# A LONGITUDINAL ANALYSIS OF AGGREGATE FERTILITY DECLIN AS A PRODUCT OF INCREASING CONTRACEPTIVE PREVALENCE

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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. Interestingly, a simultaneous population trend emerged in the 1960's, namely, fertility decline. This paper addresses the fertility decline reported in 178 countries between 1960 and 2011 drawing on data from the World Bank Data Bank. This paper focuses on the role of contraceptive prevalence in facilitating the vast fertility decline observed over this time period by estimating multilevel quadratic growth curve models to analyze the effect of contraceptive prevalence on total fertility rates among countries. The 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.

## INTRODUCTION

Sixty years ago demographers would never have imagined that more than a handful of countries would ever 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 is entrenched in the field of demography.

In fact, 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 even physically 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. For example, the United Nations Population Division refused to acknowledge the slowing global population growth that began in the late 1960's until a more recent report released in 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. 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 observer 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.

Contraceptives have created a historic demographic shift by accelerating fertility decline and sustaining low fertility regimes all over the world. Moreover, the threat of population implosion as a consequence of widespread contraceptive use is but one possibility among many, all be it a worst case scenario. Nonetheless, I contend that the longitudinal relationship between contraceptive prevalence and declining fertility is one that warrants our immediate 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 framework 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 at times stained by entrenched ideologies. As a case in point, demography has been clinging to the demographic transition theory for decades even in the face of serious flaws; such as 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. As such, the objective of this paper is to examine global fertility decline among more developed and less developed countries since the 1960's and contextualize that decline in light of increasing rates of contraceptive prevalence over the same period.

## CONTEXT

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 19$^{th}$ century and progressed very slowly, such that by the middle of the 20$^{th}$ 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 20$^{th}$ 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 1.1** Total Fertility Rate by Region of the World

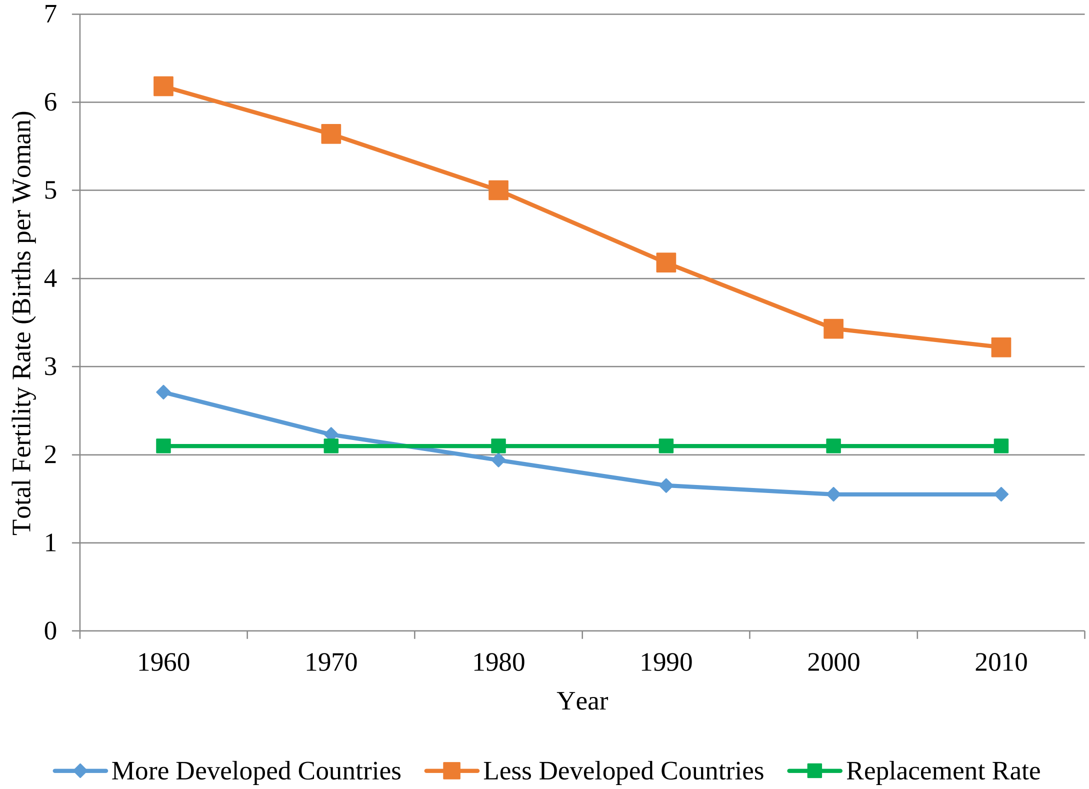



Figure 1.1 shows the dramatic difference in total fertility rates between the more developed and less developed parts of the world. By 1950 the more developed countries were well into the fertility transition. Furthermore, by the start of the 21st century, the more developed countries have already moved 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. For decades researchers have debated the ultimate cause of fertility decline.

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. DTT 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).

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). However, while family nucleation may help explain changes in fertility in parts of Africa, 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.

Theories of diffusion, or diffusion of innovation, also 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). 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).

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 (Himes 1936; McLaren 1990; Noonan 1966; Poston and Bouvier 2010).

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).

More recent theoretical frameworks, however, may provide new insight into the fertility decline observed more recently accounting for persistent low fertility. 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, Lutz and Testa 2003). 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. Finally, 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).

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 “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 all but eliminated by modern effective means of contraception and the prevailing low fertility norms. Thus, LFTH does not explicitly incorporate the role of contraceptives as a mechanism of fertility decline but the theory itself would certainly allow for the inclusion of contraception.

In sum, the objective of this paper is to describe fertility decline over the past five decades or so and examine fertility decline in light of tremendous changes in contraceptive prevalence as a mechanism of fertility decline controlling for other demographic, economic, and sociological factors as specified by LFTH. The paper will proceed in two parts. First, I examine changes in fertility and associated variables among countries divided into more developed and less developed categories. Then, apply a longitudinal quadratic growth curve model to test the effect of contraceptive prevalence on fertility decline within and across countries.

## DATA & METHODS

The data for this analysis comes 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 varies widely. 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. This analysis, however, focuses on only 178 of those countries as a consequence of missing data. The sample is discussed in more detail below.

*Measures*

The dependent variable in this analysis is the total fertility rate reported annually for each country. 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, some longitudinal analyses require researchers to lag the dependent variable if the effect being measured is only observed in the future. 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.

Additionally, 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 begins to decline 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, this analysis utilizes multilevel models. Consequently, independent variables are included in the model 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.

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 the fertility transition. Therefore, though traditional methods are less effective relative to modern contraceptive methods, even traditional methods have the capacity to greatly impact aggregate 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. However, I have developed as specific strategy to deal with the missing observations.

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.

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.

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. Fortunately, the remaining variables did not suffer from missing observations to the same extent as observed for contraceptive prevalence.

Drawing on the fertility theories discussed earlier, 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).

*Analytic Strategy*

Traditionally, multilevel models are 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).

Consequently, I 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 this analysis 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).

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.

## RESULTS

### *Descriptive Statistics*

Longitudinal data require particular care and attention when developing descriptive statistics. Typically, it is easy to generate means, standard deviations, and ranges for each of the variables in the analysis. However, such a summary description for nearly 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 descriptive statistics that roughly corresponds to each decade in my analysis and then further subdivides the tables corresponding to level of development. The final sample contains 178 countries of the original 214 contained in the database. 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 include 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). See Appendix I for tables of descriptive statistics.

There are three general conclusion based on the 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. The amount of variation on all of the variables among the LDC's was surprising. 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.

*Growth Curve Models*

The results of the multilevel model applied to the imputed data are recorded below in Table 1.1. 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.

**Table 1.1** 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 | | | | | | | | |
| $\tau_{11}$ | | | 0.008 | 0.005 | | | 0.076 | 0.018 |
| $\tau_{01}$ | | | 0.00001 | 0.00001 | | | 0.00001 | 0.0002 |
| $\tau_{00}$ | 2.839 | 0.304 | 0.963 | 0.055 | 1.666 | 0.090 | 30.063 | 0.353 |
| $\sigma^2$ | 1.259 | 0.019 | 0.099 | 0.007 | 0.717 | 0.008 | 0.009 | 0.001 |

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

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. Moreover, in the case of time squared and the cross-level interaction between development and contraceptive prevalence, the sign on the coefficient contradicted 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. Yet, some countries' first observation of contraceptive prevalence came as late as 2000. Thus, 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 1.1.

As a result, I include two additional models in this 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 missing 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.

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 ($\beta$=-.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.

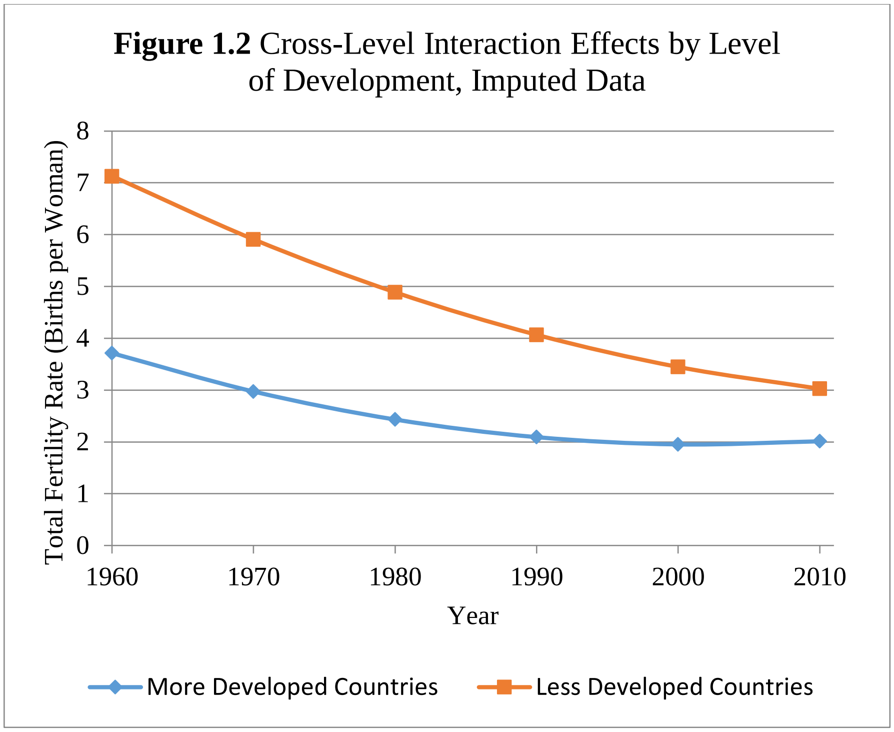
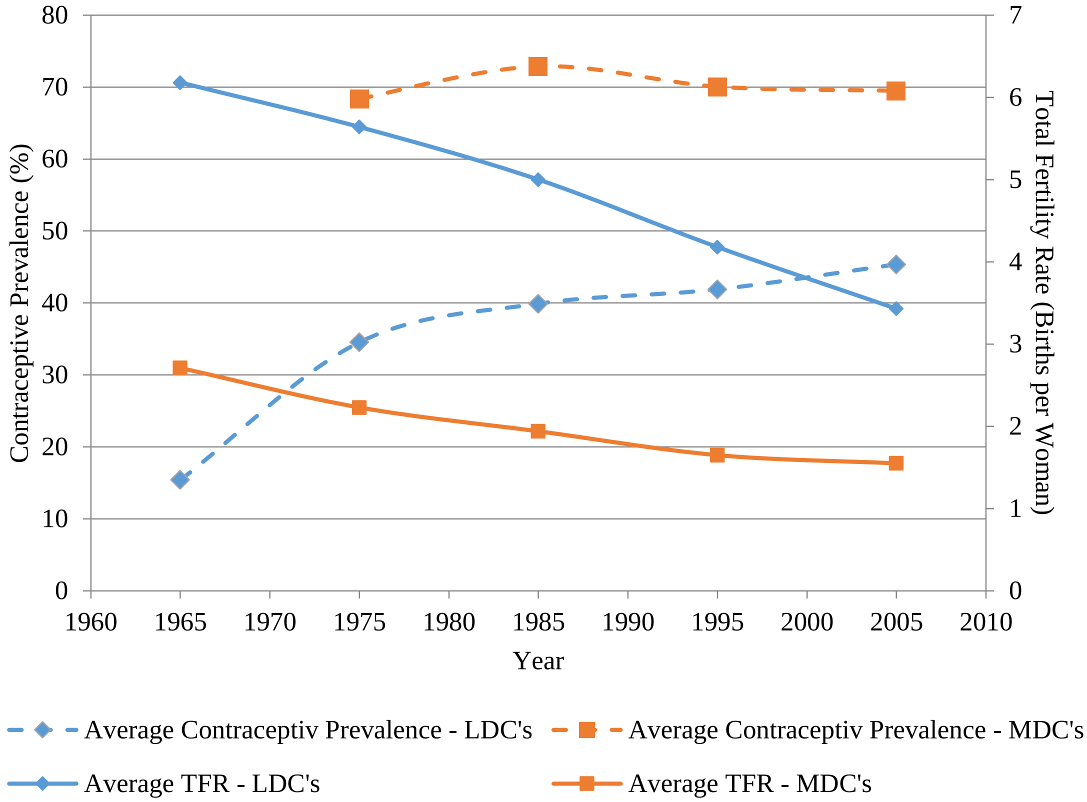



Figure 1.2 graphs these two equations by substituting meaningful values of time. The curve associated with fertility decline in less developed countries has a much higher intercept, which accurately represents their higher level of fertility at the start of the time period. Moreover, the slope of decline is sharper indicating that over time the level of development does impact declining fertility.

## DISCUSSION

Figure 1.3 below plots the average total fertility rate by level of development with the average contraceptive prevalence for each level of development.

**Figure 1.3.** 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, it may be tempting 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. This suggests that perhaps there is a ceiling effect of contraceptive prevalence. In other words, once a population reaches complete saturation the negative effect of contraceptive prevalence on fertility diminishes.

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 hypothesis 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. 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 visible in Figure 1.4 below. The slope of the curve of fertility decline in MDC's plateaus much more quickly.

**Figure 1.4.** Estimated & Actual Total Fertility Rate by Level of Development

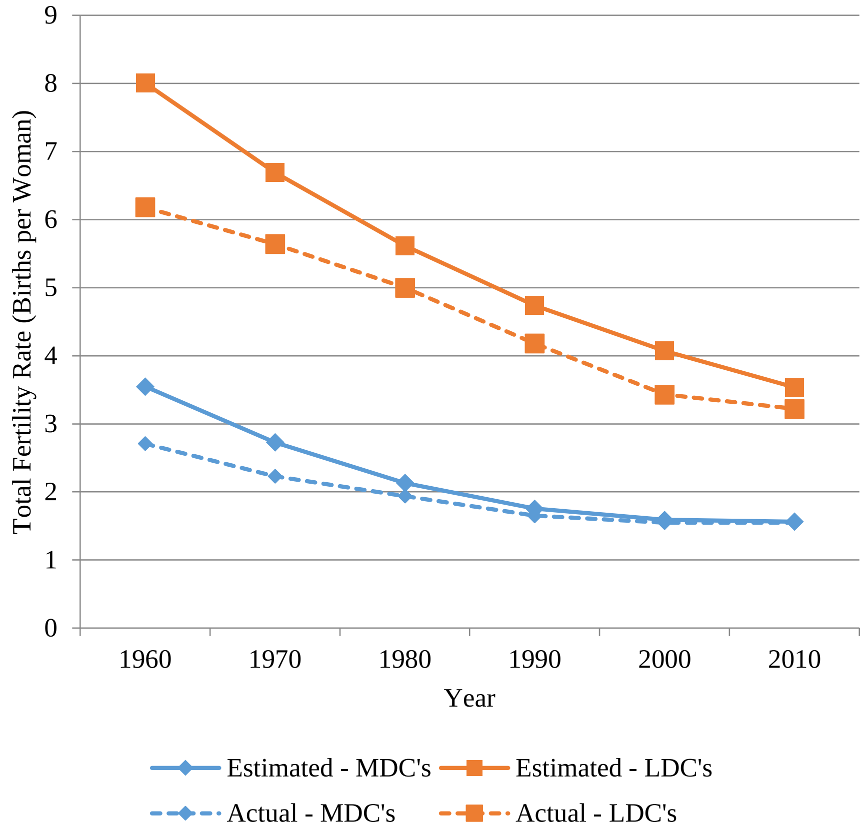



Figure 1.4 displays a similar difference between the curves of fertility decline based on level of development. The difference in fertility decline between the more developed countries and the less developed countries is clearly visible and the differential effect of contraceptive prevalence is partially responsible for that outcome. However, the plateau that occurs at the end of the time period for MDC’s is largely a consequence of the parabolic nature of the analysis and I don’t suggest that this is necessarily the direction of fertility trends.

Furthermore, Figure 1.4 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 analysis. 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. 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, 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 analysis 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 analysis.

*Theoretical Implications*

I have endeavored throughout this analysis 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 analysis 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 past year the annual meeting of the Population Association of America (PAA) marks 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 analysis 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 analysis 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 analysis 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.

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## APPENDIX I

*Descriptive Statistics 1960-69*

**Table A1** 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 A2** 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 |

**Table A3** 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 A4** 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 |

**Table A5** 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 A6** 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 |

**Table A7** 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 A8** 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 A9** 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 A10** 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 |