GLOBAL DEMOGRAPHIC CONVERGENCE? A RECONSIDERATION OF INEQUALITY IN NATIONAL FERTILITY ESTIMATES

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Abstract:

This research challenges the notion that the last half of the twentieth century was a period of global demographic convergence. To be sure, fertility rates fell substantially during the period, but with considerable unevenness. The decline in total fertility across population-weighted countries was sufficiently disproportionate that between-nation fertility inequality, estimated using standard measures of inequality, did not begin to decline until at least 1995. Regression analysis also suggests that only very recently did lagging nations begin to catch up with early adopters of low fertility. Contrary to findings from health inequality research, counterfactual models indicate that sub-Saharan Africa has had a greater impact on fertility inequality than China. The trend in fertility inequality, where convergence appears to be a relatively new phenomenon, stands in stark contrast to inequality in other domains, such as income, education, and health.

Global Demographic Convergence? A Reconsideration of Inequality in National Fertility Estimates

Using an innovative approach to the problem of global demographic change, along with an improved dataset, Wilson (2001) provided a valuable quantitative assessment of the extent to which the fertility revolution has become a truly global phenomenon. His summary finding, that the last fifty years have witnessed a steady increase in the share of the world's people living under conditions of rising life expectancy and declining fertility, led him to describe the period as one of 'global demographic convergence'. Rising and converging life expectancy is generally confirmed by a growing body of empirical research, where a number of studies have applied a wide range of convergence tests and conclude that most of the period from 1920 to 2000 was one of convergence in average life expectancy (Becker, Philipson, and Soares 2005; Bourguignon and Morrison 2002; Easterlin 2000; Goesling and Firebaugh 2004; Neumayer 2003, 2004; Pradhan, Sahn, and Younger 2003; Ram 1982, 1998, 2006; see Cornia and Menchini 2006 for an exception). But beginning around 1990, the trend toward health convergence reversed itself, due in large part to declining male life expectancy in Eastern Europe and Russia and the spread of HIV/AIDS primarily in sub-Saharan Africa, (Goesling and Firebaugh 2004; Neumayer 2004). Using United Nations life expectancy projections, Neumayer (2004, see Table 2) suggests that the current trend toward divergence will once again turn toward convergence, possibly as soon as 2015. The between-nation trend in life expectancy at birth from 1955 to 2000, then, was one of convergence in the sense that health inequality was lower in 2000 than in 1955, and only very recently did the decline in inequality begin to stall and reversed itself. The decline has been uneven, however, and the current and near future looks to be a period of continued divergence because of health declines in Eastern Europe and sub-Saharan Africa.

We know much less about level and change in between-nation fertility inequality. While Wilson's (2001) research confirms that fertility rates around the world have been falling, so much so, in fact, that by 2003, half the world's people lived in countries or regions with below replacement fertility (Wilson and Pison 2005), this doesn't necessarily mean that fertility rates are converging. As it is conventionally defined in between-nation studies, convergence occurs when the relative difference between countries on some variable *Y* declines. In other words, only if variance around the mean is declining, and proportionally faster than the decline in the mean, can we conclude that national fertility rates are converging and, unfortunately, to my knowledge, no study has directly modeled the between-nation fertility trend in this way. By piecing together studies in this area we can, however, develop an informed hypothesis and doing so provides some evidence to challenge the notion that the last half of the twentieth century was a period of fertility convergence.

Consider first what we know about the rise of the modern fertility revolution. Fertility was already low in 1950, but continued to decline; so much so, in fact, that a number of countries are now well below replacement level fertility (Kohler, Billari, and Orteg 2002). During the last fifty years nearly all less developed countries (LDCs) also began the transition, but in two rather distinct waves (see Figure 1). The first wave of this period included most of the nations of Asia, Latin America, and the Caribbean. The second included much of West Asia and North Africa and since the 1990s, sub-Saharan Africa. But these latter two waves have not included all countries in each region, as several nations in West Asia and many in sub-Saharan Africa have yet to begin the transition to low fertility. When we couple the two observations, first that many developed countries with already low fertility in 1955 continued to experience further fertility decline during the ensuing fifty years, and second, that a rather large number of high fertility countries have yet to begin the transition, the evidence suggests little, if any, convergence between high and low fertility countries. But beyond the tails of the fertility distribution, the middle of the distribution has experienced dramatic change over the last half century, with a large number of countries entering the transition during this period, but with considerable variability in the timing and pace of decline (Bongaarts and Watkins 1996; Bongaarts 2002; Bryant 2007). An additional source of variation in the middle of the distribution comes from countries staging for the fertility transition, where it has been observed that fertility increased for a decade or more just prior to the onset of fertility decline in nearly all LDCs (Dyson and Murray 1985; Garenne 2008).

FIGURE 1 ABOUT HERE

In a recent study, Casterline (2001) modeled the pace of fertility decline in less developed countries from 1950 to 2050 and found a significant level of inter-country and intra-regional variation in the pace of fertility decline. So much variation, in fact, that in his view “what is most impressive is the inter-country variability in the amount of [fertility] decline" (Casterline 2001: 26). In another recent study, Crenshaw et al. (2000) used a growth rate regression model (a conditional β-convergence model, discussed in more detail later) to test human ecology and evolutionary theory in the context of change in fertility rates. In all of their conditional models, the evidence suggested convergence. But conditional models are, in a sense, counterfactuals. They tell us what the size and direction of change in Y *would have been* if not for the contaminating influence of the independent variables. While they did report a non-significant zero order correlation (.03) between 1965 TFR and change in the TFR from 1965 to 1990, this was for a reduced set of LDCs and not for the world. Finally, data from Wilson and Pison (2004, Figure 1), which displays the cumulative distribution of the world’s population by fertility level in 1950-55, 1975-80, and 2003, suggests that despite significant change in the middle of cumulative distribution, the overall range does not appear to have declined over the period. In 1950-55, the lower bound of the TFR was about 2 and the upper bound was close to 8. By 2003, the lower bound of the TFR had declined to about 1 and the upper bound was about 7.

It is clear that both the onset and rate of fertility decline have shown remarkable cross-national variation (Casterline 2001). I argue that the observed variation in between-country fertility decline for much of the last fifty years points to divergence, rather than convergence. In this article, I begin to fill the gap between Wilson's (2001) finding of a global decline in mean fertility (TFR)[1], the Crenshaw et al. (2000) finding of what appears to be, if anything, divergence among LDCs from 1965 to 1990, and the findings of Casterline (2001) and Dyson and Murray (1985) that the fertility transition has been highly uneven, with rising and falling fertility during the period (see also Garenne 2008). Using United Nations estimates, I provide a robust convergence-divergence test of the magnitude and direction of change in fertility inequality from 1955 to 2005 for a near census of the world's countries and people. The rest of the paper will proceed as follows: section one discusses competing definitions of convergence and its measurement; section two describes the data and weights used in this analysis; section three presents analysis and discusses the results for convergence tests; and in section four I briefly draw some conclusions.

Defining and Measuring Convergence

Students of convergence have employed a variety of statistical methods to test for convergence within and between countries across a broad range of indicators and domains. Perhaps two of the most common methods, referred to as β-convergence and σ-convergence, measure growth rates and variance, respectively. A third method, using measures of inequality, estimates the spread of a distribution and adjusts for known shortcomings with the σ-convergence method.

β-convergence. In the classical definition, where it was originally applied to income inequality, convergence occurred when the growth rate among poor nations was greater than the growth rate among rich nations (Sala-i-Martin 1996, 2006). The condition where former laggards, fueled by higher growth rates, catch up with former leaders is referred to as β-convergence because it is typically modeled using ordinary least squares regression where the annualized growth rate over the study period is regressed on the observed rate at base measurement (Barro and Sala-i-Martin 1991, 1992). The equation for β-convergence is

$$\ln(Y_{jn}/Y_{j0})/\mathrm{T} = \alpha + \beta_1(Y_{j0}) + e_j \qquad (1)$$

where ln is the natural log, subscript $_{j0}$ refers to the jth country at base measurement, subscript $_{jn}$ is the jth country at second measurement, T is the number of years from base to second measurement, β_1 is the convergence coefficient, α is the constant, and e_j is the error term for the jth country. A negative sign on the convergence coefficient indicates lagging countries are catching up with leading countries (converging), while a positive coefficient indicates laggards are falling farther behind (diverging).[2] Applied to fertility, β-convergence occurs when the *rate* of decline among countries with high fertility is larger than the rate of decline among low fertility countries. This form of convergence provides us with a useful tool for measuring change within the fertility distribution and allows for the possibility that the rank ordering of countries on their level of fertility has changed over time.[3]

σ-convergence. An alternate specification of cross-national convergence, referred to as σ-convergence because it is estimated using the standard deviation, tells us about the overall spread of the fertility distribution (Sala-i-Martin 1996; Neumayer 2004). If the repeated cross-sectional

standard deviation increases, we say that countries are diverging on *Y* and if the variance declines, we conclude that countries are converging. The standard deviation has been used to test for σ-convergence in incomes (Sala-i-Martin 1996), infant and child survival rates, and life expectancy (Neumayer 2004), to mention just a few. The utility of the standard deviation in longitudinal design, however, is its appraisal of inequality under the condition of a relatively constant mean, but as has been well documented, the mean TFR for the world has been anything but constant over recent decades. When the mean of *Y* is trending down, the standard deviation might also be decreasing, but this doesn't necessarily mean that the distribution is becoming more equal. Only if the standard deviation is decreasing faster *relative* to the mean is the fertility distribution becoming more equal. This highlights an important limitation of the standard deviation for measuring the spread of *Y*, namely, its failure to meet the condition of scale invariance. Students of convergence have often turned to alternative distributional measures that capture change in the variance of *Y* while not violating the tenets of a measure of inequality.

Inequality. Inequality is a measure of *relative* disproportionality concerned with the uneven distribution of goods or services across units in a population (Firebaugh 2003). For the present study, inequality refers to the relative differences, across countries, in national TFR estimates. The distinction between absolute and relative change in fertility is important for understanding change in inequality because the two stand to affect between-nation fertility trends quite differently. When considering change in the level of inequality, it is possible that the absolute gap between countries with the highest and lowest TFR might be decreasing, while inequality is simultaneously increasing. Consider the two countries in Table 1, where the absolute decline in fertility was larger for Country A and therefore the fertility gap between the two countries decreased. Now consider the relative change, where the rate of change for

Countries A and B was 17 and 25 percent, respectively. Because the rate of change in fertility was greater for Country B, the relative difference between the two countries, measured using the ratio of Country A fertility to Country B fertility, increased even though the absolute difference between the two countries decreased. It is important to keep in mind then, that an absolute decline in fertility gaps is neither a necessary nor a sufficient condition for declining fertility *inequality*. In keeping with studies of between-nation inequality in other domains, such as income and life expectancy, I focus on relative difference and change in fertility, and so, unless otherwise noted, all reported results refer to relative inequality.[4]

TABLE 1 ABOUT HERE

Following recent research on international and global inequality in income and life expectancy (Bourguignon & Morrison 2002; Firebaugh 1999, 2003; Firebaugh & Goesling 2004; Goesling 2001; Goesling & Firebaugh 2004; Korzeniewicz and Moran 1997), I report results for a number of inequality indexes which can be expressed in summary form using the following equation:

$$I = \Sigma_j p_j f(r_j) \qquad (2)$$

where I is the index of inequality; $r_j = X_j / \overline{X}$ is the fertility ratio of the jth unit (fertility for the jth unit divided by the world average fertility); $p_j = n_j/N_j$, the population share of the jth unit; f = the functional form used to measure variance; and $\Sigma_j p_j f(r_j)$=0 when $r_j = 1$ for all j's (Firebaugh 1999; Firebaugh and Goesling 2004). Equation 2 establishes a standard formula into which various summary measures of inequality can be inserted.

Perhaps the simplest measure of inequality is the coefficient of variation, calculated as the standard deviation divided by the mean. Other measures of inequality widely used in cross-national convergence analysis include, among others, the gini coefficient, the Theil index, and the mean log deviation. While each of these measures of inequality differs slightly in formulation, their functional commonality is that the mean of *Y* is included in the denominator, making them scale invariant (Allison 1978). In this research I estimate change in the level of inequality using three population-weighted measures of inequality: the gini coefficient, the mean log deviation (MLD), and the Theil Index.[5] I use these three measures because each tells us something slightly different about fertility inequality and, taken together, help us to identify the source of change in the fertility distribution. The MLD is more sensitive to change at the bottom of the distribution[6], and the gini is relatively more sensitive to change in the middle of the distribution, where a large increase or decrease in the gini would suggest that the greater source of change in inequality is due to movement among populations with TFR's close to the world mean. Like the MLD, the Theil index also uses the log of *Y*, but does a secondary log adjustment that offsets the over importance of low tail units, leaving the Theil more sensitive to change at the top of the distribution (Allison 1978). Greater relative growth or decline in the MLD or the Theil would locate the source of change in fertility inequality in low and high fertility countries, respectively.

Data and Methods

Data. Data for this analysis cover the period from 1955 to 2005 and rely on estimates from the UN Population Division's *World Population Prospects. The 2006 Revision.*[7] United Nations fertility estimates are extensive and therefore population coverage for this analysis is unusually high. I include 195 countries covering well over 90 percent of the world's people.[8] Missing data were listwise deleted, so each nation is measured every five years from 1955 to 2005. For much of the analysis, I rely primarily on two variables, the total fertility rate and national population estimates. UN fertility and population estimates are available in 5 year intervals (1950-55, 1960-

65, etc.), but to simplify tables, figures, and discussion, I use the right endpoint for all five year interval estimates. For example, 1950-1955 estimates are referred to throughout as 1955, 1985-1990 estimates are referred to as 1990, etc. Unless otherwise noted, all fertility, life expectancy, and population data are derived from the UN quinqennia estimates. From the population estimates I constructed population shares (the ratio of the population of country *j* to the total world population) where the sum of the shares equals 1.0. Population and fertility estimates for many LDCs, particularly for the earliest years in the study, clearly contain measurement error, and we should therefore interpret trends for earlier periods with some caution. However, given that this study is looking at broad, macro-level trends, it is unlikely that even improved data would significantly alter the substantive conclusions of this analysis.

Weights. A great deal of debate over level and change in global inequality has stemmed from decisions surrounding data weights. Early studies of between-nation income inequality, conducted primarily among economists, treated each country equally because the principle units of interest were economies. More recently, sociologists entered the debate and argued that if the substantive focus is on the economic welfare of individuals, rather than economies, then the more appropriate approach is to weight countries by population size (Firebaugh 1999, 2003; Korzeniwitz and Moran, 1997). Doing so ensures that a change in *Y* for a large country like China has a greater impact on the inequality trend than a change in *Y* for a much smaller country like Jamaica. Because my focus, as was Wilson's (2001), is on change in the TFR for the world, all estimates are adjusted by population shares unless noted otherwise. I use the term *international* inequality (Milanovic 2005) when referring to population-weighted, between-nation inequality.

Implicit in this analysis, as with all studies of international inequality, is the assumption of zero within-nation variance in fertility. The zero variance assumption is made for two reasons: 1) when national fertility estimates are weighted by population size, every person is assigned the mean TFR for their country, and 2) because international inequality is, by definition, only concerned with population-weighted, between-nation differences in some variable *Y*. If we had a longitudinal measure of the within-nation variance in TFR for a share of the world's countries equal to those for which we have the national mean TFR, we could use a method similar to analysis of variance and estimate the sum of the within and between-country components to arrive at an estimate of *global* inequality. Because of data limitations, at this point, I am only able to measure international inequality, but it is clear that a significant portion of global fertility inequality is due to the within-country component.

Convergence and Inequality Analysis

Figure 2 plots the cross-sectional correlation between 1955 TFR and the annualized rate of change in TFR from 1955 to 2005. The country-weighted correlation failed to produce a statistically significant relationship between initial TFR and subsequent change in TFR while the population-weighted correlation is negative and statistically significant. The latter correlation indicates that highly populous nations with high fertility had a larger relative decline in TFR than did populations with lower fertility in 1955. According to β-convergence results, *countries* were neither converging nor diverging over the last fifty years, while *populations* appear to have converged. The country-weighted model suggests that knowing the 1955 TFR for the average *country* tells us nothing about fertility decline over the subsequent fifty years, due to the lack of correlation between the two variables. Alternatively, knowing the TFR in 1955 for a *population*, where countries are weighted by population size, tells us a great deal more about the pace and direction of decline over the last fifty years.

FIGURE 2 ABOUT HERE

An often overlooked limitation to the cross-sectional growth regression approach is that it ignores all variation occurring between base and second measurement. The implicit assumption with the cross-sectional growth model is that change for the entire period is monotonic, when the intra-period correlation between the fertility growth rate and initial fertility might instead be non-linear. To explore the possibility of contradictory underlying trends during the fifty year period, I estimated piecewise regressions that reduced the measurement period to ten year intervals. β-convergence results for the world indicate that the full, fifty year correlation for the world masks decidedly uneven underlying trends (first column of coefficients in Table 2). When the convergence coefficient is broken down into five separate 10 year periods, we see that the only period of statistically significant convergence was from 1995 to 2005.

Two additional lines of reasoning with regard to the global trend in β-convergence warrant consideration. The first is that much like its influence over the distribution of life expectancy and income, China, with its substantial demographic weight, might be a key driver behind the recent world fertility trend (Goesling 2001; Firebaugh 1999, 2003; Firebaugh and Goesling 2004; Goesling and Firebaugh 2004). The second stems from Figure 3 where, contrary to most of the rest of the world, the weighted regional mean TFR for sub-Saharan Africa has proven to be remarkably stable over much of the last half of the twentieth century. Perhaps convergence and divergence in fertility is more a story of China's demographic pull in population-weighted trends or of the relative stubbornness of African fertility to respond to the larger global trend toward fertility decline. Results from two additional β-convergence estimations, one that excludes China, and another that excludes the nations of sub-Saharan Africa, are reported in Table 2. Contrary to change in international inequality in income and life expectancy, where China has been a major contributor to recent convergence, the exclusion of China had a surprisingly small effect on the observed world fertility trend. While the exclusion of China weakens the statistical significance of the fifty year growth coefficient, the sign is still negative. In the piecewise regressions, removing China would only have secured the decade of 1955-65 from one of uncertainty to one of unequivocal divergence. Possibly the more important story regarding the *rate* of fertility decline over the last half century is the braking effect that the nations of sub-Saharan Africa appear to be exerting on β-convergence, where the counterfactual simulation indicates that without these nations, cross-national convergence would have begun a full twenty years earlier.

TABLE 2 ABOUT HERE

Figure 3 graphs the country-weighted (because each country is weighted equally) and population-weighted trends in the mean and standard deviation of the TFR for the last half century. The population-weighted standard deviation was virtually flat until the mid 1980s, after which it began a slow decline. The unweighted standard deviation followed a quite different trajectory, *increasing* until the early 1980s, before beginning a decline that has not reversed itself. Weighted σ-convergence suggests that while the overall trend from 1955 to 2005 was one of convergence in the sense that the standard deviation in 2005 was smaller than the standard deviation in 1955, the precise period of convergence has only been the last two decades. Although they disagree on the exact period of convergence, β-convergence and σ-convergence do both agree that only rather recently did countries begin to converge toward a common TFR.

FIGURE 3 ABOUT HERE

Turning to the inequality trends, we see in Table 3 that inequality increased monotonically from 1955 to 1995 for three summary measures of inequality. The inequality coefficients concur with the regression convergence coefficient for the most recent decade, where both suggest that nations only began to convergence in about 1995. The Theil registered the largest percentage increase (99 percent) during the 40 year period of rising inequality (1955 to 1995), suggesting that the single biggest source of divergence in the TFR was the delayed onset of the fertility transition for many LDCs. The MLD registered the greatest percentage decline (7 percent) for the most recent 10 year period, suggesting that what is most responsible for the recent decline in fertility inequality was the slowing of fertility decline in developed countries with already low fertility. So while Africa appears to have been a major factor in the trend toward β-divergence and rising inequality, a slowing in the relative decline in fertility among nations with low and below replacement fertility appears to have played a larger role in the recent convergence of the fertility distribution from 1995 to 2005. Somewhat surprisingly, but in full support of the β-convergence and σ-convergence findings, change in the middle of the distribution, largely comprising the countries involved in the second wave of the fertility transition, had a relatively modest influence on fertility inequality (as measured by the gini coefficient). That the inequality trend is due to change at both ends of the distribution is in line with previous research on two accounts. First, fertility continues to decline among countries with already very low fertility (Kohler, Billari, and Orteg 2002; McDonald 2006), though at an ever slower pace. Second, the movement toward higher fertility among nations with already high fertility is in line with previous research finding that most countries experience a noticeable increase in fertility just prior to sustained, long-term declines (Dyson and Murphy’s 1985; Garenne 2008).

A notable limitation with the univariate cross-sectional estimation of inequality employed here is the absence of statistical inference. Once we have estimated inequality (*I*) for each cross-sectional fertility distribution, we would like to be able ascertain the likelihood that the observed change in *I* is due to chance. Confidence interval estimates allow us to make just this sort of statistical inference about the inequality trends generated from the repeated cross-sectional distributions. If *I* at time T_n falls outside the confidence interval of $T_{0,}$ then we can cautiously conclude that the change in *I* from T_0 to T_n is not due to chance (Moran 2006). In Table 3, I report bias corrected, bootstrap confidence interval estimates for the Theil index. The 1955 Theil index estimate of .057 falls outside the confidence intervals beginning in 1985, allowing us to cautiously conclude that with a thirty year interval, the observed change in the Theil index of inequality was significant.

Finally, using United Nations medium variant projections, I extended the analysis in Table 3 from 2005 to 2050. The results, not reported here, suggest that the high water mark for fertility inequality was near the turn of the twenty-first century and the projection data indicate that the population-weighted fertility distribution will continue to decline in the coming decades.[9]

TABLE 3 ABOUT HERE

Results from the analysis of the overall and intra-period *β*-convergence and *σ*-convergence fertility trends, coupled with the inequality trends for the period from 1955 to 2005, give rise to one last question within the scope of this article. How does fertility inequality compare to inequality in other dimensions of development over recent decades? Some scholars have argued that not only are fertility rates converging, but they are doing so more rapidly than other dimensions of development (see for example, Kohler, Billari, and Orteg 2002, page 641;

Wilson and Pison 2005, page 3). Because the inequality coefficients derived from scale invariant measures of inequality are readily comparable across indicators irrespective of the scale from which the inequality coefficient is derived, we can empirically test this assertion. In Figure 4, I compare the international inequality trend in fertility to the inequality trends for income (measured as GDP per capita in PPPs), education (years of schooling completed), and health (life expectancy at birth). All three indicators are commonly used in 'standard of living' and 'quality of life' indexes. The standout finding from this comparison is that while fertility rates diverged over most of the last half century, population-weighted nations were converging on per capita income, educational attainment, and life expectancy at birth[10]. From 1960 to 2000 the gini coefficient declined by 6 points for income, by 18 points for education, and by 7 points for life expectancy. Over the same period the gini coefficient for fertility *increased* by 9 points. So while the populations of the world, in aggregate, were becoming increasingly homogeneous in three diverse quality of life indicators, the opposite was true of fertility.

Beyond just change in inequality, another clear difference between the four indicators in Figure 4 is the sizable variation in the level of inequality. Next to life expectancy, fertility inequality, though rising, is still noticeably lower than inequality in either education or income.

FIGURE 4 ABOUT HERE

Discussion and Conclusion

The object of this research was to provide a robust empirical assessment of the extent to which fertility rates have converged or diverged over the last fifty years. This research builds on Wilson's (2001) finding of a global decline in fertility by testing for two types of convergence. Recognizing that a study of convergence is essentially an analysis of inequality between nations (Peacock et al. 1988), I also included three measures of inequality. Together, the analysis estimated both the rate of convergence and also changes in the distribution of fertility over the last half of the twentieth century.

β-convergence analysis suggests that the overall trend for the last fifty years was one of convergence, but the piecewise regression results demonstrate that only very recently did the rate of decline in fertility among late adopters exceed the rate of decline among early adopters. *σ*-convergence shows a much longer stall, where an appreciable decline only began in about 1990, fully twenty years after the beginning of the decline in the world mean. The inequality analysis confirms the finding that convergence only began relatively recently, in about 1995, but contrary to *β*-convergence and *σ*-convergence, inequality analysis found that the fertility distribution increased steadily for the whole period from 1955 to 1995. It appears then, that fertility convergence across nations is a relatively new phenomenon, but one that is being driven by the twin effects of the recent onset of fertility decline among highest high fertility nations and the relative slowing of fertility decline among the lowest low fertility nations. The data indicate that the high water mark for fertility inequality was achieved around the turn of the 21st century and, barring major unforeseen shocks, this trend will continue unabated in coming decades.

This research makes four important contributions. First, it quantifies global variation in fertility such that we can now state with greater accuracy the extent to which the world as a whole has participated in fertility decline over the last fifty years. Wilson and Airey (1999: 127) claim that "our theories should combine the global nature of the forces leading to [fertility] transition and the unique path-dependent course followed within each society." I argue that the quantification of between-nation fertility inequality presented here fills a clear gap in our knowledge of the global trend in fertility inequality. While we have long been aware of significant between-nation variation in the onset and rate of fertility decline (c.f. Bongaarts and

Watkins 1996; Bongaarts 2002; Casterline 2001; Coale and Watkins 1986; Dyson and Murphy 1985), the estimates here quantify the magnitude and direction of fertility inequality over the last half of the twentieth century in a way that helps to pinpoint global turning points in macro-level variation in fertility.

The second is a two-fold methodological contribution. This research demonstrates the benefit of using multiple measures for assessing the changing nature of between-nation fertility inequality. Having only relied on the fifty year cross-sectional regression analysis, we would have concluded that the last half of the twentieth century was one of convergence. Results from the piecewise regression, as well as σ-convergence and inequality analysis, make clear that only rather recently did national fertility estimates begin to converge. These findings stand as a reminder to researchers of the importance of population weights, where unweighted analysis is appropriate when the unit of interest is countries and weighted analysis is appropriate when the unit of interest is populations. Estimates presented here found that population-weighted results generally tended to favor convergence, indicating that larger populations have been converging more so than the average, unweighted nation.

Lastly, this analysis represents the long overdue entrance of fertility into the larger debate regarding international and global inequality. Moving beyond income, global inequality research is now asking questions about processes underlying the broader diffusion of quality and quantity of life (Becker, Philipson, and Soares 2005), and material and ideational diffusion in truly world models (Meyer, Boli, Thomas, and Ramirez 1997; Meyer, Ramirez, and Soysal 1992). Rising fertility inequality over much of the last half century stands in stark contrast to inequality in most other areas, where it has generally been declining for some time. The counterfactual models estimated in Table 1 point to another way in which fertility inequality differs from trends in other development indicators. China appears to have had only a modest effect on fertility inequality, but its influence on income and health inequality has been significant (Goesling 2001; Firebaugh 1999, 2003; Firebaugh and Goesling 2004; Goesling and Firebaugh 2004). Sub-Saharan Africa, on the other hand, has had a noticeable braking effect on fertility convergence. Some researchers have recently begun to argue that the nations of sub-Saharan Africa will play an increasingly important role in global inequality in life expectancy (Neumayer 2004) and income (Dollar 2005), such that Dollar (2005) speculates about the "Africanization" of poverty and underdevelopment. So clearly there are some areas of cleavage between fertility inequality and inequality in other domains, yet there are also important areas of overlap. Demographic change, occurring in successive waves that lead to rising and then falling inequality, is true of both life expectancy (Vallin and Meslin 2004) and fertility inequality.

The study of fertility inequality has much to offer the larger debate surrounding stability and change in global inequality, where fertility research brings a particular wealth of knowledge concerning the ideational and cultural determinants of diffusion (Lestheaghe 1983, 1995; Lestheaghe and Vanderhoeft 2001; Rosero-Bixby and Casterline 1993) that is somewhat less developed in some of the other literatures. Clearly, the diffusion of ideational and material innovations related to health, wealth, and education is occurring with greater ease than is diffusion associated with fertility decline. But beyond the "diffusionist" and "ideational" theories, recently work by Bryant (2007) provides a welcome reminder of the clear link between economic development and onset and pace of fertility decline. Although sub-Saharan African fertility has begun to fall in recent decades, so also have a number of key development indicators begun to stagnate or decline in recent years, suggesting that the pace of fertility decline in this region may continue to only slow converge toward the world mean TFR.

While "nearly everything that matters" has been converging over the last fifty or more years (Kenny 2005), fertility stands out for being so heterogeneous. A possible answer to the question of convergence in health, wealth, and life expectancy is the consistent linkage between these three domains and the development project, where the development project and has been strongly associated with diffusion in other domains (Berkovitch and Bradley 1999). But thus far, fertility appears to have been less consistently linked to the development project than other variables. These findings point to the need for additional research to expand both our understanding of the determinants of the uneven diffusion of the fertility revolution and to help us better understand the mechanisms underlying global convergence and divergence.

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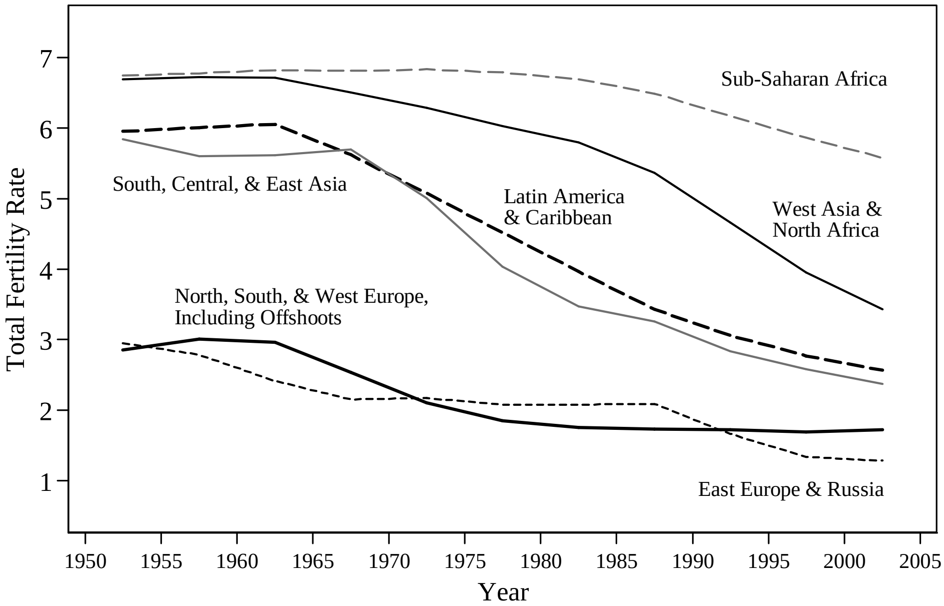
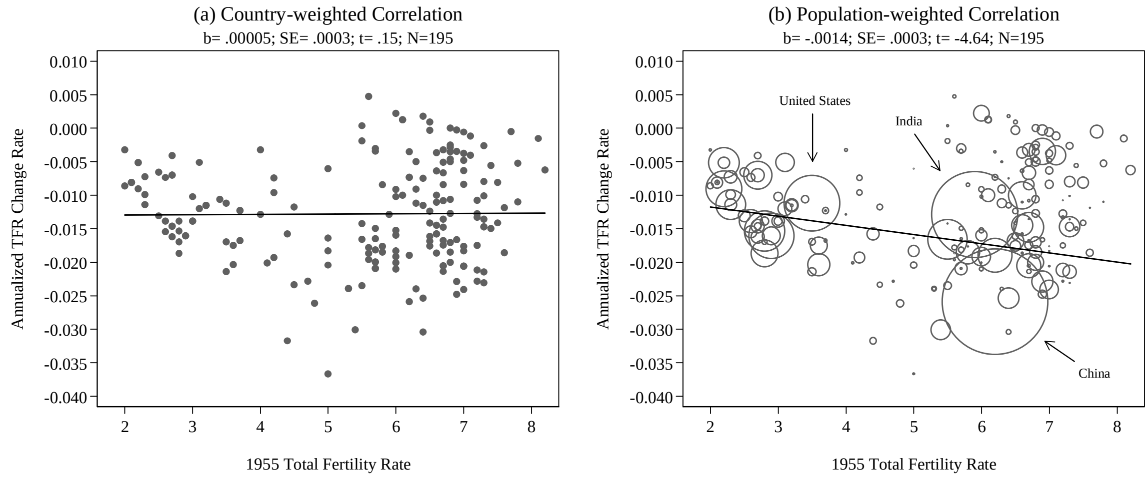
Figure 1. Population-weighted Regional Fertility Trends



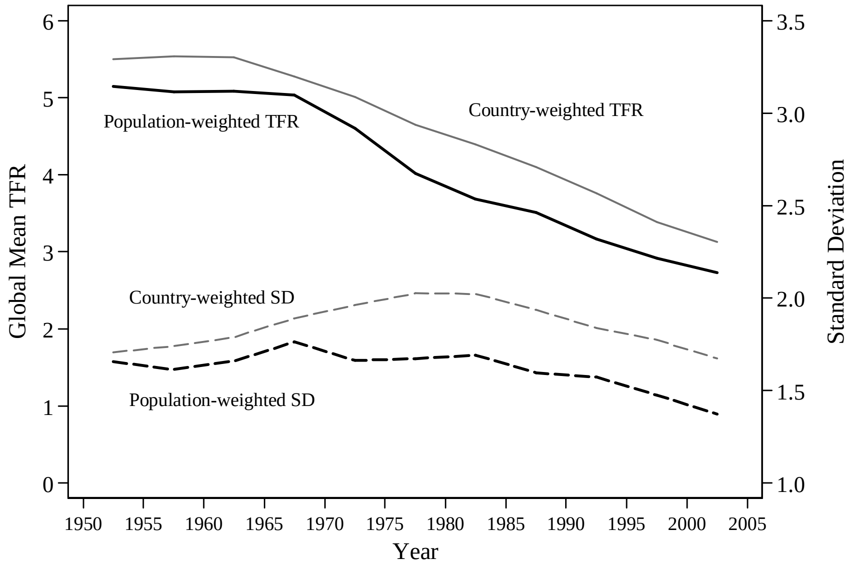
NOTE: Regional trends are weighted by the population size of the countries comprising each region, such that highly populated countries have a larger influence over regional means than low population countries. 'Offshoots' refers to the United States, Canada, Australia, and New Zealand.

Figure 2. Average Annual Rate of Change in TFR, 1955-2005, Regressed on 1955 TFR



NOTES: Dots represent countries and the diameter of each dot reflects the weight adjustment applied to each country. Each country is given equal weight in (a) and in (b) countries are weighted according to total population size. TFR Change Rate = log(2005 TFR/1955 TFR)/50. Negative slope indicates that high fertility countries experienced a larger rate of decline in TFR than low fertility countries. UN estimates are quinquennial such that 1955 data is the estimated fertility between the years 1950 and 1955. I use the right endpoint of each five year interval to simply graphs and discussion.

Figure 3. Global Mean TFR and Standard Deviation



NOTE: Population-weighted trends adjust national total fertility rate (TFR) estimates by the total population of each nation, while country-weighted trends treat each nation equally, irrespective of population size.

Table 1. Absolute vs Relative Difference and Change in TFR

	1950	*2000*	*Absolute Δ*	*Relative Δ*
Country A	6.0	5.0	1.0	17%
Country B	2.0	1.5	0.5	25%
Absolute Difference (Fertility Gap)	4.0	3.5		
Relative Difference (Fertility Ratio)	3	3.33		

NOTES: The absolute difference between Countries A and B is measured as the fertility gap (Country A TFR - Country B TFR), while the relative difference is measured using the fertility ratio (Country A TFR/Country B TFR). Similarly, absolute change is measured as the simple difference between 1950 and 2000 TFR, while relative change is measured as the percentage change from 1950 to 2000. Inequality (relative difference) may be rising even though the absolute gap between countries is declining. This condition of opposing trends occurs when the relative fertility decline of low fertility countries is greater than the relative decline of high fertility countries.

Table 2. Piecewise Correlations: Average Annual Change in TFR Regressed on Initial TFR

	World		World, Excluding China		World, Excluding sub-Saharan Africa	
Year	*β*	*Direction*[a]	*β*	*Direction*	*β*	*Direction*
1955-2005	**-.001**	↓	**-.000**	↔	**-.002**	↓
1955-1965	.001	↔	.002	↑	.001	↔
1965-1975	.005	↑	.006	↑	.004	↑
1975-1985	-.003	↔	.000	↔	-.007	↓
1985-1995	.000	↔	-.002	↔	-.003	↓
1995-2005	-.005	↓	-.004	↓	-.012	↓
N	*195*		*194*		*148*	

[a] "↑" = statistically significant divergence, "↔" = non-significant, cannot say either way, and "↓" = statistically significant convergence.

NOTES: β-convergence refers to the bivariate correlation between first year TFR and the annualized growth rate over two time periods. Convergence occurs when high fertility is correlated with low growth (declining fertility). The coefficients in the first five rows are interpreted as the annualized growth rates of fertility in ten year increments, while the last row is the annualized growth rate over the entire 50 years. United Nations fertility estimates are quinquennia such that estimates are for 5 year intervals (e.g. 1950-1955). I refer to the right endpoint of the temporal interval to simplify the table and discussion. For example, the first row regression coefficients (1955-1965) refer to the ten year fertility growth rate spanning from 1950-1955 to 1960-1965.

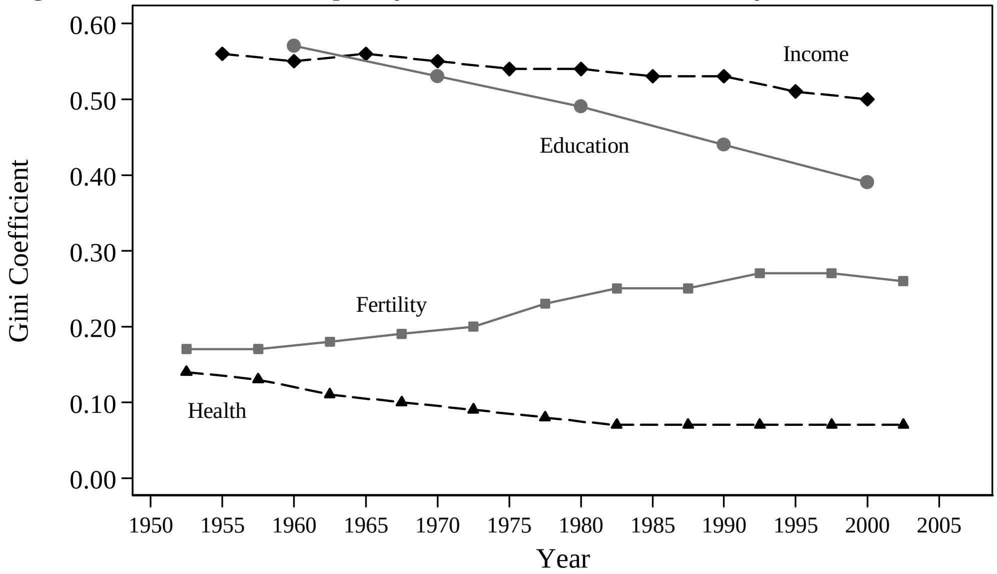
Table 3. International Fertility Inequality Trends: 1955-2005

	MLD	Gini Coefficient	Theil Index		
Year			*Upper CI*[a]	*Index of Inequality*	*Upper CI*
1955	.066	.172	.037	.057	.088
1965	.069	.175	.030	.059	.100
1975	.084	.197	.037	.072	.132
1985	.105	.254	.074	.102	.144
1995	.114	.267	.068	.114	.153
2005	.105	.258	.073	.110	.162
Percent Change in Inequality, 1955-2005	59.9	49.9	--	84.7	--
Percent Change in Inequality, 1955-1995	72.5	54.7	--	99.3	--
Percent Change in Inequality, 1995-2005	-7.3	-.3.1	--	-03.1	--

[a] Reported confidence intervals were estimated using the bias corrected, bootstrap method.

NOTES: International inequality refers to population-weighted, between-nation inequality. The MLD (Mean Log Deviation), the gini coefficient, and the Theil index are measures of inequality used to summarize the spread of a distribution. More unequal distributions will yield a larger inequality statistic.

Figure 4. International Inequality: Income, Education, Fertility, and Health



NOTES: Income is measured using GDP per capita in purchasing power parities, education is the average total years of schooling completed, health is life expectancy at birth, and fertility is measured using the TFR. International inequality refers to population-weighted, between-nation inequality.

SOURCES: Fertility and Life Expectancy (World Population Prospects. The 2006 Revision); Income (Milanovic 2005, Appendix 6); Education (Morrisson and Murtin 2005).

[1] Wilson's interpretations were primarily based on the median of the cumulative TFR distribution, rather than the mean. He also presented less formal measures than the calculations present here and so the results are not strictly comparable. For example, he emphasized the fraction of the global population for whom TFR was below replacement.

[2] Note that equation 1 is an *unconditional* model because no additional right-hand side covariates are included. Crenshaw et al. (2000) used a conditional model, in that they included control variables in their models.

[3] It is possible for countries to experience mean reversal over the study period (fertility below the mean at base measurement and fertility above the mean at second measurement) and yet inequality might remain stable (Sala-i-Martin 1996). Mean reversal to occurs when high fertility countries have a larger rate of fertility decline than low fertility countries and so β-convergence will capture the intradistributional 'switching' as evidence of convergence. While β-convergence is a necessary condition for declining inequality—the only way the distribution of *Y* can decline is if former laggards gain on former leaders—it is not a sufficient condition. By only testing for β-convergence, we run the risk of drawing faulty conclusions should the two tests yield contradictory results.

[4] One review questioned whether examining relative between-country differences in fertility was more important than a study of absolute inter-country differences (e.g., should a change in TFR from 4 to 2 be regarded as more different than a decline from 6 to 4?). As previously noted, inequality is concerned with relative, rather than absolute differences in Y, and convergence, as it is traditionally defined, is centrally focused on *rates* of change in Y. Beyond these points, Kohler, Billari, and Ortega (2002:642) provide further substantive justification for my assertion that a large absolute decline in fertility in a high fertility country might be roughly equivalent to a smaller absolute decline in a low fertility country when they observe: "a difference in the TFR between 1.0 and 1.3 is equivalent to the difference between 3.2 and 4.2 in terms of stable population growth rates."

[5] To save space, I do not present the full formulas for each of the indexes. For a more complete treatment, see Allison 1978 or Firebaugh 2003.

[6] The MLD is more sensitive to change in the bottom of the distribution because *Y* is logged, thus reducing the importance of higher values on *Y*.

[7] Data were downloaded through the UN statistics portal, The United Nations Common Database (UNCD), on October 19, 2007. The source for UNCD data is the United Nations, Department of Economic and Social Affairs,

Population Division: *World Population Prospects. The 2006 Revision*, CD-ROM Edition, Extended Dataset, New York.

[8] It should be noted that the dataset Wilson used for his analysis of fertility trends disaggregated China and India into regions and so his results and those presented here are not strictly comparable.

[9] Following Casterline (2001), I used medium variant estimates, which assume that fertility rates for all countries will settle around replacement level and will proceed at a pace equivalent to the pace measured over the observed period. Because previous analysis has shown that once fertility decline sets in, the rate of decline often increases (Bongaarts and Watkins, 1996), the medium variant estimates might be considered conservative. Results are available upon request.

[10] A large body of research has studied between-nation and global income inequality trends and not all of the findings agree with each other because of the sensitivity of income trends to population weights, choice of income measure, and countries studied. However, even in the few international income inequality studies that suggest rising income inequality over the recent decades the rise has been quite modest compared to the fertility trend (Bourguinon and Morrisson 2002, for example, find that the gini coefficient rose by .07 points from 1970 to 1992). For a nice summary of many of the major studies and finding on international income inequality trends, see Anand and Segal (2006). Questions concerning the trend in international income inequality do not alter the substantive findings presented here, that fertility has been rising quite rapidly at a time when other major indicators are stable or declining.