World Bank. The World Bank has produced nearly 50 different databases in conjunction with a host of governmental and non-governmental partners. As such, the Bank relies on numerous sources to compile each database. The Bank also mandates that all countries currently receiving aid from the World Bank participate in certain data collection endeavors. Furthermore, the Bank includes data collected by the governmental organizations of the 188 member countries and numerous non-governmental organizations such as the World Health Organization and the United Nations. More importantly, the World Bank goes to great lengths to ensure the accuracy and compatibility of the data collected by the different agencies at different points in time and from different parts of the world. The final product, therefore, is an "attempt to present data that are consistent in definition, timing and methods" (World Bank, 2013a).

The flagship database of the World Bank is the World Development Indicators database. This particular database contains over 900 indicators for approximately 200 countries that have been collected since 1960. It is important to remember, however, that the completeness of each indicator within the database widely varies. In some cases, data on a particular indicator may have only been recorded in a single year for a handful of countries. However, there are several dozen indicators with very good coverage over time and across a large number of countries. The breadth of this coverage, specifically pertaining to the total fertility rate and associated indicators of interest, is the main reason why I have selected this data set. The full database includes data on 214 countries covering 53 years of data collection beginning in 1960. Once again, the actual sample utilized in each statistical model will not include all 214 countries as a consequence of missing data. The descriptive statistics will be presented in Chapter IV.

Dependent Variable

The dependent variable in this dissertation is the total fertility rate reported by year for each country. The total fertility rate (TFR) is defined as the total number of children on average expected to be born to a woman if she spends her entire reproductive life exposed to the current age specific fertility rates. The TFR is considered a synthetic estimate since it does not represent the actual number of children born to a woman over her reproductive lifetime. The TFR is calculated by summing the age specific fertility rates (usually for seven 5-year age groups) for women in each country, and multiplying the sum by 5. The calculation of the TFR allows for two specific improvements over other available rates such as the crude birth rate (CBR). First, the TFR focuses on the female population only, whereas the CBR is simply the number of births divided by the entire population including men and women. Secondly, the TFR also accounts for the variation in the fecundity and fertility of the female population. Logically, not every woman is equally at risk of pregnancy for every year of her child-producing life, usually ages 15-49. Specifically, the TFR takes into account that generally only women between the ages of 15 and 49 are at risk of pregnancy. That is not to say that a woman younger than 15 or older than 49 are incapable of having children (infecund), but the probability of such an event is extremely low.

Furthermore, it may be argued that the principal independent variable for my analyses, i.e., contraceptive prevalence, for a certain year, say, 1970, does not directly impact the total fertility rate for the same country in 1970 and as such it may make more sense to lag the dependent variable so that contraceptive prevalence in one year is estimating the total fertility rate five years later. However, I argue that lagged dependent models are not required in this analysis. Each point estimate of contraceptive prevalence impacts the total fertility rate in real time. Keep in mind that the total fertility rate is a synthetic rate calculated by summing the age specific fertility rates. It is not representative of the fertility behaviors of any single woman. Therefore, increases in contraceptive prevalence should be apparent in aggregate fertility rates such as the TFR in real time.

Furthermore, the relationship between contraception and fertility is much different than, say, the relationship between mortality and fertility. As is clear from demographic transition theory, in many parts of the world fertility declines once mortality has already begun to decline. The need for a large number of children is relaxed as more children survive into adulthood. In this case there is a clear lag between mortality decline and fertility decline. However, contraception impacts fertility from the moment it is employed by users. Therefore, the impact occurs immediately and would not necessarily result in a lag between implementation and fertility decline.

Moreover, with growth curve models I am interested in overall trajectories and not in individual point estimates. In other words, I am estimating the curvilinear decline in total fertility based on the growth in contraceptive prevalence. One trend is predicting the other. Therefore, lagged models will not be required to model the trend in fertility decline as a function of trends in contraceptive prevalence over time.

As noted earlier, I use multilevel models in these analyses. The logic of multilevel modeling and its extension to longitudinal analysis is discussed in detail below. For now it is sufficient to note that as a consequence of the multilevel framework I include variables at two levels. Since this is a longitudinal analysis, level one represents each observation in time, which is then nested within each country (level two). The dependent variable (TFR) is entered at level one of the analysis along with the majority of the independent variables.

Independent Variables

The key independent variable is a measure of contraceptive prevalence, defined as the proportion of the married women between the ages of 15 and 49 who are practicing, or whose partners are practicing, any form of contraception. There are three potential limitations to this measure of contraceptive prevalence. First, the definition includes any method of contraception and does not distinguish between the more effective modern methods and the less effective traditional methods. In my opinion this does not represent a serious limitation. The purpose of my research is to assess the global impact of contraception on declining fertility. As such, any contraceptive use, including traditional methods, will contribute to fertility decline. France is the perfect example where a traditional method, namely coitus interruptus, was largely responsible for their fertility transition. Therefore, though traditional methods are less effective relative to modern contraceptive methods, even traditional methods have the capacity to greatly impact fertility.

Moreover, combining modern and traditional methods into a single measure effectively generates a conservative estimate of the effect of contraceptives on fertility. Clearly, traditional methods were more prevalent at the beginning of the time period since fewer modern methods were widely available at the time. Overtime, however, users in many parts of the world have transitioned to more modern methods (Alkema et al., 2013). The effectiveness of modern methods likely increases the speed of fertility decline. Thus, averaging the two groups over time should result in a conservative estimate of the overall effect of contraception on fertility.

The second potential limitation of my measure of contraceptive prevalence is that it involves the narrow focus on married men and women. When this measure was first introduced in the 1960's, the vast majority of childbearing still took place within marriage. Today, however, that is not always the case. In the United States, for instance, approximately 40% of births as of 2010 were to unwed mothers (Martin et al., 2012). Many European countries have also witnessed nonmarital births over the past decade rise to between 30-50% of all births (Ventura, 2009). However, many other parts of the world still report very low proportions of nonmarital births. Japan, for example, as of 2007, reported that only 2% of all births were to unmarried women (Ventura, 2009). Thus, the measure of contraceptive prevalence limited only to married women still adequately describes large proportions of the global population, even though it is less representative of the more developed western nations. However, this measure of contraceptive has remained in the literature in part to retain compatibility with data collected over time.

The third and most important limitation on the measure of contraceptive prevalence is specific to this data set in the form of missing responses. The complete data set with observations for 214 countries over 53 years would equal a total of 11,342 annual observations. In the case of the dependent variable, the total fertility rate, there are 9,936 reports of the TFR, or approximately 88% coverage spanning all countries and years. Contraceptive prevalence, on the other hand, has only 1,104 records or approximately 10% coverage. In other words, around 90% of the potential observations of contraceptive prevalence are missing. This is the single most limiting factor of this analysis. I discuss in the next section in some detail several strategies for coping with this missing data problem.

Drawing on the fertility theories discussed in Chapter II, I also include several control variables that are known predictors of fertility. Independent variables at level one include a measure of time in years as well as time squared, the adjusted net national income measured in current U.S. dollars, the percentage of the labor force that is female, the infant mortality rate (IMR), population size, and the percentage of the population residing in rural areas.

Several of these control variables are based on the logic of the relationship between development and fertility. For example, I include adjusted net national income in the model as an estimate of economic development under the assumption that economic development is negatively related with fertility decline. This measure of income is the gross national income minus consumption of fixed capital and natural resource depletion (World Bank, 2013b). As is often the case, the income variable is slightly skewed so I applied a logarithmic transformation to the national income prior to including it in the model.

Likewise, based on the logic of the demographic transition theory, increases in labor opportunities measured by the percent of the labor force that is female should be negatively related with the total fertility rate. In other words, as the proportion of women participating in the labor force increases, the fertility rate should decline. Unfortunately, the coverage for the labor force participation variable is weak. The first observation of female labor force participation does not occur until 1990. Therefore, I would have to either restrict my time range or impute nearly 30 years of data. Both solutions are less than ideal. Therefore, I have opted to remove this variable from the model all together. Clearly, this decision threatens proper model specification by ensuring that all pertinent variables are included. However, I did estimate the model with the variable in place and without the variable and found that removing the variable does not dramatically change the coefficients and their standard errors.

The next control variable is the infant mortality rate (IMR). The infant mortality rate represents the number of infants that die each year before reaching their first birthday per 1,000 live births. According to demographic transition theory, as the IMR declines the TFR should also decline. The hypothesized relationship between the IMR and the TFR relies on the underlying assumption that couples give birth to a greater number of children in order to insure that at least a few children survive into adulthood. Thus, if the IMR declines resulting in more children surviving into adulthood, then women will likely give birth to fewer children. Therefore, I expect a positive correlation between the IMR and the TFR. Finally, the urbanization of a population is also emblematic of development. As such, the percentage of the population residing in rural areas should be positively correlated with the total fertility rate. In other words, as people move from rural to urban areas, fertility will decline. Presumably, much of the world that still lives in rural regions relies on agriculture and as such is in need of more children as a source of labor. As families migrate to urban areas the need for labor declines resulting in a decline in fertility.

The two remaining variables at level one stem from the logic of human ecology and the low fertility trap hypothesis. I include the size of each country's population in the models based on human ecological theories of fertility decline assuming that fertility should decline as population size increases and sustenance organization becomes more complex. Therefore, I expect population size to be negatively correlated with the total fertility rate. Finally, I include a measure of the percent of the population that is female. Based on the low fertility trap hypothesis, the number of women in the population will directly impact overall fertility such that fewer women will likely result in lower fertility.

I also include one variable at level two of the analysis. Unlike the independent variables at level one, the level two variables are considered time-invariant. In other words, the single level two variable is considered as a constant for each country over the 52 year time span. The only country level variable is a measure of development based on the United Nations classification of more developed, less developed, and least developed nations. More developed nations include all of North America, all of Europe, as well as Australia, Japan, and New Zealand. All the other regions of the world are considered less developed including the 49 countries that are classified as the least developed, 34 of which are in sub-Saharan Africa, 14 in Asia, and 1 in the Caribbean (United Nations Conference on Trade Development, 2006). General descriptive statistics for all the variables are presented in Chapter IV.

Missing Data

As noted above, the most concerning limitation of this dataset is the level of missing data on a number of the independent variables. Recall that the World Development Indicators database compiled by the World Bank contains data on 214 countries for 52 years beginning in 1960, which is a total of 11,342 observations. The key independent variable is only reported in approximately 10% of those observations. Nonetheless, the available observations provide us with a wealth of information. Often, researchers have a tendency to focus on the lack of data rather than attempt to understand and make good use of what data are actually available. Honaker and King correctly summarize the issue by comparing missing data in statistical research to other types of research in the following statement:

> If archaeologists threw away every piece of evidence, every tablet, every piece of pottery that was incomplete, we would have entire cultures that disappeared from the historical record. We would no longer have the Epic of Gilgamesh, or any of the writings of Sappho. It is a ridiculous proposition because we can take all the partial sources, all the information in each fragment, and build them together to reconstruct much of the complete picture without any invention. Careful models for missingness allow us to do the same with our own fragmentary sources of data (2010:563).

Thus, missing data presents an enormous challenge to statistical modeling, one that has plagued researchers for generations. However, today there are a range of statistical techniques that enable researchers to cope with the unfortunate reality of missing data and make use of the fragments of data that are available.

A complete review of missing data theory and techniques is covered elsewhere (Allison, 2002; Graham, 2009; Laird, 1988; Little and Rubin, 2002; Rubin, 1987). Nonetheless, a basic understanding of missing data is necessary in order to discuss the approaches for handling missing data I will use in this dissertation. Missing data occurs for a number of reasons. Respondents may not want to answer particular questions such as questions regarding income or illicit behavior. Observations may also be missing in the event a respondent simply does not know the answer. Furthermore, in a longitudinal framework, missing data are often classified as intermittent or as drop out. Intermittent data occur when a subject does not "drop out of the survey but still may not respond to a particular call for data collection" (Weiss, 2005:364). In other words, intermittent missing data happen when respondents are unavailable for a particular wave but participate in future waves of data collection. Drop out missing data occur when researchers are "unable to collect further data from subjects" (Weiss, 2005:364). Drop out missing data are often the result of death, disinterest, or migration.

The cause of missing data is directly related to how we address missing data. After the researcher identifies why the data are missing, the researcher can then establish whether the data ought to be classified as missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR) (Little and Rubin, 2002). By definition data are said to be MCAR when "missing responses to a particular variable are independent of the values of any other variable in the explanatory model and of the true value of the variable in question" (Treiman, 2009:182). MAR is a similar concept except that under this condition "missingness is independent of the true value of the variable in question but not of at least some of the other variables in the explanatory model" (Treiman, 2009:182). Finally, data are considered as MNAR or *non-ignorable* if “missingness depends on the true value of the variable in question and, possibly, on the other variables as well” (Treiman, 2009:182).

Finally, it is important to recognize that missing data in a longitudinal setting are often quite different from those found in cross sectional analyses. In fact, in many longitudinal data sets, missing observations are not technically missing data in the traditional sense (Diggle et al., 2002; Hedeker and Gibbons, 2006). In this context, Diggle and colleagues (2002) have noted the following:

> Missing values arise in the analysis of longitudinal data whenever one or more of the sequences of measurements from units within the study are incomplete, in the sense that *intended* measurements are not taken, are lost, or are otherwise unavailable (2002:282).

The authors go on to say that:

> The emphasis is important: if we choose in advance to take measurements every hour on one-half of the subjects and every two hours on the other half, the resulting data could also be described as incomplete but there are no missing values in the sense that we use the term; we call such data *unbalanced*. This is not just playing with words. Unbalanced data may raise technical difficulties…missing values raise the same technical difficulties, since of necessity they result in unbalanced data, but also deeper conceptual issues, since we have to ask why the values are missing , and more specifically whether their being missing has any bearing on the practical questions posed by the data (2002:282).

In other words, unbalanced data raise technical concerns primarily regarding the ability of the selected statistical model to cope with observations that vary in number and spacing over time from one group to the next. Multilevel models are well equipped to handle unbalanced data. However, I draw attention to this difference simply because longitudinal data with missing observations do not necessarily require the same theoretical scrutiny as demanded of data that are genuinely missing.

In my case, most of the missing observations of contraceptive prevalence are largely a factor of study design. This dataset is only an amalgamation of existing data. Therefore, missing observations of contraceptive prevalence are largely a consequence of study design and the lack of interest in the topic at various points in history. In my opinion, the missing observations of contraceptive prevalence are in fact unbalanced. Nonetheless, I believe it is best practice to ask the theoretical questions regarding missingness as discussed below. Ultimately, irrespective of the reason why the observations are missing, all the missing observations will be treated statistically in the same way.

Recall that the limiting factor of this analysis is the measure of contraceptive prevalence. If the missing observations of contraceptive prevalence are missing completely at random, then the probability of missing would not depend on the real value of the missing observation or on any of the variables contained in the model. This assumption is by far the most stringent. It is more often that the data are missing at random such that the probability of missingness is not dependent of the real value of the missing observation but is correlated with another variable in the model. As long as the correlated factors are included in the analytic and imputation models, MAR is not problematic provided it is handled appropriately (Little and Rubin, 2002). Finally, if the missing observations are missing not at random, then the probability of missing is directly correlated with the real unobserved value. For example, data would be MCAR in a weight loss study assuming participants that fail to lose weight routinely drop out of the study. In that case, missing values would occur systematically as a consequence of the unobserved variable (Weiss, 2005).

The missing data in this analysis, most importantly the missing observations of contraceptive prevalence, are arguably MAR. The probability of missingness does not appear to be related to the actual value of the unobserved rate. In other words, the probability of missingness does not depend on whether the actual unobserved contraceptive prevalence rate in the population was routinely high, low, or anywhere in between. It is possible, however, that the probability of missingness is related to each country's economic ability to collect contraceptive prevalence data, but I can account for that relationship by including a measure of economic development in the imputation and analytic models. That being said, the pattern of missingness stretches across economic categories and is prevalent in both more developed and less developed countries. This is partly a consequence of the fact that the World Bank, in conjunction with a number of other partners, routinely collects this type of data in less developed countries. As a result, many of the less developed countries have more complete data than do the more developed countries. Therefore, I am confident in using the assumption that the missing observations are in fact missing at random.

Techniques to Cope with Missing Data

There are several existing techniques to handle missing data. The first technique is commonly known as listwise deletion or complete case analysis. This approach only utilizes complete rows of data and eliminates any row with a missing value from the analysis. Listwise deletion ultimately leads to a reduction in the sample size and therefore can reduce statistical power (Weiss, 2005). But as long as the data are MCAR the reduction in sample size is really the only complication, though many times “the reduction in sample size is quite dramatic” (Treiman, 2009:183). Moreover, if the data are not MCAR, then listwise deletion can lead to biased estimates (Treiman, 2009). Listwise deletion is not the only option. There are several other techniques that allow the researcher to impute values for missing observations.

The first imputation technique is known as mean substitution. In this approach, researchers simply impute the mean or median value of a given variable for all missing observations. For example, if I were to use mean substitution for missing observations of contraceptive prevalence I would simply impute the average contraceptive prevalence rate for every missing observation. I could improve the estimate by imputing the mean for each country or even each decade. Nonetheless, this technique is no longer considered to be adequate since mean substitution will ultimately bias the regression coefficients (Treiman, 2009).

A more sophisticated imputation technique currently in use by the U.S. Census Bureau for public use datasets and samples is referred to as hotdeck imputation. In hotdeck imputation the data are broken down into strata. Each missing observation is then replaced with a randomly drawn value from within the same stratum. This technique is far superior to the previous two in that hotdeck imputation results in unbiased coefficients. However, hotdeck imputation does result in biased standard errors and is known to perform more poorly when “a substantial fraction of cases have at least one missing vale” (Treiman, 2009:185).

Finally, the most sophisticated technique for handling missing data is known as multiple imputation. Multiple imputation is now widely held as the gold standard for many social science applications. Multiple imputation is generally credited to Rubin (1987) and more recently to Little and Rubin (2002). Multiple imputation is generally considered a three step process. The first step is to generate imputed data sets in which the values of missing observations are developed based on existing observations. The second step involves estimating a series of statistical models using each of the newly created imputed data sets. The third involves averaging the estimates and parameters to develop unbiased estimates and standard errors as the final result. It is important to note that multiple imputation does not simply “give something for nothing,” but rather, multiple imputation “allows one to make use of all of the available data” (Graham and Hofer, 2000:201). For a thorough treatment on the development and execution of multiple imputation see Rubin (1987), Little and Rubin (2002), and Allison (2002).

Multiple imputation has several advantages. The most important advantage is the ability to generate accurate unbiased estimates and standard errors. Secondly, multiple imputation is highly efficient and does not require a large number of iterations as is common with other techniques (Schafer and Graham, 2002). The common recommendation is currently to create at least 5 to 10 imputed data sets prior to generating statistical estimates (Allison, 2002). However, more recent research suggests that the number of imputations depends on the degree of missingness, or the proportion of complete cases in the analysis (Bodner, 2008; Graham, Olchowski and Gilreath, 2007). Analyses with a larger proportion of missing data require a larger number of imputations, as many as 50 to 100 imputations. Finally, multiple imputation can be combined with a wide array of statistical techniques and software packages. This allows most applied researchers to address missing data problems utilizing a wide assortment of techniques and packages.

There are a few disadvantages of multiple imputation. First, the results will vary with the number of imputations, especially with a fair amount of missing data. It is important, therefore, to fully document the number of imputations so as to assist in the replication of the analysis. Moreover, since the imputed values are randomly drawn, each draw will result in slightly different estimates. This limitation can be overcome by setting a manual seed (Allison, 2002). Finally, the imputation model may vary from one researcher to the next. In other words, researchers may not include the exact same variables in the imputation model thereby producing different results.

Clearly, missing data are a complication that virtually every researcher must confront. However, the problem of missing data is particularly complex in a longitudinal analysis, as is the case here. Moreover, typical methods of imputation are not always well suited for longitudinal data, particularly for time series cross sectional (TSCS) data (Honaker and King, 2010). TSCS data are structured such that observations over time are nested within cross-sectional units such as countries. Thus, unlike typical longitudinal data sets, the pattern of missingness in TSCS rarely occurs from dropout, item non-response, or other forms of attrition. Alternatively, missing data in TSCS are best described as "Swiss Cheese" since missing observations often occur in a random pattern (Honaker and King, 2010). The typical imputation approach, therefore, is not always well suited to TSCS data. Honaker and King note that:

> When standard imputation models are applied to TSCS data in comparative and international relations, they often give absurd results, as when imputations in an otherwise smooth time series fall far from previous and subsequent observations, or when imputed values are highly implausible on the basis of genuine local knowledge (2010:562).

TSCS data, therefore, require a slightly different approach for imputing missing observations. Fortunately, King and colleagues (2001) introduced a new imputation algorithm which is well suited to TSCS data. The algorithm is referred to as an Expectation Maximization with Bootstrapping algorithm, EMB for short. EMB differs from the more standard algorithms of imputation-posterior (IP) and expectation maximization importance sampling (EMis) in that it requires less expertise to properly run and is far less computationally intensive. Furthermore, with EMB "importance sampling need not be conducted and evaluated (as in EMis), and Markov chains need not be burnt in and checked for convergence (as in IP)" (Honaker and King, 2010:565). Moreover, the EMB algorithm properly accounts for the time series component nested within each country. The EMB algorithm is well supported in the literature (Beck and Katz, 2011; Graham, 2009; Horton and Kleinman, 2007).

Additionally, Honaker, King and Blackwell (2012) have developed a statistical package by the name of "Amelia II" that easily implements the EMB algorithm and purposefully accounts for the time series and cross sectional aspects of the data being imputed. Amelia II is a statistical package developed for use with the statistical program

R. Thankfully, Amelia II may also be deployed as a standalone statistical system so that the user does not need to be familiar with the R programming language. Furthermore, Amelia II allows users to import and export files into a variety of formats including STATA files. Finally, the EMB algorithm for imputation as deployed by Amelia II correctly imputes sensible values for TSCS data. This is critically important since variables in TSCS data tend to "move smoothly over time, to jump sharply between some cross-sectional units like countries, to jump less or be similar between some countries in close proximity, and for time-series patterns to differ across many countries" (Honaker and King, 2010:566). Based on these advantages, I use Amelia II to conduct multiple imputation in conjunction with the so-called "mi estimate" command in STATA to estimate my models.

Methods

The Logic of Multilevel Models

In this section I first discuss the logic of multilevel models and how the same logic can be applied to longitudinal data. Then I describe the series of models that I will estimate, focusing in particular on the multilevel curvilinear growth model. Finally, I discuss my strategy for addressing the missing data issues.

Often in social research individuals are nested within groups. The classic example is that of students who are nested in classrooms. We might presume, then, that these individuals may share some common characteristics. For example, an individual student's score on a math exam is likely due to a combination of individual and classroom characteristics. Yes, the student's score is a function of his or her own initiative and effort, but it is also likely a function of classroom factors such as the teaching effectiveness of his/her teachers, access to classroom resources, and time spent in-class covering material. The latter characteristics would be the same, or at least similar, for every student in that particular classroom. This situation is by definition hierarchical, or structured in such a way that the individual is nested in a larger group (Hox, 2010). From a demographic perspective, hierarchical data are quite common. For example, researchers may be interested in cities nested within counties, counties nested in states, states within countries, and countries nested in regions of the world. All of these data are by their nature hierarchical.

This type of hierarchical data requires special statistical models that account for the dependency found across observations within the group. In other words, analyzing the math scores of students in a classroom using a standard ordinary least squares regression model, which assumes independent observations, would be statistically inappropriate and would lead to biased standard errors (Raudenbush and Bryk, 2002). Furthermore, Hox notes that "if the assumption [of independent observations] is violated the estimates of the standard errors of conventional statistical tests are much too small, and this results in many spuriously 'significant' results" (Hox, 2010:5).

There are, however, statistical models that correctly account for the nested structure of the data and accurately calculate the standard errors. These models are generally referred to as multilevel models (MLM's), hierarchical linear models, variance component models, or random coefficient models. Multilevel models correctly account for the hierarchical nature of the data and produce accurate standard errors (Snijders and Bosker, 2012). Thus, the key improvement of multilevel models over standard ordinary least squares regression models is that multilevel models accurately estimate the standard errors, hence decreasing the likelihood of Type I errors (Snijders and Bosker, 2012).

In the language of multilevel models, variables enter the model at different levels. With the classroom example, the characteristics of the individual students would be entered at level one of the model, the lowest level. Characteristics of the classroom would be included at level two of the model. Thus, lower order levels are nested within higher order levels. As such, a multilevel model can contain several levels. For instance, we could assess students nested in classrooms, which are nested in different schools, school districts, and even states provided we have the appropriate data.

Multilevel models are well established in the demographic literature. For examples of multilevel models in demographic research see Entwisle and colleagues (1984), Entwisle, Mason and Hermalin (1986), Hirschman and Guest (1990), Benefo (1995), and Brady and Burroway (2012). In fact, a quick keyword search of the flagship journal *Demography* returned over 100 articles published in the last 20 years containing some form of multilevel model. This is not surprising since much of demographic data are well suited for multilevel models.

Multilevel Models and Longitudinal Analysis

Though multilevel models are often employed when smaller units of data are nested within larger units, such as counties within states, multilevel models are also appropriate within a longitudinal framework. The logic of multilevel models is substantively the same in a longitudinal framework as it is in a cross sectional analysis (Snijders and Bosker, 2012). However, instead of students nested within classrooms, now observations are nested within students. In the longitudinal example the student would become the level two unit and each observation on that student would serve as the level one unit. For example, suppose we wanted to evaluate how a student's math score changes over time; we would test the student on five different occasions over the school year. We can then take those five test scores for each student in the data set and nest the individual scores at each point in time within the student and use a multilevel model to describe the pattern of growth or change in test scores as a function of the characteristics of each observation (level one) as well as characteristics of each student (level two). According to Weiss:

> The correlation of observations across time within a subject gives the study of longitudinal data its special flavor and separates longitudinal data analyses from cross-sectional regression analyses. We expect longitudinal…measurements on the same person to be more similar to each other than would two separate measurements on different people (2005:13).

Thus, the similarity found among students in a classroom is no different than the similarly between observations within each student. I employ a similar logic with regard to fertility decline. I have obtained data for 178 countries beginning in 1960 through 2012 from the World Bank. The data are time series cross sectional data, meaning each country has 51 years of observations. In my case, the country serves as the level two unit, and each annual observation becomes the level one unit of analysis. As such, years are nested within countries. In the same way that we expect some similarity of math scores among students in the same class, so too we would expect some similarity in total fertility rates over time within the same country.

Moreover, I make use of a specific type of multilevel model known as the growth curve model. I use growth curve models to then analyze fertility decline in light of changes in contraceptive prevalence and other covariates. Growth curve models are a "special case of random-coefficient models where it is the coefficient of time that varies randomly between subjects" (Rabe-Hesketh and Skrondal, 2012:343). The growth curve model is simply an extension of multilevel models that allows me to develop an independent trajectory of fertility decline for each country in the analysis (Snijders and Bosker, 2012). Multilevel models are particularly well suited for this type of analysis in part because these models are robust to both the number of country observations (the level two unit) as well as variation in the time between each observation (the level one unit) (Hedeker and Gibbons, 2006).

Over the years numerous approaches have been employed to analyze repeated measures data. For example, statistical strategies including repeated measures analysis of variance or multivariate analysis of variance were once popular approaches. Similarly, analyzing change scores as either raw difference scores or some form of residualized change scores was also common (Curran, Obeidat and Losardo, 2010). However, multilevel modeling, more specifically growth curve modeling, presents several advantages over these other approaches. Curran and colleagues (2010) note:

> Current approaches to growth modeling are highly flexible in terms of the inclusion of a variety of complexities including partially missing data, unequally spaced time points, non-normally distributed or discretely scaled repeated measures, complex nonlinear or compound-shaped trajectories, time-varying covariates, and multivariate growth processes (2010:124).

Thus, it is not inherently problematic for some countries to have fewer observations than others, or for observations within some countries to be spaced further apart than those in other countries. Moreover, multilevel growth models permit me to include a second order polynomial thereby modeling non-linear growth as is the case with fertility decline.

Furthermore, a method known as pooled cross-sectional time series analysis (PTCA) has long been the standard in political science. However, there are several advantages of multilevel modeling over PTCA. For example, with respect to international comparisons, Western (1998) states:

> From a substantive perspective, a key idea of comparative research is that causal processes vary across countries. The fundamental problem of comparative research is contextual explanation where differences in causal processes within countries are related to characteristics that vary across countries… Hierarchical models provide a powerful tool for examining these sorts of contextual effects…Hierarchical models also provide several important statistical advantages. The models yield estimates of institutional effects that take account of uncertainty about time-series effects…They are more accurate and yield more accurate out-of-sample predictions. Hierarchical models also offer a more realistic assessment of uncertainty in comparative data than interaction models (1998:1255-56).

Moreover, Stadelmann-Steffen and Bühlmann (2008) directly compare pooled time series cross-sectional analysis to multilevel models and note that multilevel models present two distinct advantages. First, the two authors note:

> [Multilevel models] would allow for various model extensions, be it the introduction of an additional level (e.g., an intervening municipality level), the estimation of random slopes or even cross-level interactions, or the calculation of growth curves in order to model particular developments over time (2008:17).

Second, the authors suggest that multilevel modeling treats variance more appropriately:

> Heterogeneity in the data is not just corrected for as in the pooled time-series cross-section analysis, but is modeled. Conceptually this is a more elegant way to handle the statistical problem, because heterogeneity is not just seen as a problem that has to be eliminated, but as an important (realistic) characteristic of the data that should be adequately modeled (2008:17).

Thus, alternative statistical methods are available for comparing international data over time. However, the advantages of multilevel models make it the logical choice in this context.

Finally, in terms of model equations, growth curve models are defined in the same way as traditional multilevel models. Model equations exist at level one and at level two, although the notation in growth curve models is a bit different from that found in typical multilevel models. The equations for the complete model in this analysis are as follows:

Level 1: $\text{TFR}_{ti} = \pi_{0i} + \pi_{1i}\,Time_{ti} + \pi_{2i}\,Time^2_{ti} + \pi_{3i}\,Prevalence_{ti} + \pi_{4i}\,Income_{ti} + \pi_{5i}\,Labor_{ti} + \pi_{6i}\,IMR_{ti} + \pi_{7i}\,Population_{ti} + \pi_{8i}\,Rural_{ti} + \pi_{9i}\,Female_{ti} + e_{ti}$

Level 2: $\pi_{0i} = \beta_{00} + \beta_{01}Developed_i + U_{0i}$

$\pi_{1i} = \beta_{10} + \beta_{11}Developed_i + U_{1i}$

$\pi_{2i} = \beta_{20} + U_{2i}$

$\pi_{3i} = \beta_{30} + \beta_{31}Developed_i + U_{3i}$

$\pi_{4i} = \beta_{40} + U_{4i}$
$\pi_{5i} = \beta_{50} + U_{5i}$
$\pi_{6i} = \beta_{60} + U_{6i}$
$\pi_{7i} = \beta_{70} + U_{7i}$
$\pi_{8i} = \beta_{80} + U_{8i}$
$\pi_{9i} = \beta_{90} + U_{9i}$

Combined, the two above equations produced the following multilevel equation that is estimated with the data:

$$\text{TFR}_{ti} = \beta_{00} + \beta_{01}Developed_i + \beta_{10}\ Time_{ti} + \beta_{11}Developed_i{*}\ Time_{ti} + \beta_{20}\ Time^2_{ti} + \beta_{30}\ Prevalence_{ti} + \beta_{31}Developed_i{*}\ Prevalence_{ti} + \beta_{40}\ Income_{ti} + \beta_{50}\ Labor_{ti} + \beta_{60}\ IMR_{ti} + \beta_{70}\ Population_{ti} + \beta_{80}\ Rural_{ti} + \beta_{90}\ Female_{ti} + e_{ti} + U_{1i} + U_{2i} + U_{3i} + U_{4i} + U_{5i} + U_{6i} + U_{7i} + U_{8i} + U_{9i}$$

Notice, that I am estimating a cross-level interaction between the level of development with time and contraceptive prevalence. There are likely other significant cross-level interactions, but my hypotheses only address time and contraceptive prevalence. Thus, in each of the following three analyses the above model is applied to various datasets.

Typically, researchers have several options when specifying models based on the assumptions inherent in each model. Multilevel quadratic growth models are no exception. As noted above, in growth curve models, generally only the time component is allowed to vary. I have also allowed the squared time variable to also vary meaning that each slope of time is allowed to vary for each country as well as the slopes rate of change.

Generally, the standard estimation method for multilevel models in most statistical packages such as SAS (PROC MIXED) and SPSS (MIXED) is what is commonly known as restricted maximum likelihood estimation (Kwok et al., 2008).

However, since STATA 13 the default estimation is the maximum likelihood estimation or full information maximum likelihood estimation. With large data sets, particularly one with a large number of level two groups, the differences between each estimation type are minimal (Hox, 2010). Nonetheless, the "posterior variances will be larger - and more realistic- under the restricted maximum likelihood than under maximum likelihood" (Bryk and Raudenbush, 1992:53). Thus, for this dissertation I have specified the restricted maximum likelihood estimate (REML) in my STATA commands.

Finally, one key difference to my model as opposed to the traditional use of multilevel growth models is that I am incorporating a squared component of time. This squared variable converts the linear growth model into a quadratic growth model. I have opted to include the second order polynomial since it is clear from the descriptive statistics that total fertility rates at the national level tend to decline in a curvilinear fashion. Therefore, it would be statistically inappropriate to treat a clearly non-linear trend with a linear model. However, one of the difficulties with quadratic growth models is that their coefficients are not interpreted straightforwardly. For example, in a linear growth model the overall slope coefficient represents the corresponding per unit growth in the dependent variable for every one unit change in the independent variable of interest. Linear models thus have a very straightforward interpretation.

Quadratic models, on the other hand, are a bit more complex and difficult to interpret. The individual slope coefficient only represents the "instantaneous slope" at one point in time, whereas the coefficient associated with the squared term represents the rate of change in the slope over the course of the time period (Grimm, Ram and

Hamagami, 2011:1361). Therefore, there is no straightforward interpretation of the actual coefficients beyond a very basic description. All that can be said of the coefficients in a quadratic growth curve model relates to the size and direction of the slope in conjunction with the rate of change for the slope. I discuss this issue further in the Chapter V, where I present the results from the actual models.

Analytical Strategy

As noted earlier, the missing data in the World Bank data set present me with a particularly difficult problem. The lack of observations on the key independent variable, namely contraceptive prevalence, may dissuade some researchers from using this dataset or attempting this analysis at all. However, as mentioned earlier by Honaker and King (2010), data fragments can provide a wealth of information if handled correctly. Therefore, for the purpose of my dissertation I conduct three separate analyses applying the multilevel curvilinear growth model described above; I used the original data set as well as two variations of that dataset.

In the first analysis I employ listwise deletion to reduce the dataset to only those countries containing at least two observations of the key independent variable, contraceptive prevalence. As expected, this approach greatly diminishes my sample size. However, as noted above, multilevel models are well suited to handle time series cross sectional data in which the number of observations and spacing of those observations vary from one country to the next. Moreover, the resulting dataset in this analysis is still representative of global fertility decline. Because the data are missing at random the listwise deletion essentially results in a sample of countries from all over the world across a broad range of indicators. Additionally, recall that the World Bank requires that countries doing business with the World Bank provide data on many of the indicators in this study. Thus, even after the listwise deletion method is implemented, there remains a general mix of countries across the range of indicators representing various levels of economic and social development.

In the second analysis I apply a missing data strategy that is somewhat common in political science research (Honaker and King, 2010). For this analysis I average all of the data over a five year time span. For example, the total fertility rate for the United States in 1970, 1971, 1972, 1973, and 1974 is aggregated to a five year average representing the average total fertility rate from 1970 to 1974. The same is done for each of the covariates. The average then replaces any missing observations. This means that each country only needs 1 observation of contraceptive prevalence in each five year range. This technique boosts the total number of countries included in the analysis as well as the number of observations per country. The obvious limitation of this approach is that I will be losing a tremendous amount of detail by averaging all my data across five year segments of time. Moreover, this technique is not drastically different than other mean imputation techniques. Therefore, the standard errors produced are somewhat questionable.

Finally, in the third analysis I use Amelia II to create 50 imputed datasets. I have selected 50 imputations based on the extent of missing data. The newly created datasets are then imported into STATA 13 using the “mi import” command. Then I proceed to execute the multilevel growth model using the “mi estimate” package, which executes the command on each imputed data set and then combines the results according to Rubin's rules. This approach incorporates all 178 countries in the original dataset with data on the dependent variable and at least two years of data on of contraceptive prevalence.

Hypotheses

The hypothesized relationship between each covariate and the total fertility rate has already been discussed above in the section covering the independent variables. As noted throughout, the main focus of this dissertation is with the role of contraceptive prevalence in the fertility decline witnessed all over the world since the 1960's. As such, the main hypotheses center on contraceptive prevalence.

The first hypothesis simply states that increases in contraceptive prevalence will result in a decline in the total fertility rate holding all other covariates in the model constant. This hypothesis asserts that the coefficient associated with contraceptive prevalence is statistically significant and with a negative sign. This hypothesis may seem obvious, but it is not implausible that the effect of contraceptive prevalence will not be significant once all other predictors of fertility decline are incorporated into the model. However, I am confident that contraceptive prevalence will be statistically significant even after controlling for the other predictors of fertility decline.

The second main hypothesis states that the effect of contraceptive prevalence on fertility decline will vary depending on the countries level of development. The statistical evidence for this hypothesis will be found in the cross level interaction between level of development and the slope of contraceptive prevalence on fertility. A statistically significant interaction term will provide evidence that there is some difference in the effect of contraceptive prevalence on fertility decline between the more developed and the less developed countries.

Specifically, I hypothesize that the effect of contraceptive prevalence on fertility decline will be greater in the less developed countries compared to the more developed countries. Many of the more developed countries in this analysis enter the time period with relatively low fertility rates compared to the fertility rates found in the less developed countries at the same point in history. Therefore, I believe there is a greater capacity for change in the dependent variable in the less developed countries, which contraceptive prevalence can then facilitate.

In this chapter, I have discussed four key issues. First, I have discussed the origins of the data including several advantages and limitations. The World Bank has developed an excellent database although the database is incomplete for a number of variables. My analytic strategy takes this limitation into account by applying three strategies to cope with the missing observations. The second issue addressed in this chapter is in reference to the dependent and independent variables. I have carefully selected and defined each of these variables and demonstrated, theoretically, why each variable is necessary to the model.

Thirdly, I have discussed the logic of multilevel models and how that same logic can be applied to longitudinal data. Multilevel modeling is advantageous when analyzing longitudinal data for several reasons, in part due to the capacity of multilevel models to handle observations that are unequally spaced and vary in number from one country to the next. Also, in this discussion of longitudinal data I have noted how missing observations over time create a unique problem and must be handled accordingly. Finally, I have laid out my specific research hypothesis that will be tested over the next two chapters. More specifically, Chapter V displays the results from the actual statistical models. However, prior to discussing the results I would like to discuss the data in more detail, particularly the changes in contraceptive prevalence over time. Therefore, Chapter IV includes a thorough discussion of the descriptive statistics as well as a discussion of how contraceptive prevalence has changed over time.

CHAPTER IV

DESCRIPTIVE STATISTICS & TRENDS IN CONTRACEPTIVE PREVALENCE

This chapter is divided into two sections. In the first section I present the descriptive statistics for the data with the exception of descriptive statistics of contraception prevalence. Longitudinal data require particular care and attention when developing descriptive statistics. I could easily generate means, standard deviations, and ranges for each of the variables in the analysis. However, such a summary description for some 200 hundred countries over a fifty year period would provide very little usable information. This is particularly the case when we consider the dramatic variation in development both within and between countries over this time period. Therefore, I have developed a strategy for the descriptive statistics that roughly corresponds to each decade in my analysis and then further subdivides the tables corresponding to level of development.

The descriptive statistics were generated with the “xtsummary” command in STATA. This command builds on the basic “summary” command by accounting for the cross sectional time series structure of the data. Essentially, the command generates the typical mean, standard deviation, and range but includes other useful statistics describing the variance between groups as well as a measure of how many countries and years are included in each measure. The number of countries reporting, and the total number of years observed, are then used to calculate the average number of country years contributed by each country.

The second section of this chapter then focuses explicitly on the descriptive trends on contraceptive prevalence. I argue that many of the striking trends observed in fertility decline are related to changes in contraceptive prevalence. Therefore, following a general discussion of the descriptive statistics comparing less developed countries to more developed countries, I will provide a thorough analysis of trends in contraceptive prevalence.

Descriptive Statistics

In this section I discuss the descriptive statistics for more developed and less developed countries. This section is further subdivided into the various 5 decades contained in my time period, with the exception of the last decade that actually ranges from 2000 through 2011. Finally, the last table in this section summarizes the descriptive statistics by comparing selected statistics between the more developed and less developed countries over the entire time period.

Before I discuss each decade it is necessary to make a quick comment on the inclusion criteria of the data in my final dataset. The World Bank collects data on 214 countries and has currently posted data from 1960 through 2012. However, owing to missing data on my dependent variable, the total fertility rate, I have restricted my sample to only those countries with fewer than five missing observations on the dependent variable. This reduced the overall sample down to 187 countries. Most of the countries eliminated from the analysis were extremely small in size and plagued by missing data across virtually all indicators. Some of the countries dropped from the analysis are Tuvalu, South Sudan, St. Martin (French and Dutch), Palau, and Monaco. The remaining 178 countries consist of 137 less developed countries (LDC's) and 41 more developed countries (MDC's).

Descriptive Statistics 1960-69

Table 4.1 Descriptive Statistics for Less Developed Countries from 1960-69

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	6.18	1.17	2.22	8.17	N = 1370
	between		1.14	2.45	8.13	n = 137
	within		0.25	4.85	7.40	T = 10
Contraceptive Prevalence	overall	15.40	.	15.40	15.40	N = 1
	between		.	15.40	15.40	n = 1
	within		.	15.40	15.40	T = 1
National Income (Millions)	overall	.	.	.	.	N = 0
	between		.	.	.	n = 0
	within		.	.	.	T = .
Infant Mortality Rate	overall	118.50	49.16	22.90	272.70	N = 926
	between		48.46	27.30	235.72	n = 107
	within		9.32	84.73	156.94	T = 8.65
Population (Millions)	overall	16.20	72.68	0.03	796.03	N = 1370
	between		72.75	0.04	714.95	n = 137
	within		4.74	-38.42	97.27	T = 10
Rural Population (%)	overall	68.09	21.77	0.00	97.96	N = 1370
	between		21.75	0.00	97.81	n = 137
	within		2.02	56.59	76.36	T = 10
Female Population (%)	overall	49.88	2.13	36.59	55.20	N = 1370
	between		2.08	38.63	54.20	n = 137
	within		0.48	44.83	56.96	T = 10

Table 4.2 Descriptive Statistics for More Developed Countries from 1960-69

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	2.71	0.71	1.58	5.95	N = 428
	between		0.67	1.84	5.50	n = 41
	within		0.25	1.90	3.89	T = 9.95
Contraceptive Prevalence	overall	.	.	.	.	N = 0
	between		.	.	.	n = 0
	within		.	.	.	T = .
National Income (Millions)	overall	.	.	.	.	N = 0
	between		.	.	.	n = 0
	within		.	.	.	T = .
Infant Mortality Rate	overall	28.46	14.67	11.80	82.10	N = 273
	between		14.00	14.03	69.27	n = 30
	within		3.75	15.89	42.88	T = 9.1
Population (Millions)	overall	22.03	37.79	0.18	202.68	N = 410
	between		38.17	0.19	192.50	n = 41
	within		1.38	10.20	32.21	T = 10
Rural Population (%)	overall	43.40	18.30	6.30	81.21	N = 410
	between		18.36	6.92	77.71	n = 41
	within		2.18	36.41	50.77	T = 10
Female Population (%)	overall	51.49	1.63	48.71	55.85	N = 410
	between		1.64	48.73	55.07	n = 41
	within		0.15	50.77	52.27	T = 10

The descriptive statistics for the less developed countries between 1960 and 1969 are displayed in Table 4.1. The same statistics over the 1960's for the more developed countries are found in table 4.2. The average fertility rate across the 137 less developed countries during the 1960's was 6.18 compared to 2.71 among the 41 more developed countries. The TFR among the less developed countries ranged from a minimum of 2.2

to a maximum of 8.17. Not surprisingly, there was less variation among the 41 more developed countries in which the TFR ranged between 1.58 and 5.95.

Moreover, the difference between less developed and more developed countries is immediately apparent in the TFR. Notice, the minimum observed TFR among LDC's (2.22) is not far from the average TFR found in MDC's (2.71) during this decade. Furthermore, the maximum reported TFR among MDC's was only 5.95, which is slightly less than the average TFR reported by LDC's.

Additionally, the average TFR among LDC's for the ten year time span ranged from 2.45 to 8.13 compared to 1.84 to 5.50 for MDC's. In other words, the variation in the average TFR among each country over ten years was higher in less developed countries relative to more developed countries. Nonetheless, the variation in the average TFR among MDC's was still a bit surprising. There were only five countries among the MDC's that reported a TFR higher than 4.0 in any one year between 1960 and 1969. Yet, only Albania, which reported a high TFR of 5.95 in 1960 and New Zealand continually reported TFR's that exceeded 4.0. Therefore, I imagine the variation in TFR among MDC's would decline if I removed these two countries.

Unfortunately, national income was not recorded at all among MDC's in the 1960's. However, there are many more reports of national income beginning in the 1970's. Not surprisingly, the infant mortality rate among LDC's (118.5) is substantially higher than that of the MDC's (28.46) during the same time period. This means that on average 118 children in less developed countries died before reaching their first birthday per one thousand live births. It is expected that LDC's will have a higher IMR owing to fewer healthcare services locally available to rural populations. However, the variation in the IMR among LDC's is a bit surprising. LDC's average IMR ranged from 22.9 to 272.7. In other words, countries on the lower end of the IMR range have rates similar or even better than many of the MDC's. The variation among MDC's is substantially lower.

The population averages are a bit misleading. Average population size across all LDC's was about 16 million, compared to 22 million for MDC's. However, the maximum populations reported tell a much different story with the largest MDC reporting a population of 202 million while the largest LDC reported a population of 796 billion people. Furthermore, a much larger proportion of the population in LDC's was reported as living in rural areas at nearly 68 percent, which is much higher than MDC's at only 43 percent. Some MDC's averaged as much as 77 percent of their population living in rural areas. Nonetheless, this number pales in comparison to the maximum rural population reported by LDC's at nearly 98 percent.

On a separate note, the country with the smallest rural population throughout the dataset is found in Singapore. Singapore reports that zero percent of the population resides in a rural area; this is not unrealistic given knowledge of Singapore's geography and demography. Singapore's land area (276 square miles) is actually smaller than that of New York City (302 square miles). By 2011 Singapore reports a population of over 5 million people. The lack of rural residents is more sensible when considering the small area of the country coupled with the millions of citizens.

The last population statistic addresses the proportion of the population that is female. The average, as expected, in both sets of countries stays close to 50 percent. The average in MDC's ranged between 48 and 55 percent. However, the average across LDC's was as low as 38 percent. The lowest proportion of females reported was in 1961 by Kuwait at just over 36 percent. The majority of the imbalanced populations were found in the Middle East. This imbalance between the sexes is likely in response to the increasing demand for crude oil around the world and the importation of a primarily all male workforce to develop and sustain the booming oilfields across the region.

Table 4.3 Descriptive Statistics for Less Developed Countries from 1970-79

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	5.64	1.54	1.44	8.84	N = 1370
	between		1.52	1.66	8.22	n = 137
	within		0.30	4.34	7.12	T = 10
Contraceptive Prevalence	overall	34.53	18.81	1.60	71.90	N = 71
	between		19.11	1.60	65.70	n = 46
	within		6.06	16.53	55.13	T = 1.54
National Income (Millions)	overall	9629.14	22382.50	17.21	194803.00	N = 912
	between		20489.92	30.80	120453.50	n = 95
	within		8423.05	-59258.73	97454.77	T = 9.6
Infant Mortality Rate	overall	92.74	43.03	11.90	207.20	N = 1157
	between		42.57	15.97	191.01	n = 122
	within		8.05	63.34	122.89	T = 9.48
Population (Millions)	overall	20.60	91.41	0.06	969.01	N = 1370
	between		91.53	0.06	901.94	n = 137
	within		5.46	-63.03	87.66	T = 10
Rural Population (%)	overall	62.68	22.83	0.00	97.62	N = 1370
	between		22.80	0.00	96.81	n = 137
	within		2.11	50.09	79.90	T = 10
Female Population (%)	overall	49.77	2.43	29.68	53.65	N = 1370
	between		2.41	31.93	53.49	n = 137
	within		0.34	47.35	54.19	T = 10

Table 4.4 Descriptive Statistics for More Developed Countries from 1970-79

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	2.23	0.54	1.38	4.87	N = 429
	between		0.51	1.58	4.47	n = 41
	within		0.19	1.74	2.93	T = 9.98
Contraceptive Prevalence	overall	68.35	11.59	42.90	95.00	N = 40
	between		12.87	42.90	87.00	n = 23
	within		4.54	53.85	82.85	T = 1.73913
National Income (Millions)	overall	163405.30	328193.60	437.99	2142130.00	N = 219
	between		314775.20	1284.00	1439153.00	n = 22
	within		111217.30	-353242.40	866382.60	T = 9.95
Infant Mortality Rate	overall	20.11	10.40	7.40	55.30	N = 324
	between		9.68	9.16	46.46	n = 35
	within		3.11	7.11	35.31	T = 9.26
Population (Millions)	overall	23.98	41.54	0.20	225.06	N = 410
	between		41.97	0.22	215.03	n = 41
	within		1.24	14.01	34.01	T = 10
Rural Population (%)	overall	37.46	16.43	4.80	73.15	N = 410
	between		16.50	5.53	69.09	n = 41
	within		1.81	31.95	43.26	T = 10
Female Population (%)	overall	51.37	1.37	48.71	54.80	N = 410
	between		1.39	48.74	54.57	n = 41
	within		0.10	51.01	51.71	T = 10

For the most part the trends across all variables in the 1970's are consistent with expectations (See Table 4.4). The TFR for example fell in the MDC's to an average of 2.23, which is down from 2.71 in the prior decade. Moreover, the average among each MDC ranges from 1.58 to 4.47, also a decline from the previous decade. By the end of the decade, only two of the more developed countries report a TFR of 3 or higher with

Ireland at 3.2 and Albania at 4.1. All the other MDC's reported a TFR of 2.5 or less by 1979. In other words, by 1979 virtually all of the more developed countries were near or below replacement fertility.

On the other hand, the average TFR across all LDC's in the 1970's also declined to 5.64 from 6.18 in the 1960's. However, the average TFR for each LDC in the 1970's ranges from 1.66 to 8.22. This is interesting for two reasons. First, by the end of the 1970's five less developed countries fell below replacement level fertility: Singapore, Cuba, Barbados, Hong Kong, and Georgia. Second, several less developed countries such as Yemen, Rwanda, and Oman maintained exceptionally high fertility rates with a TFR averaging around 8 for the 1970's. As noted in Table 4.3, the highest average TFR in LDC's in the 1970's actually rose slightly to 8.22 from 8.13 in the 1960's. This is not a substantial change but the lack of decline is emblematic of the resistance to fertility decline among many of the less developed countries.

The 1970's is the first decade with reported data on national income adjusted to current U.S. dollars. The average national income across all LDC's in the 1970's was approximately 9.6 billion dollars and 163.4 billion dollars for MDC's. However, the variation between countries in both groups is substantial. The average national income in the 1970's for LDC's ranges from 30 million dollars up to over 120 billion dollars. Similarly, the average national income in the 1970's for MDC's is spread from 1.2 billion to 1.4 trillion dollars.

Both LDC's and MDC's witnessed declines in the infant mortality rate in the 1970's. The average IMR across all LDC's in the 1970's was 92.74, 20.11 for MDC's.

The proportion of the population residing in rural regions also fell for both groups, to 62 percent for the LDCs, and to 37 percent for the MDCs. The average population size for LDC's increased to 20.6 million, presumably due to the higher birth rate, while the average population size across MDC's in the 1970's only increased to less than 24 million. This figure is not surprising give the tremendous difference in fertility rates between the two groups.

Finally, LDC's in the 1970's report the lowest proportion of females in the population of any country at any point in the analysis. The average proportion of females in the population for each less developed country ranged from 32 percent to 53 percent. The lowest reported percentage was record in the United Arab Emirates in 1978 where only 30 percent of the population was female. Once again this is likely a consequence of the large male labor force required for crude oil production.

Descriptive Statistics 1980-89

Table 4.5 Descriptive Statistics for Less Developed Countries from 1980-89

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	5.00	1.71	1.30	9.22	N = 1370
	between		1.69	1.44	9.08	n = 137
	within		0.28	3.53	6.23	T = 10
Contraceptive Prevalence	overall	39.89	20.95	0.80	83.00	N = 135
	between		21.98	0.80	83.00	n = 76
	within		4.56	16.15	54.15	T = 1.77
National Income (Millions)	overall	19712.68	43331.44	54.70	396476.00	N = 1046
	between		40794.75	72.11	233658.30	n = 112
	within		11359.89	-52049.62	182530.40	T = 9.34
Infant Mortality Rate	overall	71.49	39.91	6.70	176.10	N = 1321
	between		39.72	9.10	159.53	n = 134
	within		5.97	50.56	96.96	T = 9.86
Population (Millions)	overall	25.50	109.08	0.06	1118.65	N = 1370
	between		109.26	0.06	1046.60	n = 137
	within		5.78	-49.58	102.82	T = 10
Rural Population (%)	overall	57.78	23.53	0.00	95.66	N = 1370
	between		23.54	0.00	94.97	n = 137
	within		1.86	45.58	67.99	T = 10
Female Population (%)	overall	49.70	2.42	30.38	53.24	N = 1370
	between		2.41	33.73	52.80	n = 137
	within		0.30	46.35	52.59	T = 10

Table 4.6 Descriptive Statistics for More Developed Countries from 1980-89

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	1.94	0.42	1.28	4.04	N = 410
	between		0.40	1.40	3.79	n = 41
	within		0.12	1.40	2.55	T = 10
Contraceptive Prevalence	overall	72.89	7.27	56.30	83.00	N = 27
	between		5.85	59.40	81.20	n = 19
	within		2.70	64.22	78.22	T = 1.42
National Income (Millions)	overall	334415.20	729190.20	1541.15	4771780.00	N = 272
	between		671049.70	1777.59	3487308.00	n = 31
	within		206555.50	-843522.80	1618887.00	T = 8.77
Infant Mortality Rate	overall	15.19	9.00	4.70	55.40	N = 419
	between		9.05	5.87	45.82	n = 41
	within		1.93	5.67	24.77	T = 9.74
Population (Millions)	overall	25.58	45.01	0.23	246.82	N = 410
	between		45.47	0.24	236.96	n = 41
	within		1.12	15.84	35.44	T = 10
Rural Population (%)	overall	33.27	14.51	3.71	66.24	N = 410
	between		14.60	4.15	65.04	n = 41
	within		1.33	26.05	40.55	T = 10
Female Population (%)	overall	51.32	1.17	48.71	54.29	N = 410
	between		1.18	48.74	54.04	n = 41
	within		0.10	50.98	51.78	T = 10

Descriptive statistics for LDC's and MDC's in the 1980's are reported in Table 4.5 and 4.6 and are essentially a continuation of the patterns witnessed in the previous two decades. Nonetheless, there are a few notable developments in the 1980's. The total fertility rate across all 137 less developed countries fell during this decade to 5.0. However, the range of averages for each country continued to spread with countries averaging a TFR of 1.44 to 9.08. In fact, Yemen reported in 1981 the highest TFR over the entire analysis, at 9.1.

Also of interest, the TFR across all MDC's in the 1980's fell to 1.94. By the end of the decade nearly all of the more developed countries watched their TFR's fall below the replacement fertility rate of 2.1. Italy, Spain, and Germany fell to the lowest levels in 1989 reporting a TFR of 1.28, 1.36, and 1.41 respectively. Moreover, by 1989 only eight of the more developed countries reported a total fertility rate of 2.1 or higher.

The average national income for LDC's and MDC's in the 1980's grew to 2 billion dollars and 33 billion dollars respectively. Moreover, as was the case in previous decades the IMR for both groups of countries continued to fall with LDC's averaging an IMR of 71.5 and MDC's at 15.19. Interestingly, the average population size for both LDC's and MDC's was approximately 25 million. However, the maximum population size for each group was drastically different with maximum population size among LDC's reported by China in 1989 of 1.1 billion people compared to the 246 million people reported by the United States in the same year. Finally, the rural population in both LDC's and MDC's continued to decline.

Descriptive Statistics 1990-99

Table 4.7 Descriptive Statistics for Less Developed Countries from 1990-99

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	4.18	1.65	0.98	8.66	N = 1370
	between		1.62	1.22	7.99	n = 137
	within		0.32	2.57	5.79	T = 10
Contraceptive Prevalence	overall	41.88	23.35	1.70	91.10	N = 230
	between		22.95	2.60	87.27	n = 114
	within		3.75	23.62	53.55	T = 2.02
National Income (Millions)	overall	35514.77	96166.01	-883.93	944178.00	N = 1176
	between		90278.87	107.01	587413.90	n = 122
	within		29838.33	-255033.10	392278.90	T = 9.64
Infant Mortality Rate	overall	57.48	36.80	3.10	162.00	N = 1350
	between		36.55	4.35	155.12	n = 135
	within		5.19	30.75	78.73	T = 10
Population (Millions)	overall	31.02	128.15	0.06	1252.74	N = 1437
	between		128.30	0.08	1196.84	n = 137
	within		5.55	-47.16	108.96	T = 9.98
Rural Population (%)	overall	53.69	23.89	0.00	94.58	N = 1370
	between		23.92	0.00	92.86	n = 137
	within		1.53	44.69	65.66	T = 10
Female Population (%)	overall	49.68	2.47	32.59	53.11	N = 1370
	between		2.46	33.53	52.52	n = 137
	within		0.31	47.25	53.68	T = 10

Table 4.8 Descriptive Statistics for More Developed Countries from 1990-99

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	1.65	0.32	1.09	3.22	N = 410
	between		0.28	1.23	2.70	n = 41
	within		0.16	1.28	2.25	T = 10
Contraceptive Prevalence	overall	70.05	9.99	48.00	86.50	N = 56
	between		10.06	48.00	86.50	n = 34
	within		3.97	58.80	81.30	T = 1.65
National Income (Millions)	overall	479423.70	1181930.00	555.15	8341740.00	N = 390
	between		1166026.00	1874.57	6452819.00	n = 40
	within		197662.50	-959735.30	2368345.00	T = 9.75
Infant Mortality Rate	overall	10.61	6.82	3.10	35.70	N = 410
	between		6.69	4.07	30.39	n = 41
	within		1.67	2.29	21.19	T = 10
Population (Millions)	overall	26.91	48.73	0.25	279.04	N = 410
	between		49.23	0.27	264.54	n = 41
	within		1.47	11.99	41.41	T = 10
Rural Population (%)	overall	30.84	13.51	2.95	63.57	N = 410
	between		13.63	3.27	61.27	n = 41
	within		0.86	26.14	35.61	T = 10
Female Population (%)	overall	51.33	1.02	48.76	53.98	N = 410
	between		1.03	49.38	53.79	n = 41
	within		0.13	50.63	51.99	T = 10

Table 4.7 and Table 4.8 report the descriptive statistics for countries between 1990 and 1999. As expected, the total fertility rate for LDC's continued to decline in the 1990's. The average total fertility rate across all 137 less developed countries between 1990 and 1999 fell to 4.18. The average TFR for each LDC ranged from a low of 1.22

all the way up to 7.99. Similarly, the average total fertility rate for MDC's fell to 1.65 with individual countries ranging from a low of 1.23 to 2.7.

Both the LDC's and the MDC's witnessed substantial increases in the average national average income at 35.5 billion dollars and 479.4 billion dollar respectively. The economic disparity continued to expand over the course of this decade. The highest recorded national income among less developed countries was in China in 1999 at 944 billion dollars, a substantial sum no doubt. However, the figure doesn't compare to the maximum recorded national income in the more developed countries which occurred in the United States, also in 1999, at 8.34 trillion dollars.

All the other indicators continued their respective trends from the previous decades. Infant mortality continued to decline in the 1990's for both LDC's and MDC's. The same is true for rural populations. Finally, the population size in both LDC's and MDC's continued to increase, though the rate of increase in the average population across all 41 MDC's in the 1990's slowed considerably. The average population among MDC's in the 1980's was 25.58 million and grew to only 26.91 million in the 1990's.

Table 4.9 Descriptive Statistics for Less Developed Countries from 2000-11

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	3.43	1.53	0.85	7.73	N = 1641
	between		1.51	0.95	7.27	n = 137
	within		0.24	2.45	4.49	T = 11.98
Contraceptive Prevalence	overall	45.36	23.21	2.80	96.00	N = 359
	between		22.96	5.17	88.53	n = 126
	within		4.80	27.16	67.31	T = 2.85
National Income (Millions)	overall	82826.38	327065.10	-1733.03	6053250.00	N = 1461
	between		281391.00	123.42	2716693.00	n = 126
	within		160555.20	-1598276.00	3419384.00	T = 11.60
Infant Mortality Rate	overall	43.28	30.85	2.00	145.50	N = 1620
	between		30.42	2.36	132.07	n = 135
	within		5.72	13.28	83.98	T = 12
Population (Millions)	overall	36.68	145.32	0.09	1344.13	N = 1644
	between		145.68	0.10	1305.81	n = 137
	within		5.65	54.73	124.17	T = 12
Rural Population (%)	overall	50.00	24.01	0.00	91.75	N = 1644
	between		24.03	0.00	90.46	n = 137
	within		1.66	41.40	59.11	T = 12
Female Population (%)	overall	49.69	2.81	23.78	53.23	N = 1644
	between		2.77	30.85	52.81	n = 137
	within		0.51	42.62	54.97	T = 12

Table 4.10 Descriptive Statistics for More Developed Countries from 2000-11

Variable		Mean	Std. Dev.	Min	Max	Observations
Total Fertility Rate	overall	1.55	0.27	1.10	2.24	N = 492
	between		0.25	1.23	2.07	n = 41
	within		0.09	1.28	2.00	T = 12
Contraceptive Prevalence	overall	69.48	14.56	13.50	89.00	N = 49
	between		15.86	13.50	88.40	n = 23
	within		4.18	58.02	82.22	T = 2.13
National Income (Millions)	overall	743645.00	1858781.00	1189.22	12900000.00	N = 479
	between		1854676.00	3638.37	11100000.00	n = 40
	within		296861.40	-1449314.00	2592836.00	T = 11.98
Infant Mortality Rate	overall	6.58	4.26	1.70	23.30	N = 492
	between		4.07	2.27	17.54	n = 41
	within		1.37	0.28	12.68	T = 12
Population (Millions)	overall	28.03	52.50	0.28	311.59	N = 492
	between		53.05	0.30	297.05	n = 41
	within		1.56	13.14	42.57	T = 12
Rural Population (%)	overall	28.77	13.36	2.51	58.26	N = 492
	between		13.45	2.69	55.16	n = 41
	within		1.25	22.85	35.84	T = 12
Female Population (%)	overall	51.34	1.13	49.69	54.31	N = 492
	between		1.14	49.76	54.17	n = 41
	within		0.11	50.79	51.69	T = 12

The last time period in the analysis begins in 2000 and runs through 2011 with descriptive statistics reported in Table 4.9 and Table 4.10. By the first decade of the twenty-first century the average total fertility rate across 137 less develop countries fell to 3.43. This average hides the tremendous variation among LDC's. For example, the average TFR for each country in this time period ranges from a low of .95 to a high of

7.27. The lowest TFR reported in any particular year among LDC's was reported by Hong Kong in 2003 with a TFR of .90. About half a dozen LDC's reported an annual TFR of less than one over the course of these 12 years. The highest reported TFR in a single year among the LDC's was in Afghanistan in 2000 at 7.73. By 2011, 62 of the 137 LDC's reported a total fertility rate of 3.0 or higher, 38 of those countries had TFR's of 4.0 or higher.

The situation is much different in the more develop countries. The average total fertility rate across all 41 countries for this twelve year time span was a meager 1.55. The average TFR for each country over the time period ranged from 1.23 to 2.07. The highest recorded TFR in any single year for the more developed countries was reported by Albania in 2000 at 2.24. However, the low level of fertility among MDC's is perhaps better characterized by the fact that by 2011 only one of the 41 countries reported a TFR of 2.1 (New Zealand), all 40 other MDC's reported a TFR of less than 2.1. Moreover, also in 2011 19 of 41 MDC's reported a TFR of less than 1.5.

Average national income continued to grow in both LDC's and MDC's at 82 billion dollars and a staggering 743 billion dollars, respectively. There were similar positive gains in population size, and urban populations. Both sets of countries also witnessed an overall improvement in infant mortality. The proportion of the population residing rural areas fell to an average of 50 percent for LDC's and 29 percent for MDC's.

General Summary of Descriptive Statistics

There are three general conclusion based on the above descriptive statistics. First, there are clear differences between the less developed and the more developed countries. This only confirms what most social scientist already knew. Nonetheless, in the context of globalization the absolute disparity between less developed and more developed countries is still a very important finding. Far too often Westerns have a tendency to view the world from an ethnocentric perspective and in so doing tend to marginalize the problematic conditions plaguing the rest of the world.

The second general finding is in regards to the variation in each of the above indicators within less developed and more developed countries. By all accounts the more developed countries are far more homogenous as a group than those labeled as less developed countries. I was surprised to see as much variation on all of the variables among the LDC’s. For example, consider the infant mortality rate; every country in the analysis witnessed and improvement in IMR from 1960 through 2011. However, by the last decade the average infant mortality rate in each LDC ranged from a low of 2.4 to a high of 132. In other words countries such as Singapore, Cyprus, Cuba, and the UAE reported on average that 5 or fewer children died before reaching their first birthday per thousand live births in 2011. At the same time, countries such as the Central African Republic, Somalia, the Democratic Republic of the Congo, and Sierra Leone reported on average that 100 or more children died before reaching their first birthday per thousand live births in 2011. The difference is staggering when compared to the average infant mortality rates reported between 2000 and 2011 in more developed countries, which ranged from 2.3 to 17.5.

The third conclusion, and perhaps the most important in the context of this analysis, highlights the radical change in total fertility rates witnessed around the world between 1960 and 2011. The most startling observation is the overall decline in the average total fertility rates among the less developed countries. Recall that the average TFR for all 137 LDC's in the 1960's was estimated at a high of 6.18, with some countries reporting averages as high as 8.13. By the last decade (2000-2011), the average TFR across all 137 LDC's plummeted to 3.43, with some countries reporting averages over the decade of less than 1.0. This only confirms the statement that "never have birth and fertility rates fallen so far, so fast, so low, for so long, in so many places, so surprisingly" (Wattenberg, 2005:5).

Simultaneously, fertility rates in the more developed countries also continued a prolonged decline to sub-replacement rates with no realistic floor in sight. The overall average TFR among the 41 MDC's in the 1960's stood at 2.71. Admittedly, the fertility decline began some 100 years prior to the 1960's in some parts of the more developed world. Nonetheless, the tragic decline in fertility rates to a very low average TFR across all 41 MDC's between 2000 and 2011 of just 1.55 is a crucial trend that demands attention.

Moreover, as noted in Chapter II, none of the current mainstream theories of fertility decline adequately explain or predict either of these remarkable trends in the less developed or more developed countries. However, it is my supposition that the rapid fertility decline observed in the LDC's and the continual march towards unsustainable fertility levels in the MDC's is directly related to contraceptive prevalence. Therefore, it is now essential to focus attention on contraceptive prevalence among the LDC's and the MDC's over the same time period.

Trends in Contraceptive Prevalence

This section contains two subsections. First, I discuss the general trends in contraceptive prevalence by decade for less developed countries and more developed countries. As such, the format is very similar to the general descriptive statistics presented above. The purpose here is to familiarize the reader with the available data on contraceptive prevalence and to highlight some interesting trends. The second half of the section focuses more closely on a select number of countries. In reviewing the data I have identified four, more or less distinct, patterns in the trends of contraceptive prevalence. In this section I discuss each pattern and provide a specific country as a concrete example.

Aggregate Trends in Contraceptive Prevalence

Data on contraceptive prevalence are presented in Table 4.11. As noted, the format is very similar to that used for the presentation of the data in the first half of this chapter with one important difference. The column labeled “Obs.” provides three key pieces of information including the number of countries reporting contraceptive prevalence (n), the number of years in which contraceptive prevalence is reported (N) and the average number of years each reporting country contributes to the total number of years reported (T). These three statistics are perhaps more important with regards to contraceptive prevalence than with the previously discussed variables because contraceptive prevalence is reported by fewer countries and far less frequently than any other variable in the data set. For example, in the 1960’s only one less developed country reported data on contraceptive prevalence and only did so for a single year. The Philippines reported in 1968 that approximately 15 percent of married women were currently using any form of contraception. No other country, MDC or LDC, recorded contraceptive prevalence during the 1960’s.

Fortunately, reporting improved by the 1970’s. Over the course of the 1970’s 46 less developed countries reported an average of 1.54 observations totaling 71 records of contraceptive prevalence. Similarly, 23 more developed countries reported an average of 1.74 observations totaling 40 records of contraceptive prevalence.

Table 4.11 Contraceptive Prevalence by Level of Development & Time Period

		Less Developed Countries					More Developed Countries				
		Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	Obs.
	overall	15.40	.	15.40	15.40	N = 1	.	.	.	.	N = 0
1960-69	between		.	15.40	15.40	n = 1		.	.	.	n = 0
	within		.	15.40	15.40	T =1		.	.	.	T = 0
	overall	34.53	18.81	1.60	71.90	N = 71	67.67	10.89	42.90	87.00	N = 39
1970-79	between		19.11	1.60	65.70	n = 46		12.55	42.90	87.00	n = 23
	within		6.06	16.53	55.13	T = 1.5		3.18	60.17	75.69	T = 1.69
	overall	39.89	20.95	0.80	83.00	N = 135	72.89	7.27	56.30	83.00	N = 27
1980-89	between		21.98	0.80	83.00	n = 76		5.85	59.40	81.20	n = 19
	within		4.56	16.15	54.15	T = 1.78		2.70	64.22	78.22	T = 1.42
	overall	41.88	23.35	1.70	91.10	N = 230	70.05	9.99	48.00	86.50	N = 56
1990-99	between		22.95	2.60	87.27	n = 114		10.06	48.00	86.50	n = 34
	within		3.75	23.62	53.55	T = 2.02		3.97	58.80	81.30	T = 1.65
	overall	45.36	23.21	2.80	96.00	N = 359	69.48	14.56	13.50	89.00	N = 49
2000-11	between		22.96	5.17	88.53	n = 126		15.86	13.50	88.40	n = 23
	within		4.80	27.16	67.31	T = 2.85		4.18	58.02	82.22	T = 2.13

Each decade thereafter more of the less developed countries began collecting data on contraceptive prevalence. Between 1980 and 1989 76 less developed countries reported 135 observations of contraceptive prevalence. In the 1990's 114 countries reported a total of 230 observations and finally over the first 11 years of the twenty-first century 126 countries contributed a total of 359 observations of contraceptive prevalence.

Collection in the more developed countries was far less consistent. Beginning in the 1970's only 23 of the 41 countries reported a total of 40 observations. From 1980 to 1989, however, the number of countries reporting contraceptive prevalence fell to only 19 countries reporting 27 observations. Data collection improved in the 1990's with some 34 countries collecting data on contraceptive prevalence and recording 56 annual observations. Yet, between 2000 and 2011, the number of countries reporting contraceptive prevalence once again declined to only 23 countries reporting a total of 49 observations.

At first the difference in collection is puzzling particularly in light of the increased ability of the more developed countries to actually collect data in general. Countries with more resources and a structure in place to collect data should, presumably, be more likely to collect data on virtually any social indicator. However, I believe the lack of data in the more developed countries and the growing availability of data on contraceptive prevalence in the less developed countries is yet another reflection of the predominant focus on overpopulation. There are fewer observations of contraceptive prevalence in the more developed countries simply because these populations were not growing at sufficient high enough rates so as to incite fears of overpopulation. At the very least, these populations did not overtly threaten western ideological and political structures (Last, 2013; Mosher, 2008; Wattenberg, 2012).

On the other hand, population growth was supposedly out of control in many of the less developed countries and thereby stifling development. As I discussed previously in Chapter II, family planning was a substantial part of reducing fertility levels in the developing world. Thus, over time there was a need for accurate measures of contraceptive prevalence so as to gauge the effectiveness of family planning policy. Ultimately, the concern of overpopulation resulted in data collection in areas most perceived as a threat and much less data on the more developed countries. Nonetheless, I utilize all the available data to further evaluate the role of contraceptive prevalence on aggregate fertility decline.

I turn now to contraceptive prevalence for each decade. Beginning in the 1970's, the average contraceptive prevalence across 46 less developed countries was just 34.53 percent. In other words, among these countries approximately 35 percent of married women were using some form on contraception in the 1970's. The average for each of the 46 countries varied from a low of 16.3 percent up to nearly 67 percent. The lowest contraceptive prevalence recorded by a less developed country in the 1970's was Afghanistan in 1973 at 1.6 percent. The highest recorded observation belongs to Hong Kong in 1977 at nearly 72 percent followed closely by Singapore in the same year at 71 percent.

There was much less variation among the more developed countries reporting contraceptive prevalence in the 1970's. The average contraceptive prevalence across 23 reporting countries in the 1970's was just over 68 percent with individual countries averaging between 43 percent and 87 percent during the same time period. The lowest annual record of contraceptive prevalence was in Bosnia in 1970 at 43 percent. The highest record was reported by Malta in 1971 and again by Belgium in 1976 with contraceptive prevalence rates of 87 percent.

The years between 1980 and 1989 are characterized by modest growth in contraceptive prevalence across the LDC's and the MDC's. The average contraceptive prevalence for LDC's increased nearly 40 percent and increased to almost 73 percent across all MDC's. Once again, however, the variation among the LDC's is staggering; the average contraceptive prevalence for each LDC over the 1980's ranging from 16 percent to 54 percent. The range among MDC's is less substantial with the average contraceptive prevalence for each country falling between 60 percent and 81 percent over the 1980's.

Between 1990 and 1999 the trends begun in the prior two decades continues. The average contraceptive prevalence across all the reporting 114 LDC's increased to 42 percent, with individual countries averaging between 24 percent and 54 percent. The total average among MDC's fell slightly to just over 70 percent with individual countries ranging from a low of 48 percent to a high of 87 percent. The decline in the overall average from 73 percent in the 1980's to 70 percent in the 1990's is likely a consequence of the composition of countries reporting and not actually representative of a substantive decline in contraceptive prevalence. The average continues to decline in the first 11 years of the twenty-first century to 69.5 percent, which may also be an artifact of the data. Moreover, it further demonstrates that general descriptive statistics are incapable of adequately illustrating the trends. Finally, over the period of 2000 to 2011 the average contraceptive prevalence across all reporting MDC's increased to 45 percent with individual countries ranging from 5 percent to 89 percent. Similarly, the average contraceptive prevalence across all reporting LDC's was 69.5 percent with countries averaging between 14 percent and 88 percent.

Figure 4.1 and 4.2 below graphically display the aggregate trends in contraceptive prevalence reported in Table 4.10 and total fertility rates discussed above. As is clear from these figures, there is much more movement at the aggregate level among the less developed countries compared to the more developed countries. For example, the total fertility rate among LDC's declines rapidly over the 52 year period and contraceptive prevalence increases dramatically. However, there is much less change in the more developed countries. For example, the TFR among MDC's entered the analysis just above the replacement rate of 2.1 but quickly fell below this rate for the remainder of the time period. Similarly, contraceptive prevalence, at the aggregate level, remains fairly constant over the time period. Yet, these aggregate averages disguise a great deal of change in both sets of countries that is further explored in the last section of this chapter.

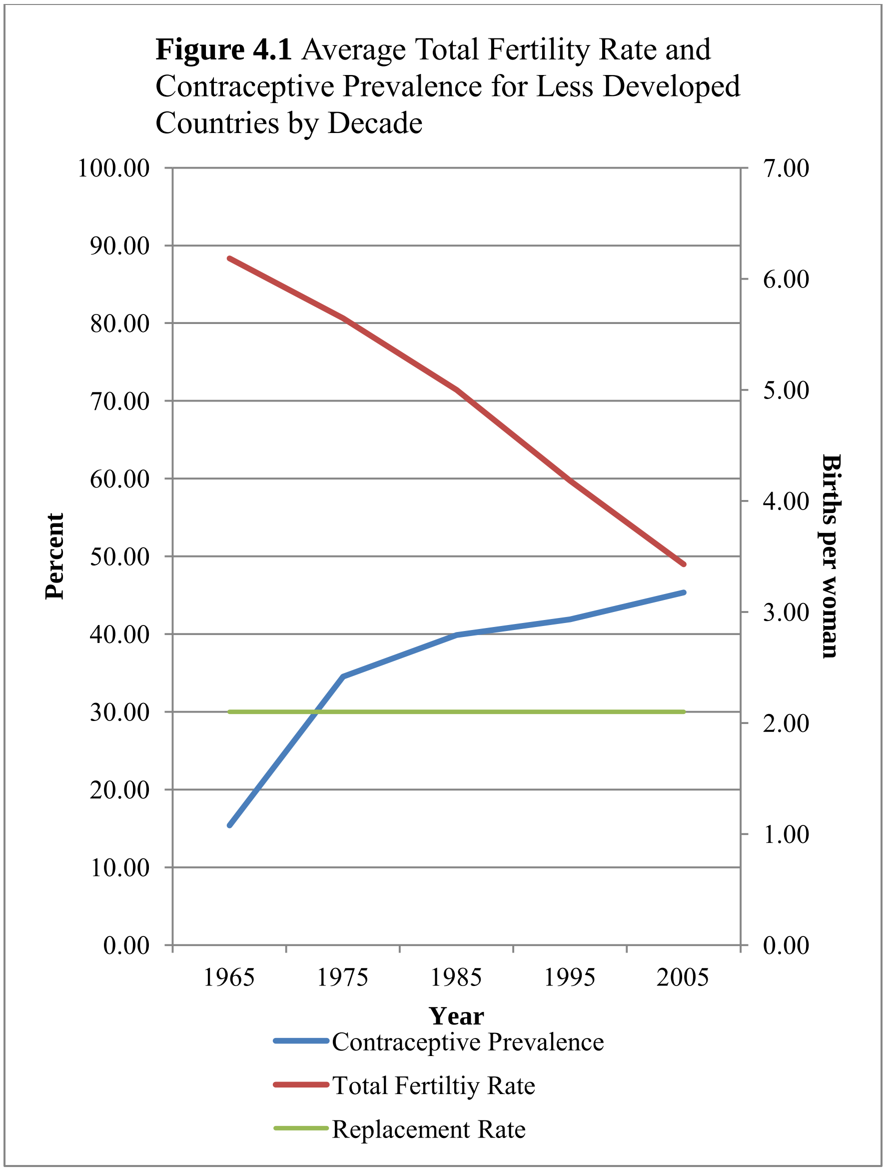
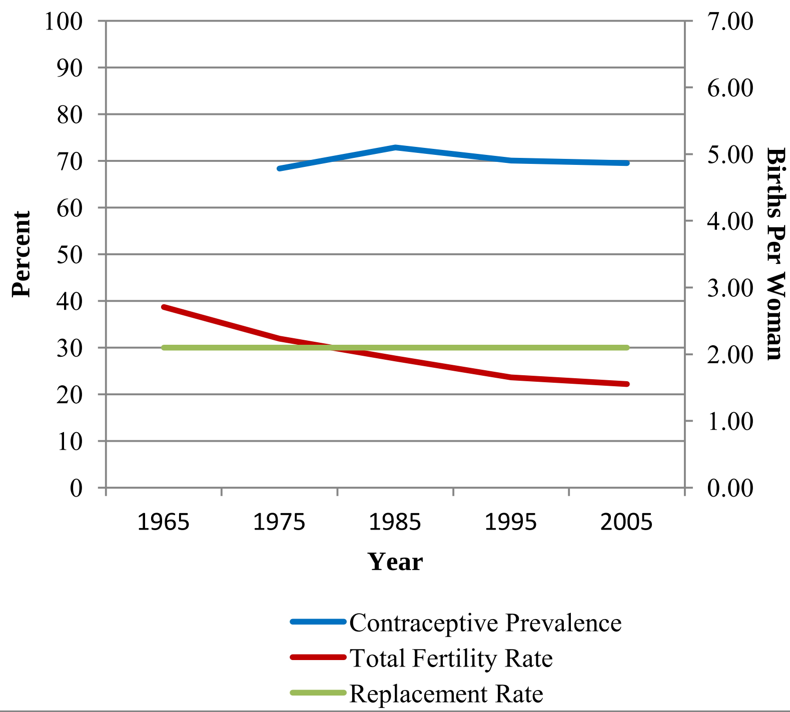


Figure 4.1 Average Total Fertility Rate and Contraceptive Prevalence for Less Developed Countries by Decade
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Percent
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Births per woman
1965
1975
1985
1995
2005
Year
Contraceptive Prevalence
Total Fertiltiy Rate
Replacement Rate

Figure 4.2 Average Total Fertility Rate and Contraceptive Prevalence for More Developed Countries by Decade



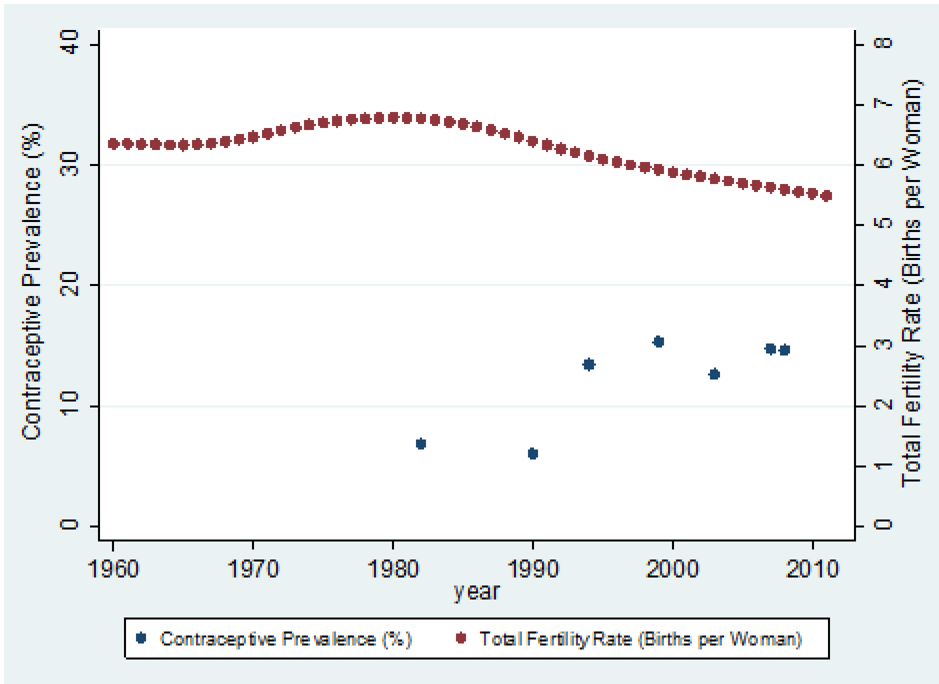
Various Patterns of Contraceptive Prevalence

In this section I investigate the changes in contraceptive prevalence more closely by subdividing countries in various ways. First, I have identified three broad categories that generally define the overall change in contraceptive prevalence. Then I review recent levels of contraceptive prevalence by grouping the countries by their level of development and by their total fertility rate.

In reviewing the data, I have noticed that there are a few consistent patterns in terms of contraceptive prevalence. I have endeavored to broadly categorize countries according to three more or less distinct patterns. The first pattern I have labeled as a “resistant” growth pattern. Resistant countries report very low levels of contraceptive prevalence at 30 percent or less at the beginning of the analysis. Moreover, these countries maintain these very low levels of contraceptive prevalence with end values of less than 40 percent. Only less developed countries fall into this category based on the inclusion criteria of persistently low contraceptive prevalence, a starting value of less than 30 percent and a final value of no more than 40 percent. In total there are 46 resistant countries.

Examples of less developed resistant countries include: Sudan, Sierra Leone, Angola, Cameroon, Niger, Ghana, Madagascar, Somalia, Haiti, Ethiopia, Afghanistan, Uganda, and UAE. Figure 4.3 below displays the total fertility rate and contraceptive prevalence for the country of Nigeria from 1960 to 2011. Resistant countries, like Nigeria, maintain very low levels of contraceptive prevalence and retain very high TFR’s.

Figure 4.3 Contraceptive Prevalence & Total Fertility Rate for Nigeria, 1960-2011

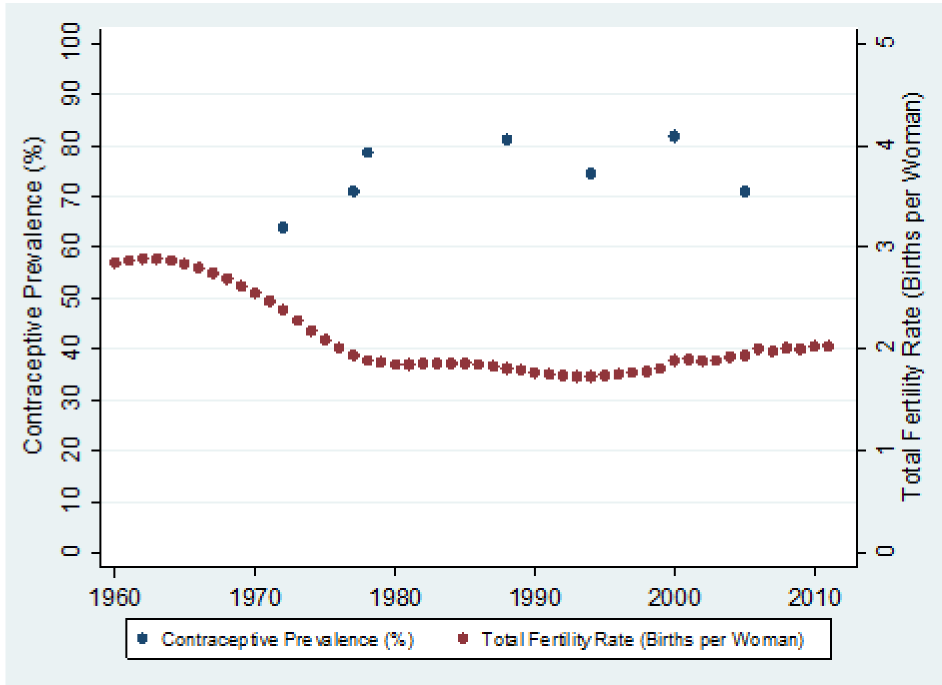


However, some resistant countries did observe some modest growth in contraceptive prevalence. Yemen, for example, reported the largest change in contraceptive prevalence of nearly 26 percentage point starting at 1.7 percent in 1979 and ending at over 27 percent in 2006. However, the average growth in contraceptive prevalence among the resistant countries was only approximately ten percentage points from start to finish.

The second pattern describes countries at the opposite end of the spectrum. I have labeled these countries as “stable” countries. Stable countries reported a relatively high contraceptive prevalence towards the beginning of the analysis of 65 percent or higher. These countries also reported high contraceptive prevalence rates at the end of the time period of 60 percent or higher. In all there are 41 stable countries 37 of which are more developed. Examples of stable more developed countries include Italy, Greece, Germany, Switzerland, Canada, the United Kingdom, and the United States. The four less developed stable countries include Uruguay, Argentina, Israel, and the Virgin Islands.

Figure 4.4 below displays the total fertility rate and contraceptive prevalence for France. France is classified as a stable country because the country's contraceptive prevalence at the start of the analysis is high and it remains high. Stable countries tended to have much lower total fertility rates averaging only 2.1 children per woman. The contraceptive prevalence among stable countries was just over 76 percent and tended to change very little. The average difference between starting values and ending values among stable countries was a little over 1 percentage point, which means on average that the stable countries witnessed very little growth or decline over the 52 year period. The largest growth in contraceptive prevalence among the stable countries was in Norway, which reported that in 1978 approximately 71 percent of married women between the ages of 15 and 49 were currently using any form of contraceptive method. This figure grew to just over 88 percent by 2005.

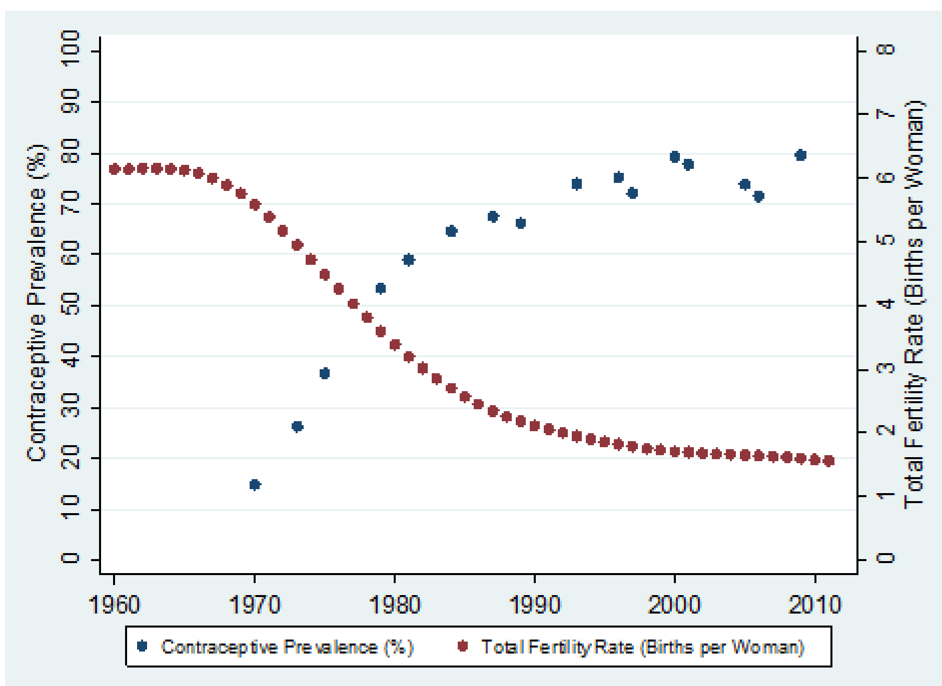
Figure 4.4 Contraceptive Prevalence & Total Fertility Rate for France, 1960-2011



The third and final category contains countries that correspond to what I have termed "transition" patterns of growth in contraceptive prevalence. Transition countries tend to have lower levels of contraceptive prevalence towards the beginning of the time period and higher values toward the end. However, the defining characteristic of transition countries is the dramatic increase in contraceptive prevalence over the total time period. Recall, the average percentage point increase in stable countries was just over 1 percentage point and approximately 10 percentage points for resistant countries. Transition countries average a nearly 21 percentage point increase from starting values to ending values of contraceptive prevalence. The most dramatic increase in contraceptive prevalence was recorded in Thailand. In 1970 Thailand reported a contraceptive prevalence of approximately 15 percent. A little over a decade later contraceptive prevalence had climbed to 59 percent. By 2009 roughly 80 percent of married women between the ages of 15 and 49 in Thailand were using some method of contraception. This radical change is graphically displayed below in Figure 4.5.

In total there are 91 transition countries. Of these 91 countries, 87 are less developed countries. Examples of less developed transition countries include Thailand, Mexico, Bangladesh, Bolivia, the Republic of Korea, China, Kenya, and Guatemala. The four more developed transition countries include Albania, Bosnia, Macedonia, and Spain.

Figure 4.5 Contraceptive Prevalence & Total Fertility Rate for Thailand, 1960-2011



On a separate note, there were approximately 40 countries that reported a decline in contraceptive prevalence. These countries were mainly spread between resistant countries and stable countries. The average decline among these countries was less than five percentage points.

Finally, in addition to the discussion above both describing the aggregate levels of contraceptive prevalence and the three growth patterns, I examine the most recent levels of contraceptive prevalence by total fertility rate and level of development. I have divided countries according to the TFR at the end of 2011 as follows: a TFR of 1.3 or less are lowest-low, 1.4-2.09 represent low fertility, 2.1-3.0 replacement fertility, and 3.0 and above as high fertility. As displayed in Table 4.12, contraceptive prevalence falls as we move to higher fertility levels.

Table 4.12 Average Contraceptive Prevalence by Fertility Level, Circa 2011

Fertility Level	N	Average Prevalence
Lowest-Low (<1.3)	7	68.69
Low (1.3 - 2.09)	63	66.26
Replacement (2.1 - 2.9)	45	57.98
High (3+)	64	30.65

Table 4.13 Total Fertility Rate, Recent Measure of Contraceptive Prevalence, & Percent Change in Contraceptive Prevalence by Level of Development, Circa 2011

	Less Developed (N=137)		More Developed (N=41)	
	Mean	Std. Dev.	Mean	Std. Dev.
Total Fertility Rate (Births per Woman)	3.245868	1.394161	1.576449	0.2477315
Ending Contraceptive Prevalence (%)	46.40073	22.15304	68.19024	14.53781
Percent Change in Contraceptive Prevalence	166.155	288.5929	2.042533	19.70616

Lastly, Table 4.13 reports the percent change in contraceptive prevalence by level of development. The percent change in contraceptive prevalence accentuates the tremendous difference among less developed and more developed countries. The average percent change in contraceptive prevalence across all 41 of the more developed countries was 2.04 suggesting that on average more developed countries recorded a 2 percent increase in contraceptive prevalence over the entire time period. This lack of growth is largely a consequence of the majority of MDC's entering the analysis with high (stable) rates of contraceptive prevalence. Nonetheless, the average percent change in contraceptive prevalence among the less developed countries jumps to a staggering 166 percent. The majority of growth in contraceptive prevalence occurred in less developed countries over this time period.

In sum, this chapter has addressed three issues. First, I have provided detailed descriptive statistics for all 178 countries over five decades by level of development. Tables 4.1 – 4.10 attest to the substantial amount of change that has occurred over recent history. For example, the total fertility rate in LDC's fell from 6.18 in the 1960's to an average of 3.43 during the first decade of the twenty-first century. Over the same period, infant mortality in less developed countries fell from a high of 118.5 in the first decade of the analysis to 43.28 by the end of the time period. The more developed countries also witnessed a substantial amount of change in various measures of development. For example, in the 1960's approximately 43 percent of the population in more developed countries resided in rural areas. By the end of the time period the percentage of the population residing in rural regions in more developed countries fell to an average of less than 29 percent.

In the second section of this chapter I endeavored to characterize the change in contraceptive prevalence into three broad categories: resistant, stable, and transition countries. Resistant countries reported little to know increase in contraceptive prevalence. Stable countries, for the most part, came into the analysis at the beginning of the time period with relatively high levels of contraceptive prevalence and retained those levels throughout the analysis. Finally, transition countries are characterized by the tremendous increase in contraceptive prevalence.

Lastly, I examined contraceptive prevalence based on the ending total fertility rate. Those countries reporting lower levels of fertility also reported higher levels of the contraceptive prevalence. Finally, I noted the difference in percent change in contraceptive prevalence between less developed countries and more developed countries. Not only did more change occur in the less developed countries but the variation in less developed countries in the percent change in contraceptive prevalence was much greater. In the following chapter I formally test several of the trends observed in the descriptive statistics discussed in this chapter.

CHAPTER V

RESULTS

In this chapter I present the results from each of the three analyses described earlier. Each analysis applies the same multilevel quadratic growth model to datasets that are differentially adjusted for missing data. In the first analysis I apply listwise deletion retaining only complete rows of data. In the second analysis I simply average all variables over five years. Finally, in the third analysis I make use of Amelia II software to use the method of multiple imputation, which is then imported into STATA for the actual analysis.

Analysis 1 – Listwise Deletion

In the first analysis I have applied listwise deletion or what is sometimes referred to as complete case analysis in order to correct for the missing data. This, of course, will most always lead to a smaller dataset. This particular sample includes a total of 159 countries including 38 more developed countries and 121 less developed countries. There were a total of 868 annual observations with each country contributing an average of 5.5 observations. The results for Analysis 1 are reported below in Table 5.1.

Table 5.1 Fixed & Random Effects for Listwise Deletion

	Model 1		Model 2	
	B	SE	B	SE
ICC	0.7895			
Fixed Effects				
Intercept	3.60*	0.1316507	8.414838	1.264563
Contraceptive Prevalence (%)			-0.013761	0.001347
Time (Years)			-0.099482	0.018026
$Time^2$			0.000658	0.000215
IMR			0.010498	0.001647
Female Population (%)			-0.082493	0.021261
Rural Population (%)			0.022062	0.003071
More Developed			-3.701639	0.437970
Log of National Income			0.067427	0.022179
Population (Millions)			-0.001768	0.000478
Time*More Developed			0.041931	0.008997
Cont. Prev.*More Developed			0.012202	0.002859
Random Effects				
$\tau_{11\ time}$			0.0306455	0.00573950
$\tau_{01\ time2}$			0.0000044	0.00000081
$\tau_{00\ constant}$	2.571126		13.1366900	2.43460400
σ^2	.685		0.0146854	0.00106590

*p<.05

There are two models reported in Table 5.1. Model 1 is referred to as the null model. The null model only includes the dependent variable and grouping variable. The null model then represents the proportion of variance in the total fertility rate that is explained by grouping observations by country. This is best described by the intraclass correlation coefficient (ICC). Technically, the intraclass correlation coefficient is the ratio of the variance in the dependent variable that exists between groups compared to the total variance, that is the sum of the variance between groups and the variance within groups (Tabachnick and Fidell, 2007). Mathematically, the ICC is defined as follows:

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2)$$

Where:

ρ = intraclass correlation coefficient

τ_{00} = variance between groups

σ^2 = variance within groups

$\tau_{00} + \sigma^2$ = total variance

The intraclass correlation coefficient typically ranges from zero to one although it can be negative under certain rare circumstances. In the first analysis the ICC is approximately .79, which means that 79 percent of the variation in the total fertility rate is explained by differences between countries. Alternatively, approximately 21 percent of the variation in the total fertility rate can be explained by differences within countries.

The intercept for Model 1, also known as the grand mean, is 3.60. This coefficient is interpreted as the total fertility rate (dependent variable) when all independent variables equal zero. In this case, 3.60 would be interpreted as the expected TFR for a country in 1960 with zero contraceptive prevalence, an infant mortality rate of zero, with zero percent of the population residing in rural areas, and so on. Clearly, the intercept is not directly interpretable. Ordinarily, researchers will center each level one variable so that the intercept becomes more meaningful (Enders and Tofighi, 2007; Raudenbush and Bryk, 2002). However, even with the assistance of common centering techniques, the intercept in this case is difficult to interpret. For example, assume that I were to grand mean center each of the level one variables by subtracting each value of each individual observation from the overall mean of all countries for each variable. Then the intercept would represent the average TFR for a country with average time, contraceptive prevalence, percent rural, IMR, and so on. At first glance centering appears reasonable.

However, grand mean centering does not necessarily make the intercept more interpretable. Centering the time variable does not really make much sense. The average time would simply approximate the middle of the time period, which is not all that meaningful. It is possible to leave time alone since time already has a meaningful zero representing the start of the time period (1960) and then center all the other variables. Once again, the solution appears reasonable, but the interpretation is still less than meaningful. By centering all variables with the exception of time the intercept becomes the average TFR in 1960 when a country has the average contraceptive prevalence, IMR, rural population and so on. The average TFR in 1960 for a country with the average level of development based on 159 countries and 52 years of data does not result in a meaningful interpretation. Thus, in this dissertation, I have decided to ignore the intercept in most of my analyses.

The results for Model 2 are also reported in Table 5.1. Model 2 includes as the X variables the measure of contraceptive prevalence, time and time squared, as well as all the significant control variables and cross level interactions. All level one variables along with the single level two variable are significant with a *p* value of less than .05. Interestingly, the only cross level interactions that are significant are the level of development interacted with time, contraceptive prevalence, and rural population.

As noted earlier, the coefficients in a quadratic growth curve model have no easily understood and direct interpretation beyond the shape and direction of the resulting curve. The intercept for Model 2 is 8.34, which means that the curve begins with a positive integer. Moreover, the coefficient of time is -.098. This represents the average instantaneous slope when time is zero. The negative sign of this coefficient demonstrates that the total fertility rate will initially decline. However, the coefficient of the squared time variable is .0006. This coefficient represents the rate of change of the slope of time. The positive sign of the time squared variable suggests that the slope of time will move toward zero as time progresses. In other words, the slope of the curve associated with the total fertility rate will flatten out as we move forward in time.

According to the regression results for Model 2 in Table 5.1, nearly all variables are moving in the hypothesized directions. For example, the coefficient for contraceptive prevalence was negative indicating that over time as contraceptive prevalence increases the total fertility rate declines. Moreover, as the infant mortality rate increases and as the proportion of the population residing in rural regions of the country increases, the total fertility rate decreases. On the other hand, according to human ecological theory, we expect that as population size increases the total fertility rate declines.

However, two of the level one variables did not behave as hypothesized. The number of women as a percent of the total population has a negative sign implying that as the proportion of women in the total population increases fertility rates will decline. Based on the low fertility trap hypothesis we would expect that as the number of women increases, fertility rates will increase. Furthermore, the log of national income was positive suggesting that as national income increases the fertility rate increases. Both of these results are discussed later in Chapter VI. Finally, the level two variable (time-invariant) representing the two classifications of development was significant with a value of -2.83, which suggests that the more developed countries on average have lower total fertility rates than the less developed countries of the world.

The results pertaining to the random effects in Model 2 reveal variation in all three random coefficients. For example, τ_{00} represents the variation around the grand mean. Recall that the grand mean was 8.34. The variation around that mean of 13.05 suggests that countries vary considerably in regards to the average total fertility rate. Moreover, the variance associated with the slope of time (.03) suggests that the slope of fertility decline over time associated with each country also varies. However, the size of the variance in the slope is somewhat smaller than expected. Additionally, the rate of change for the slope of time does vary from one country to the next (0.00000433) but the variance is nearly zero indicating that there is in fact very little difference in the rate of change of the slope between countries.

Finally, both cross level interactions are significant. The first cross level interaction is between level of development and time. The coefficient of the effect was .041 suggesting that the slope of the effect of time on the total fertility rate moves closer to zero in more developed countries. In other words, the effect of time on fertility decline is weaker in more developed countries. The second cross level interaction was between level of development and contraceptive prevalence resulting in a coefficient of .012. This result implies that the slope of contraceptive prevalence moves closer to zero in more developed countries. More specifically, the effect of contraceptive prevalence on the total fertility rate is weaker in more developed countries than in less developed countries.

The simplest way to understand the cross-level interaction effects is by reducing the three dimensional effect to a more simple two dimensional effect and graphing the differences (Kwok et al., 2008). For example, the final equation from the complete model is as follows:

$$TFR_{ti} = 8.41 - .014*Contracept_i - .099*Time_{ti} - .0007*Time_{ti}^2 + .01*IMR_i - .082*Female_i + .022*Rural_i - 3.70*Developed_i + .067*Log\_Inc_i + .041*Developed\_Time_{ti} + .012*Developed\_Contracept_i$$

The equation can be rewritten so as to isolate the random effect of time from the cross level interaction.

$$TFR_{ti} = 8.41 - .014*Contracept_i – (.099 + .041*Develop)*Time_{ti} + .0007*Time_{ti}^2 + .01*IMR_i - .082*Female\%_i + .022*Rural\%_i - 3.70*MoreDevelop_i + .067*Log\_Inc_i + .012*Develop\_Contracept_i$$

The next step is to substitute meaningful values for all variables including the level two variable of development. For example, I calculated the average contraceptive prevalence for all countries in the last decade of the analysis (48.5%) and substituted that value into the equation. I did the same for all remaining variables resulting in two different equations, one equation for each level of development.

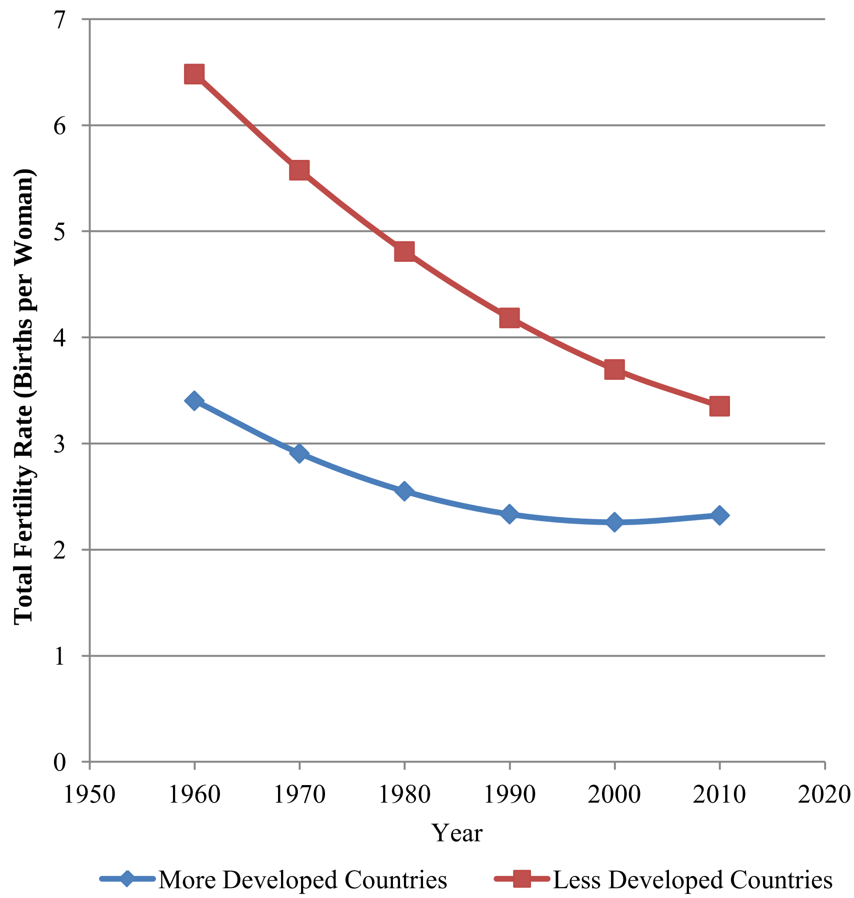
For each level of development the equation reduces to:

TFR_{ti} =3.52-.058*$Time_{ti}$ +.0007*$Time_{ti}^2$, for more developed countries and

TFR_{ti} =6.65-.099*$Time_{ti}$ +.0007*$Time_{ti}^2$, for less developed countries

Finally, I substituted the values of time ranging from 1960 (Time=1) to 2011 (Time=52) and plotted the curves. The resulting graph is displayed below in Figure 5.1.

Figure 5.1. Cross Level Interaction Effects by Level of Development, Complete Cases



Thus, Figure 5.1 graphs the interaction effect associated with the two different levels of development while holding all other variables constant. Not surprisingly, the effect of time and contraceptive prevalence combine to create the difference in fertility decline between these two levels of development. Keep in mind that this growth curve model is specified such that only the variable of time and time squared are allowed to vary. Thus, the cross-level interaction between level of development and contraceptive prevalence only really impacts the intercept. The interaction between time and level of development alters the slope of the curve as displayed above.

Analysis 2 – Five Year Averages

The second analysis estimates the same multilevel model as described above. However, the dataset in this analysis has been modified so as to minimize the missing data problem. In this analysis I averaged all variables, including the dependent variable, across five years of observations. For example, the TFR for the United States for 1970 to 1974 by each year is 2.48, 2.27, 2.01, 1.88, and 1.84 respectively. However, in this analysis the total fertility rate for those five years becomes 2.094. The same is done for each variable in the analysis. This approach allows me to retain more observations because anytime countries report an observation of contraceptive prevalence, that single observation becomes the average for that five year period.

This dataset includes data from a total of 159 countries including 121 less developed and 38 more developed countries. This is the same number of countries as in the previous dataset. However, this analysis includes 3,212 annual observations as opposed to the 868 observations included in the previous analysis. Thus, while the raw number of countries has not increased, the amount of information on the remaining has increased substantially. The results for this analysis are displayed below in Table 5.2.

Table 5.2 Fixed & Random Effects for Five Year Averages

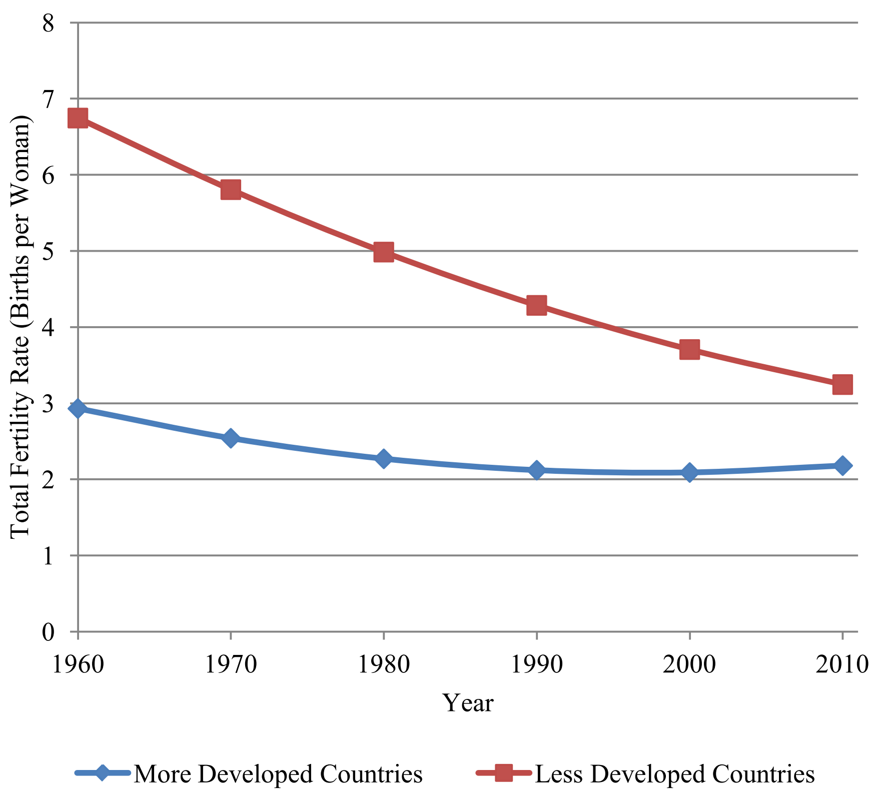
	Model 1		Model 2	
	B	SE	B	SE
ICC	0.693		0.99893519	
Fixed Effects				
Intercept	4.229	0.127	8.827*	0.696
Contraceptive Prevalence (%)			-0.012*	0.001
Time (years)			-0.531*	0.030
$Time^2$			0.015*	0.002
IMR			$0.0016^{\dagger}$	0.001
Female Population (%)			-0.078*	0.013
Rural Population (%)			0.028*	0.002
More Developed			-4.643*	0.273
Log of National Income			0.066*	0.010
Population (Millions)			$-0.0008^{\dagger}$	0.00004
Time*More Developed			0.275*	0.018
Cont. Prev.*More Developed			0.012*	0.002
Random Effects				
τ_{11}			0.026	0.003
τ_{01}			0.00000339	0.00000046
τ_{00}	2.839153	0.3043245	11.569	1.559
σ^2	1.259426	0.018513	0.012	0.001

*p<.05; $^{\dagger}p$<.10

The results of this analysis are very similar to those reported in the first analysis. The intraclass correlation coefficient reported in Model 1 is .693, which means that approximately 70 percent of the variation in total fertility rates is attributed to differences between countries. All signs associated with each coefficient were also consistent with the results from the previous analysis. For example, the effect of contraceptive prevalence is -.012 suggesting that as contraceptive prevalence increases the total fertility rate will decline. Moreover, there is some measurable variation in the intercept (τ_{00}=11.569) and in the slope of time (τ_{11} =0.026).

Two of the level one variables in this analysis were only marginally significant. The infant mortality rate returned a p-value of .055, while the effect of population size on the TFR was only significant at a p-value of .056. I retained both variables in the model since the respective p-values were so close to achieving significance based on an alpha of .05.

Figure 5.2. Cross-Level Interaction Effects by Level of Development, Five Year Averages



The cross-level interaction effects are once again decomposed and graphed above in Figure 5.2. The individual equations for each level of developed are:

$TFR_{ti} = 3.17 - .255*Time_{ti} + .015*Time_{ti}^2$, for more developed countries

$TFR_{ti} = 7.26 - .530*Time_{ti} + .015*Time_{ti}^2$, for less developed countries.

Once again, the cross-level interaction effects from Analysis 1 to Analysis 2 are not substantially different. In comparing Figure 5.1 with Figure 5.2, the only difference visible to the naked eye is that the slope for both curves in Figure 5.2 is slightly shallower than that found in Figure 5.1.

Analysis 3 – Multiple Imputation

In this third analysis I use a multiple imputation technique to generate estimates for the missing observations. As discussed in Chapter III, I employ the standalone package of Amelia II to conduct the imputation procedure. Amelia II then produces 50 imputed datasets with a starting seed of 1234 which are then imported back into STATA 13 as a single stacked dataset. Then using the “mi set flong” command I inform STATA which observations compose the original dataset and which observations have been imputed. Following this procedure I use the “mi estimate” suite of commands to then estimate my multilevel models. The original dataset includes 178 countries including 41 more developed countries and 137 less developed countries. Moreover, the original dataset contains information beginning in 1960 and ending in 2011 culminating in 9,256 annual observations. The results of the multilevel model applied to the imputed data are recorded below in Table 5.3.

Table 5.3 Fixed & Random Effects for Multiple Imputation Data

	Model 1		Model 2		Model 3		Model 4	
	B	SE	B	SE	B	SE	B	SE
ICC	0.693		0.906		0.699		1.000	
Fixed Effects								
Intercept	4.229*	0.127	9.144*	0.462	3.624*	0.126	9.392*	0.681
Contraceptive Prevalence (%)			-0.0018*	0.001			-0.0012*	0.0002
Time (years)			-0.057*	0.008			-0.134*	0.023
$Time^2$			-0.0001	0.0001			0.001*	0.0003
IMR			0.002*	0.001			0.0012*	0.0006
Female Population (%)			-0.058*	0.009			-0.046*	0.009
Rural Population (%)			0.002	0.002			0.016*	0.003
More Developed			-3.299*	0.201			-4.145*	0.472
Log of National Income			0.006	0.005			0.008^*	0.003
Population (Millions)			-0.002*	0.001			$-0.001^\dagger$	0.0007
Time*More Developed			0.040*	0.005			0.048*	0.010
Cont. Prev.*More Developed			-0.0002	0.000			0.001*	0.0005
Random Effects								
τ_{11}			0.008	0.005			0.076	0.018
τ_{01}			0.00001	0.00001			0.00001	0.0002
τ_{00}	2.839	0.304	0.963	0.055	1.666	0.090	30.063	0.353
σ^2	1.259	0.019	0.099	0.007	0.717	0.008	0.009	0.001

$^*p<.05$; $^\dagger p<.10$

Model 1 represents the null model, which only includes the dependent variable. The ICC for this model is .693 suggesting that nearly 70 percent of the variation in the dependent variable is explained by differences between countries. Model 2 includes all variables and returned several unexpected findings. First, the curvilinear slope effect of time, as measured by time squared, is no longer significant. This suggests that the relationship between time and the total fertility rate is best modeled by a linear relationship. This finding is somewhat disconcerting since results from the previous two analyses both confirmed the curvilinear nature of fertility decline. Moreover, theoretically I expected fertility to decline in a non-linear fashion in that the slope of decline will be sharper at the beginning of the time period and flatten out toward the end of the time period. However, the results of this model do not support that expectation.

Additionally, the coefficients associated with size of rural populations as a percentage of the total population, the log of national income, and the cross-level interaction between contraceptive prevalence and level of development all failed to achieve statistical significance with p-values of .10 or less. Once again, all three of these coefficients were statistically significant in the two prior analyses. Thus, it is perplexing as to why all of these variables are no longer significant. Moreover, in the case of time squared and the cross-level interaction between development and contraceptive prevalence, the sign on the coefficient changed contradicting the original hypothesized direction.

These results prompted me to rethink the analytical strategy of imputing values for the entire time period. For example, Afghanistan is the first country listed in the dataset. The first observation of contraceptive prevalence in Afghanistan was in 1973. Afghanistan reports a total of five observations of contraceptive prevalence with the last observation recorded in 2010. This means that under the first model of imputed data I imputed estimates for contraceptive prevalence for 14 years prior to the first observation of contraceptive prevalence. My initial rationale was that contraceptive prevalence generally increases smoothly allowing for data to be imputed along a curve for each country. This is largely why I utilized Amelia II to conduct the imputations. However, the literature associated with Amelia II is never really very clear as to the effects of imputing outside of existing observations. Moreover, some countries' first observation of contraceptive prevalence came as late as 2000. It is likely that imputing values of contraceptive prevalence over that extensive period of time greatly introduces error into the estimation.

Essentially, this becomes a problem of extrapolation versus interpolation. Extrapolation involves imputing values from outside existing observations, whereas interpolation only imputes data that are found between existing observations (Albridge, Standish and Fries, 1988). A quick review of the literature suggests that extrapolation on large scale has the potential to produce erroneous estimates (Albridge et al., 1988; Marwala, 2009; Roth, 1994). Thus I suspect that my heavy use of extrapolation for some countries in the third analysis may well have resulted in the somewhat atypical results displayed above in Model 2 in Table 5.3.

As a result, I include two additional models in this third analysis. In Model 3 and Model 4 I estimate essentially the same multilevel model but I use another imputed dataset. In this final imputed dataset I have only allowed Amelia II to impute values for missed observations that fall between two existing observations of contraceptive prevalence. Essentially, this approach represents imputation by interpolation. Not surprisingly, the overall number of observations is reduced to 3,936 annual observations. Nonetheless, the model includes data on all 178 countries with the earliest record of time beginning in 1968 and continuing through 2011. The results are then reported in columns Model 3 and Model 4 in Table 5.3.

The results of the final model are very similar to the results from my listwise and five year average analyses. And all the predicted effects are significant. However, the effect of population size on total fertility rates is only marginally significant (p=.088). The only unusual result is that the sign associated with infant mortality is negative implying that as infant mortality increases the total fertility rate will decline. This result is the opposite of what is expected and from what was found in Analysis 1 and Analysis 2. The actual coefficient is small (β=-.001) but still significant (p=.05). Reducing the interaction effects to two dimensions results in the following equations corresponding to each level of development:

$TFR_{ti} = 3.80 - .086*Time_{ti} + .001*Time_{ti}^2$, for more developed countries

$TFR_{ti} = 7.90 - .134*Time_{ti} + .001*Time_{ti}^2$, for less developed countries.

Figure 5.3 Cross-Level Interaction Effects by Level of Development, Imputed Data

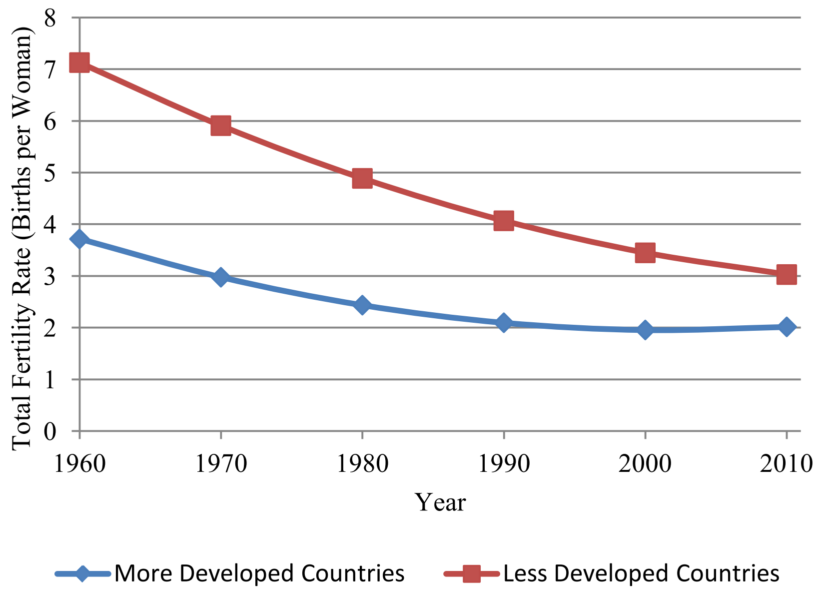


Figure 5.3 graphs these two equations by substituting meaningful values of time. The curve associated with fertility decline in less developed countries has a much higher intercept, which accurately represents their higher level of fertility. Moreover, the slope of decline is sharper indicating that over time the level of development does impact declining fertility.

In sum, in this chapter I have estimated an identical multilevel model with datasets handling the problem of missing data in different ways. Overall, the results from each analysis are strikingly similar with the exception of the extrapolated dataset, i.e., the first analyses from Analysis 3. Direct comparisons of the results from each analysis are discussed in more detail in the following chapter.

In this sixth and last chapter of my dissertation, I compare and discuss the empirical results reported above. I also discuss the results of each treatment of the missing observations as well as potential limitations of this analysis. Finally, I include a discussion of the theoretical implications of my empirical findings and conclude with a general summary.

CHAPTER VI

DISCUSSION & CONCLUSION

This final chapter consists of three sections. . In the first section I discuss the empirical findings. I compare the results of the various treatments of missing observations, revisit the original hypotheses in light of the empirical evidence, and address the unexpected findings. I also cover some of the empirical limitations of this dissertation. In the second section I present a theoretical discussion focusing on how the findings of this analysis challenge the prevailing approach to the study of fertility and contraception. Finally, in the last section I highlight where I intend to take this research in the future and conclude with a general summary of the analysis.

Empirical Conclusions

This section is divided into four subsections. First, I address the treatment of missing observations in light of the results from all three analyses. Second, I review the original hypotheses and discuss to what extent the analyses support or fail to support the hypotheses. Third, I discuss in more detail the unexpected findings. Fourth, I address the limitations of this analysis.

Treatment of Missing Observations

The single most important limiting factor of this analysis is the lack of data on the key independent variable of contraceptive prevalence. However, one goal of this analysis was to investigate various methods of dealing with missing observations. Recall that each of the three analyses applied the same multilevel quadratic growth curve model to three different datasets. Each dataset differed according to how I handled the missing observations. I have compiled the results of each model and displayed them in Table 6.1 below.

Table 6.1 Fixed & Random Effects for Various Treatments of Missing Observations

	Analysis 1	Analysis 2	Analysis 3	
Treatment	Listwise Delete	Five Year Average	Multiple Imputation	
Fixed Effects			Extrapolate	Interpolate
Intercept	8.415*	8.827*	9.144*	9.392*
Contraceptive Prevalence (%)	-0.014*	-0.012*	-0.0018*	-0.0012*
Time (years)	-0.099*	-0.531*	-0.057*	-0.134*
$Time^2$	0.0007*	0.015*	-0.0001	0.001*
IMR	0.010*	$0.0016^{\dagger}$	0.002*	0.0012*
Female Population (%)	-0.082*	-0.078*	-0.058*	-0.046*
Rural Population (%)	0.022*	0.028*	0.002	0.016*
More Developed	-3.701*	-4.643*	-3.299*	-4.145*
Log of National Income	0.067*	0.066*	0.006	0.008^{*}
Population (Millions)	-0.002*	$-0.0008^{\dagger}$	-0.002*	$-0.001^{\dagger}$
Time*More Developed	0.042*	0.275*	0.040*	0.048*
Cont. Prev.*More Developed	0.012*	0.012*	-0.0002	0.001*
Random Effects				
τ_{11}	0.031	0.026	0.008	0.076
τ_{01}	0.0000044	0.00000339	0.00001	0.00001
τ_{00}	13.137	11.569	0.963	30.063
σ^2	0.015	0.012	0.099	0.009

*$p<.05$; $^{\dagger}p<.10$

The results associated with each analysis are strikingly similar. The coefficient associated with each model is significant and retains the same sign in each analysis. Typically, the comparison of coefficients within a model requires the use of standardized coefficients. This is certainly possible within a multilevel framework, though it demands some thought as to whether coefficients are standardized by the standard deviation for each country or according to the overall standard deviation (Snijders and Bosker, 2012). However, even with standardized coefficients it is somewhat difficult to compare results across samples (Greenland et al., 1991; Greenland, Schlesselman and Criqui, 1986; Rabe-Hesketh and Skrondal, 2012).

Often, researchers will compare overall model fit rather than the individual coefficients. There are several methods of estimating model fit within a multilevel framework. It is common to calculate residuals or Wald's tests when models are nested within one another (Curran et al., 2010). Otherwise, researchers can compare models based on either the Bayseian Information Criterion (BIC) or the Akaike Information Criterion (AIC). However, both of these estimates rely on the log likelihood associated with each model. As such BIC and AIC are only appropriate comparisons when models are fit to the same dataset with the same number of observations since "models with different sets of covariates, different missingness patterns for different covariates will often result in different estimation samples" (Rabe-Hesketh and Skrondal, 2012:324). Therefore, BIC and AIC are really not appropriate comparisons for the models reported in Table 6.1.

The simplest manner of comparing the results from each method of handling data is to observe the curves depicted in Figure 5.1, Figure 5.2, and Figure 5.3. There is some variation in the intercepts and ending values. However, the shapes of the curves are nearly identical. Thus, it is reasonable to conclude that the results across all three analyses are substantively the same. This similarity implies two conclusions.

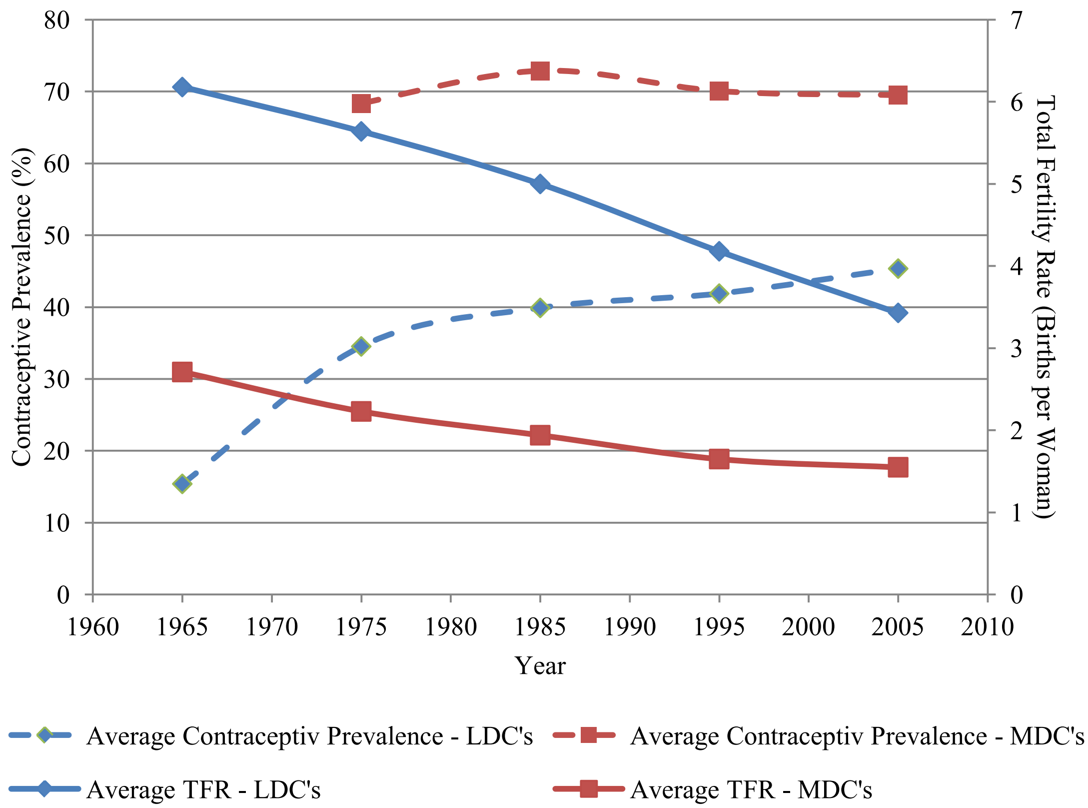
First, the similarity of results across the various approaches to missing observations suggests that the ability of multilevel models to cope with missing observations is quite robust. The model estimates were similar despite the differences in each dataset from the complete case analysis, the five year average analysis, and the multiple imputation analysis. The second conclusion pertains to the robustness of the findings. The similarity of results across each treatment of missing observations provides some evidence to support the claim that my findings are in fact representative of real trends occurring in countries all over the world.

Finally, the only model that resulted in a questionable fit was the imputation model in which estimates were extrapolated from outside the range of existing observations. This model resulted in several non-significant coefficients and two instances in which the direction of the relationship was the opposite of that hypothesized. As noted in Chapter V, I attributed these findings to the erroneous estimates imputed through extrapolation. In many cases, I was asking the program to impute dozens of years of data prior to the first observation of contraceptive prevalence. Imputing estimates so far outside of the range of the existing data most likely introduced error into the model. The results of the extrapolation model stood alone in many respects suggesting that either the other three models, which all resulted in similar estimates, were all incorrect or that the extrapolation model was inaccurate. Based on the model similarity among the remaining models I can only conclude that the extrapolation model was incorrect as a result of poor estimates generated in the imputation process.

Empirical Findings

Recall that I am formally testing two hypotheses in this dissertation. The first hypothesis describes the relationship between contraceptive prevalence and fertility rates, that is, that as contraceptive prevalence increases, fertility rates will decline, holding all other factors constant. As noted in the previous chapter, the coefficient associated with contraceptive prevalence is significant across all the models with the appropriate negative sign. Figure 6.1 below plots the average total fertility rate by level of development with the average contraceptive prevalence for each level of development.

Figure 6.1. Average Total Fertility & Contraceptive Prevelance by Level of Development



The relationship between contraceptive prevalence and fertility decline is clearly shown in the less developed countries. The figure demonstrates that as contraceptive prevalence increases the fertility rate in less developed countries declines.

However, I do not want to overstate the roll of contraception in fertility decline. There was substantial development in all the indicators in the models over the fifty year time period. Clearly, multiple factors contribute to fertility decline. The fact remains, however, that contraception contributes to fertility decline holding constant all the other factors such as economic development, urbanization, and mortality decline.

Furthermore, the relationship between contraceptive prevalence and total fertility rates in more developed countries functions in a similar manner, though the relationship is less pronounced. The differences observed between contraceptive prevalence in less developed countries and more developed countries is likely due to the fact that more developed countries are further along in the process of fertility decline. Nonetheless, the slight uptick in contraceptive prevalence towards the beginning of the time period in more developed countries corresponds to declines in the average total fertility rate among more developed countries.

Interestingly, as the average contraceptive prevalence levels off in the MDC's, fertility continues to decline. This continued fertility decline likely occurs for two reasons. First, as noted above, multiple factors affect fertility decline. Therefore, even though the trends in contraceptive prevalence plateau, other factors may continue to negatively influence fertility. For example, even with high levels of contraceptive prevalence, countries may continue to see advancements in mortality or increased urbanization, which both negatively impact fertility. Secondly, it is possible that the effect of contraceptive prevalence on fertility decline is unidirectional. In other words, once a large proportion of women are currently using some form of contraceptive method, the downward effect on fertility becomes self perpetuating such that small fluctuations in contraceptive prevalence on the order of three to five percentage points will not result in any change in fertility. This is precisely what is predicted by the Low Fertility Trap Hypothesis (LFTH).

According to the logic of LFTH, contraceptive prevalence should have a direct effect on fertility decline in addition to an indirect effect by manipulating other contributing factors. For example, more women using contraceptives results in fewer women having children, fewer women entering the population, potentially better economic opportunities for the women in the population, and further suppressing desired fertility. Thus, contraceptives have the potential to continue to effect fertility indirectly through economic, social, and demographic factors. Ultimately, I find support for the first hypothesis that increases in contraceptive prevalence do result in declines in fertility after controlling for other major factors.

Similarly, I also find support for the second hypothesis, namely, that the effect of contraceptive prevalence would vary based on a country's level of development such that the effect of contraceptive prevalence in LDC's would be stronger than the effect of contraceptive prevalence in MDC's. Again, the coefficients associated with this interaction effect were significant across all models and in the hypothesized direction. Figures 5.1-5.3 explicitly breakdown the interaction effect and graphically display the difference based on the level of development. The coefficient associated with the interaction was relatively small (.012), which suggests that there are other contributing factors to the substantial differences in fertility levels in countries on the basis of development. Nonetheless, the effect of contraceptive prevalence does vary depending on a country's level of development.

In order to further test this theory, I computed a three-way interaction between level of development, contraceptive prevalence, and time. The interaction was statistically significant and suggests that over time the effect of contraceptive prevalence in more developed countries weakens. This effect is already visible in Figures 5.1-5.3 as well as in Figure 6.2 below. The slope of the curve of fertility decline in MDC's plateaus much more quickly.

Figure 6.2. Estimated & Actual Total Fertility Rate by Level of Development

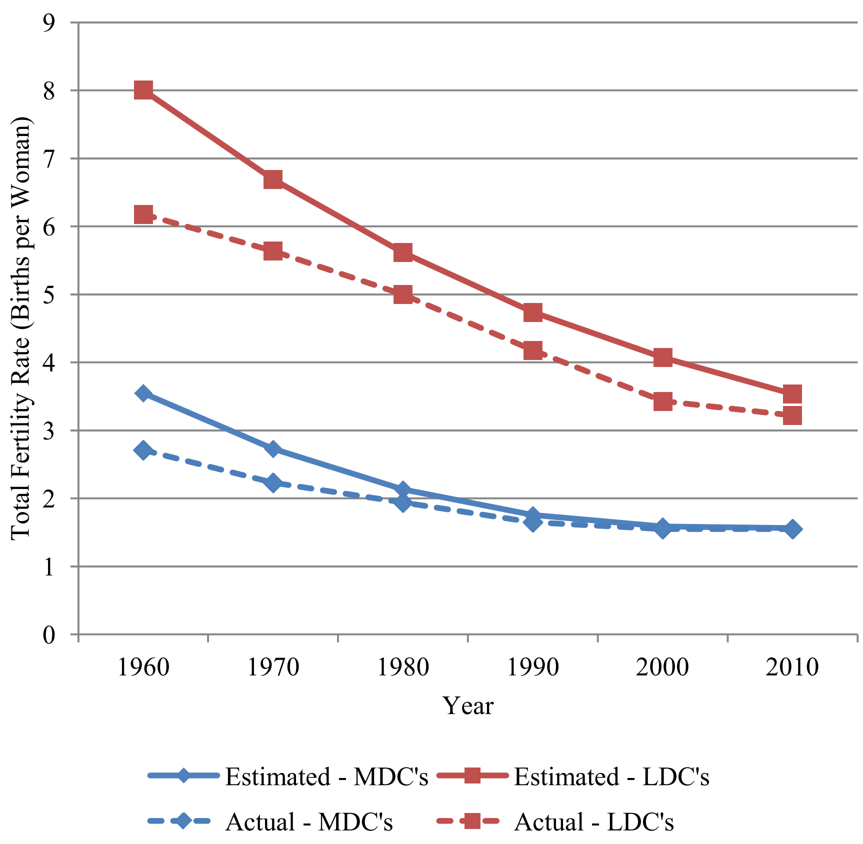


Figure 6.2 displays a similar difference between the curves of fertility decline based on level of development. However, Figure 6.2 differs from the results reported in Chapter V in that I have incorporated averages for each variable at each point in time thus allowing them to vary based on level of development. The results in Chapter V isolated the interaction effect by holding all else equal, whereas Figure 6.2 represents that actual difference between MDC's and LDC's based on the variation between these two groups on all five variables included in the model. Nonetheless, the difference in fertility decline between the more developed countries and the less developed countries is clearly visible and the differential effect of contraceptive prevalence is partially responsible for that outcome.

Furthermore, Figure 6.2 compares the estimated fertility decline with the actual average fertility decline reported by countries based on level of development. In both cases the model I have developed underestimates fertility decline. The model appears to adequately fit the experience of more developed countries. However, among less developed countries, the model consistently overestimates the total fertility rate. The modest inaccuracy of the model in reference to more developed countries is likely due to the consistency among more developed countries across the majority of the variables. However, there was massive variation among less developed countries in respect to all the variables in the model including the total fertility rate. This greater amount of variation likely contributed to the inaccuracy of the model relative to the mean total fertility rate reported by less developed countries.

Interestingly, there were two findings that were unanticipated. First, for a long time researchers have assumed that economic development is negatively related to fertility. However, the coefficient for economic development, measured as the log of net national income, returned a positive sign. This result implies that as the log of net national income increases fertility will increase. The size of the relationship is quite small (.008 in the final model) suggesting that a 10 percent increase in net national income results in an increase of .0003 in the aggregate total fertility rate, if we were to assume that the relationship was linear. Nonetheless, the results are the opposite of what is typically expected.

It is possible that this particular measure of economic development is insufficient. For example, it is possible that a net measure of economic development fails to accurately reflect economic change at the individual level where the fertility decisions are actually made. In other words, the overall improvement of a country's net national income may not reflect any actual improvement in the economic situation of an individual woman who may be considering having another child. Therefore, in my future research it will be important for me to consider alternative measures of economic development perhaps at the individual level. Unfortunately, this particular measure was selected based on the availability of data. The data for alternative economic measures were far more incomplete.

The second unexpected finding is in regards to the relationship between the proportion of women in the population and the total fertility rate. The coefficient associated with the female population was positive suggesting that as the proportion of the women in the population increases the fertility rate will increase. The meaning of this result is not clear. Consider two scenarios. First, think about countries where women make up less than 50 percent of the population. As the proportion of women increases closer to 50 percent, fertility may increase because more women are now a part of the population and there are an equal number of men and women to procreate. However, consider the second scenario in which women already comprise more than 50 percent of the population. Under this condition the results suggest that as women continue to increase relative to the proportion of men, fertility will still increase. Perhaps, in this situation the surplus of women creates a greater demand for partners and children to secure those partnerships. This result deserves more attention in future analyses.

Limitations

There are a few limitations associated with this analysis. Most of the limitations relate to the problem of missing observations. More specifically, there are three ways in which missing observations limit this dissertation. These include the number of missing observations on the key independent variable of contraceptive prevalence, the limited time period, and missing observations that limit the inclusion of potentially pertinent variables.

Of the three limitations, the most significant is the amount of missing observations with respect to the key independent variable of contraceptive prevalence. As discussed in detail in previous chapters this is the most concerning and one the most challenging limitations to overcome. The original dataset included information on some

214 countries, but immediately I dropped 36 countries because these countries failed to meet the inclusion criteria of at least two observations of contraceptive prevalence.

Moreover, the 178 countries included in the analysis originally contained 52 observations beginning in 1960 through 2011. However, only around 10 percent of the observations included a measure of contraceptive prevalence. As noted previously, I employed two strategies to cope with this limitation. First, I estimated multilevel models to carry out the analysis. Multilevel models are well suited to cope with variation in the number of observations as well as the spacing between each observation within a longitudinal context. Second, I estimated three identical models with what amounted to be three separate datasets in which the missing observations were differentially treated. These three datasets were the raw data, a five year average of all variables, and one in which the missing observations were imputed through a multiple imputation technique. The conformity of the results across the three datasets supports the overall validity of my results. However, multiple imputation was only successful in the context of interpolation and performed poorly when extrapolating data.

My findings demonstrate a serious need for more investigation into the behavior of multiple imputation in a longitudinal analysis particularly focused on the boundaries of reasonable estimates. For example, extrapolation may be more feasible when employed on a more limited basis. Perhaps, limiting extrapolation to only five years on either side of existing data points would produce reliable estimates.

The second limitation of this analysis deals with the narrow time period. In many analyses a time period stretching over five decades would be sufficient. However, fertility decline began in some European countries nearly two hundred years ago. Therefore, the fifty two years covered in this analysis only captures the tail end of that time period. More importantly, the majority of the more developed countries entered this analysis with already relatively low levels of fertility suggesting that this particular analysis fails to capture a substantial proportion of fertility decline in the more developed countries. That is not to say that what is captured in more developed countries in this analysis is not important for our understanding of contemporary fertility trends. However, it would be ideal to use a dataset which encompasses the entirety of fertility decline beginning with the start of the nineteenth-century.

Unfortunately, the type of data necessary to capture the entirety of fertility decline is difficult if not impossible to collect retroactively. For example, it may be possible to generate estimates of contraceptive prevalence for many of these countries. However, many of them would be only rough estimates. Moreover, estimates for many of the variables in this analysis would be simply conjecture particularly the further we move backwards in time.

The third limitation of this analysis involves missing observations on a number of variables that may aid in our understanding of fertility decline. As noted earlier, female labor force participation rates likely influence fertility decline to some degree. However, the first measure of female labor force participation was in the 1990's. Thus, once again, the analysis would be severely limited if female labor force participation was included in the model. Moreover, as discussed in the previous section of this chapter, an alternative measure of economic development may better capture the relationship between the economic context and fertility. For example, an individual measure of economic development could be helpful.

Nonetheless, in face of these limitations this dissertation furthers our understanding of fertility decline, particularly with regard to the role of contraceptives in shaping the fertility decline all around the globe. The analytical strategy efficiently minimizes the impact of the above limitations. Nonetheless, the presence of these limitations is important to consider when interpreting the results of this dissertation. In the next section of this chapter I discuss in more detail the theoretical implications of my results.

Theoretical Implications

I have endeavored throughout this dissertation to demonstrate a need for a new approach to fertility research. For the past 200 years fertility researchers have largely focused on ways to restrict fertility, or at the very least, to encourage lower fertility, so as to attenuate the problem of overpopulation. This paradigm persists to this day in the face of clear evidence to the contrary. For example, my dissertation clearly catalogs massive fertility declines in countries all around the globe with no evidence over the past fifty years of any substantial recovery. Furthermore, many regions of the world, particularly in the developed nations, are now facing serious consequences of sustained low fertility. Thus, my research results in two major theoretical implications that are discussed in more detail below. First, my results support the conclusion that fertility decline is here to stay. Second, my results suggest that contraceptives function as a mechanism to enable rapid fertility decline as well as to sustain very low levels of fertility.

This year the annual meeting of the Population Association of America (PAA) will mark the fifty year anniversary of the comments made by Donald Bogue in his presidential address all the way back in 1964 (Bogue, 1964). Bogue's statement that high fertility will soon be behind us was scorned then and unfortunately, not much has changed. Recently, David Lam in his presidential address echoed similar sentiments by stating:

> We have seen that during the last 50 years of historically unprecedented population growth, we experienced substantial increases in food production per capita, declines in resource prices during the period of most rapid growth, and decreases in poverty rates in developing countries. School-age populations grew faster than they will ever grow again, yet we saw the largest increases in schooling we'll ever see. Given all this, I remain in the camp of the optimists. I'm sure that by the time of the 2050 PAA annual meeting, the world will still face important challenges, but I also expect that it will have improved in many ways, including lower poverty rates, higher levels of education, and plenty of food to go around (Lam, 2011:1258-1259).

Lam argued that in the face of dramatic increases in the human population, many people around the world saw dramatic improvements in their standard of living. However, this perspective was quickly criticized. Stan Becker wrote a formal response to Lam's address in which he criticized Lam for ignoring the "looming major ecological problems that have been the result of this human progress" (Becker, 2013:2179). As has become typical of the neo-Malthusian perspective, Becker suggested that demography is too narrowly focused on the human population and any discussion of how the world has survived the population bomb must necessarily include a broader ecological perspective.

Lam (2013) countered Becker (2013) by conceding that in fact his argument was focused on the effects of human growth on the human population and that "whether humans are more worthy of consideration than other species is a philosophical and ethical issue" outside of Lam's expertise (2013:2184). Lam went on to say:

> It seems worth pondering the following, however: suppose someone predicted in 1960 that the world would add 4 billion people in the next 50 years (by far the fastest increase in human history), that after 50 years the human population would be considerably better off than it was in 1960, and that the main focus of debate would be on the consequences of the human population explosion for nonhumans. Surely that would have been considered a wildly optimistic scenario in 1960, given concerns at the time about mass starvation and impoverishment. Yet this is, for the most part, exactly where we find ourselves. On a wide range of measures—food consumption, income, infant mortality, life expectancy, poverty, education, and many others—the average human in 2013 is much better off than the average human in 1960, in spite of the fact that there are 4 billion more of us today. Although it is important to consider what damage may have been done to the environment and to nonhumans in order to accomplish this, it is nonetheless an amazing accomplishment that is worthy of recognition (Lam, 2013:2184).

In other words, the human population has weathered the population bomb remarkably well. Yes, aspects of an ecological nature have presented themselves and warrant immediate attention. Yet, that does not negate the fact that the human population has improved in the face of the demographic disaster declared by Malthus and his contemporaries.

The exchange between Lam and Becker is emblematic of the current state of demography in general. I believe that many demographers still side with Becker. Nonetheless, Lam's (2011, 2013) argument is encouraging. Hopefully, more demographers will take a second look at what has been accomplished over the past fifty years. Of course, appreciating the success is only half of the battle. Now we need research oriented towards the aftermath of the supposed population bomb. The policies developed under the population bomb mentality have set in motion demographic trends that will likely be far more difficult to reverse.

Thus, the one theoretical implication of this dissertation is in reference to the paradigmatic approach we take to studying fertility. It is time to move past the ideological baggage accumulated since the work of Malthus. That is not to suggest that we should ignore the important work on overpopulation developed over the past 200 years. However, in reality, the human population is facing a disturbing trend towards very low rates of fertility, a problem which gets less attention in the literature today.

Based on my analysis the average total fertility rate for more developed countries over the last 11 years of the analysis fell to 1.55 children per woman. At this rate several countries will start to lose populations. Germany, for example, reported a population size of 82.2 million in 2000 falling to 81.7 million by 2010 for a loss of approximately 500,000 people. Other regions of the world are experiencing more serious losses. For example, over the last few years the Japanese Bureau of Statistics has reported population losses exceeding 200,000 people (Japanese Bureau of Statistics, 2013). The Japanese experience of population loss will not be an isolated event if current trends in fertility decline as documented in this dissertation continue. Moreover, there is no indication that we should expect fertility to suddenly rebound. Japan, among several other countries, has heavily invested in various policies and programs to encourage fertility with virtually no success (Boling, 2008).

Population scholars need to move away from the population bomb mentality and recognize the potential population implosion on the horizon. Some contemporary scholars have addressed population decline as did Philip Morgan (2003), but have remained skeptical of any real crisis since fertility decline is only an issue in more developed nations; and these countries have the financial capital to offset the financial burdens that will likely accompany declining populations. However, to the contrary, population decline will not be limited to more developed countries if the current trends continue. In fact, many less developed nations will likely witness population losses by the end of this century. Moreover, fertility is declining in these countries at faster rates increasing the likelihood of population aging and economically burdening these populations more swiftly.

I have also encountered another rebuttal in conversations with scholars and members of the general public. When confronted with the possibility of population decline many people respond that low fertility will not continue indefinitely because at some point we will spontaneously have another baby boom. However, the baby boom from 1946 to 1964 in the U.S. and many of the other countries that participated in World War II was largely a product of historical circumstances (Carlson, 2008). Certainly, a second baby boom is possible. However, the economic, demographic, and cultural context of the first baby boom no longer exists today. Therefore, to achieve a similar rebound in fertility rates women in the second baby boom would need to give birth to a much larger number of children without the economic opportunities of the 1950's and

1960's, and in a cultural context that favors much smaller families. Yes, it is possible but very unlikely.

However, the bulk of demographic research seems to ignore the reality that fertility is declining. Thus, I suggest that moving towards a new theoretical paradigm, such as the low fertility trap hypothesis, would properly orient fertility research and focus on the upcoming issues presented by low fertility.

The second theoretical implication resulting from this dissertation involves the role of contraceptives in furthering our understanding of fertility decline. As researchers transition to a low fertility trap mindset, the role of contraceptives will become more evident. Bear in mind that the low fertility trap hypothesis theorizes that fertility decline contains demographic, economic, and social factors that only intensify as fertility declines. However, I argue that this paradigm is incomplete without acknowledging the role of contraceptive technology to enable all of these demographic, economic, and social trends. Contraceptives form the link between intentions and reality; this is so because prior to reliable modern contraceptives it was much more difficult for individuals to actualize their fertility intentions.

Admittedly, even more crude forms of contraception have proven to be effective in comparison to no contraceptive method. Nonetheless, the rapid fertility decline reported in countries like Taiwan, Mexico, South Korea, and China would not have been possible without the use of modern effective contraceptives. Newer contraceptives, specifically the long-acting hormonal methods, permit users to more easily avoid bearing children. Contraceptive technology enables many of the demographic, economic, and social changes described in the low fertility trap hypothesis. My results demonstrate that contraception impacts fertility rates even after controlling for many of these other factors. Therefore, the theoretical implication following from this reality is that researchers need to investigate the ways in which contraceptives contribute to demographic, economic, and social changes that then traps populations in low fertility regimes.

This new approach to studying contraception is indeed a paradigmatic shift from previous perspectives. The overwhelming majority of contraceptive research has focused on two issues, how to improve effectiveness and how to increase distribution. My findings suggest that future research on contraceptives needs to focus on the ways in which contraceptives contribute to sustained low fertility.

If contraceptives do in fact contribute to rapid fertility decline and sustained low fertility, then perhaps it is time to reconsider the manner in which contraceptives are incorporated into development initiatives. It is no secret that for the past fifty years the United States has bundled contraceptives under various titles in foreign aid packages (Wattenberg, 2005). In fact "between 1965 and 1985 the United States contributed more to foreign population control programs than all other countries combined" (Kasun, 1999:102). Future research should assess the impact of contraceptive policy initiatives on actual fertility, while remaining open to the possibility that these policies may drive fertility rates too low too fast.

Summary & Future Research

I began this dissertation by recalling the events that unfolded on August 6, 1945 over Hiroshima, Japan. That single moment in history indefinitely altered the course of international relations. Yet, the dawn of the nuclear age is not alone. Various ideologies and technological developments throughout the ages have the capacity to fundamentally alter the course of human development. Thomas Malthus gave rise to an ideology at the turn of the nineteenth century, which spawned a new generation of contraceptive methods and devices some 150 years later. The combination of a deep-seated ideology with technological expansion crafted one of the most radical transitions in human history.

Once again, "never have birth and fertility rates fallen so far, so fast, so low, for so long, in so many places, so surprisingly" (Wattenberg, 2005:5). Yet, for the past five decades scholars and the general public have largely ignored these tremendous declines in fertility. When scholars did raise the issue as did Donald Bogue (1964), they were often met with skepticism, if not outright derision. I argued in this dissertation that much of this conflict stems from the entrenchment of the Malthusian perspective.

The fear of overpopulation is still evident in many of the leading theories of fertility decline; this may well explain the inability of the majority of these theories to anticipate or explain current fertility trends. Demographic transition theory, for example, has a clear targeted fertility rate of 2.1, even though this figure has proven to be unrealistic since virtually no population as settled at this rate. Countries continue to observe declines in their aggregate fertility rates. This is why I have suggested that more researchers embrace the low fertility trap hypothesis. LFTH examines demographic, economic, and social trends that all contribute in unique ways to declining fertility rates. Moreover, LFTH further explains why so many countries seem incapable of escaping very low levels of fertility. This perspective promises to offer a better explanation of the current situation as an increasing number of countries begin to grapple with the complications of population aging occurring as a result of low fertility.

Thus, the purpose of my dissertation was twofold. First, I endeavored to catalog the incredible amount of change in several developmental factors, including fertility rates, which has occurred in countries all across the globe over the past fifty years. The descriptive statistics speak volumes to the incredible amount of change witnessed over the past five decades. For example, the average total fertility rate in the 1960's among less developed countries was just over 6 children per woman. However, by the first decade of the twenty-first century this figure had fallen to an average of 3.43 children per women. Simultaneously, the rural populations in less developed countries declined from 68 percent to only 50 percent. There were similar sweeping changes across all the other variables in the analysis in more developed countries as well.

Several countries reported incredible declines in fertility over the time period captured in this dissertation. For example, 45 less developed countries reported fertility declines of at least 4 children per woman. Costa Rica began the analysis with a total fertility rate of 7.3 and ended the analysis with a total fertility rate of 1.8. Mexico, Thailand, South Korea, Vietnam, Saudi Arabia, Colombia, and Brazil all reported similar declines. These countries also reported large increases in the proportion of married women using any form of contraception. These concurrent declines in fertility and increasing contraceptive prevalence led me to develop three typologies. “Stable countries” came into the analysis with high levels of contraceptive prevalence and lower fertility rates. “Resistant countries,” on the other hand, reported low levels of contraceptive prevalence in the 1960’s and 1970’s and high levels of fertility. These trends remained fairly constant over the 50 year period suggesting that these countries are resistant to contraceptives. Finally, “transition countries” reported tremendous change in both fertility rates and contraceptive prevalence. These countries began the analysis with less contraceptive use and very high levels of fertility but reported dramatic increases in contraceptive prevalence and fertility declines.

These typologies began to provide evidence supporting the second purpose of this dissertation, which focuses on the contribution of increasing contraceptive prevalence on declining fertility. I formally tested this relationship with the use of quadratic multilevel growth curve models. This advanced longitudinal statistical technique permitted me to develop an individual curve of fertility decline for each country. Furthermore, I was able to statistically demonstrate that contraceptive prevalence impacts fertility decline independent of several other leading explanatory factors such as economic development, urbanization, and declines in mortality.

Moreover, these results suggest that perhaps population scholars should reconsider the ideological perspective under which the majority of population studies are analyzed. The dominant neo-Malthusian perspective no longer appears to be appropriate given the incredible amount of fertility decline and population loss facing many countries today. This is particularly true when better alternative perspectives, such as the low fertility trap hypothesis, are readily available to serve as the theoretical foundation of future analyses. Furthermore, it is clear that contraceptives are encouraging fertility decline even after controlling for other factors. The reality of sustained low fertility, population aging, and population decline necessitate a reevaluation of current family planning policies which include aggressive contraceptive policies. Otherwise, rapid fertility decline coupled with swift population aging will likely place many countries at risk politically, economically, and demographically.

Finally, there are several avenues of future research I will likely pursue that have developed from this dissertation. First, from a methodological standpoint, I would like to further explore the utility of growth curve analyses within population studies. So many issues in demography are well suited for longitudinal analyses. As such, growth curve models offer many advantages to researchers. Moreover, there is a need for the further investigation into the role of multiple imputation in a longitudinal context. For example, researchers need to answer the question of how much of the imputation can be conducted through extrapolation?

The second research trajectory stemming from this dissertation follows the sizeable amount of demographic change cataloged in Chapter IV. More specifically, I would like to further develop the three country typologies I identified in Chapter IV. These typologies may provide greater insight into the mechanisms of fertility decline and how they operate differently under these various conditions. For example, are policy initiatives more successful in transition countries, and if so, why? Why is it that resistant countries still report incredibly low levels of contraceptive prevalence? Has fertility decline in stable countries subsided or is there the potential for further levels well below replacement levels?

Finally, there are several avenues to be explored to further our understanding of contraception. I would like to focus future analyses on a broader range of interaction effects to better grasp whether or not contraceptives mediate or moderate the relationship between other economic, social, and demographic factors and fertility decline. For example, is it possible that contraceptives interact with economic development? Are contraceptives more effective with concomitant increases in educational opportunities for women? Plus, there may be a need to assess the role of contraceptives in sustaining low fertility and even perhaps combating low fertility. This may be useful in countries that have poured billions of dollars into pronatalist programs with little to no success.

Ultimately, there is still so much that we do not know about contraception at an aggregate level or how this technology has assisted in shaping the demographic future of the human species. What we do know is that contraceptives have the capacity to dramatically shape the future, but most research still only focuses on increasing effectiveness and distribution. Imagine if we lived in a world in which research and policy initiatives, and organizations, only sought to increase the yield of nuclear weapons and the efficiency of delivery systems. Moreover, what if scholars only considered one side of any issue or developing technology? Yet, this is largely the case with contraceptives and fertility decline. It is time to further our understanding of these issues in hopes of avoiding the low fertility trap.

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