Human Development and Low Fertility

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Mikko Myrskylä[1], Hans-Peter Kohler[2], Francesco Billari[3]

Abstract

We study the relationship between development indicators and fertility with focus on low fertility countries. The most developed countries led both the first and second demographic transitions, and during these transitions, development indicators were inversely correlated with fertility levels. Results from data on 100 countries for the period 1975-2005 suggest that countries with highest development are again leading the transition by showing signs of fertility recovery from low and lowest-low levels closer to replacement levels, and among the most developed countries, the association between fertility and development has changed signs from negative to positive.

[1] Population Studies Center, University of Pennsylvania, 250 McNeil Bldg, 3718 Locust Walk, Philadelphia, PA 19104, USA. Email myrskylm@pop.upenn.edu.

[2] Professor, Department of Sociology, University of Pennsylvania, 272 McNeil Bldg 3718, Locust Walk Philadelphia, PA 19104

[3] Professor of Demography, IMQ - Università Bocconi, viale Isonzo 25, I-20135 Milano, Italy

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1 Introduction

In the western world both fertility and mortality started declining in the 19th century, and by now almost all other countries are following suit. In the last quarter of the 20th century this first demographic transition was followed by a second transition, where the role of family started to change rapidly, and in conjunction with this change fertility rates fell below replacement levels.

The countries with highest development were the first to experience the first transition, and less developed countries lagged behind. The same holds for the second transition. Moreover, in many countries with high development, fertility continued to decline in the 1980s and 1990s. This raises the question whether continuing development – rising standard of living, improving education, and increasing longevity – always means declining fertility.

In this paper we study the association between development and fertility with focus on contemporary developed world. There is little new in studying the co-variation between development and fertility, but most of the work has focused on developing countries (e.g. Bongaarts and Watkins 1996; Bryant 2007). This research has confirmed a strong negative association between development and fertility. Our results, obtained using yearly data for 100 countries from 1975 to 2005, suggest that among the most developed countries the picture is changing: the countries with highest level of development are again leading the transition by entering a new of regime where development and fertility are positively correlated.

The paper is organized as follows. Section 2 sets the background for the study by reviewing what is known about development and low fertility, Section 3 introduces the data. Empirical analyses are conducted in Section 4, and results are discussed in Section 5.

2 Low fertility and development

In most developed countries fertility is below replacement level (defined as total fertility rate TFR<2.1), and low fertility has been spreading fast to developing countries (Kohler et al. 2006). There is no evidence that once fertility starts to decline, it would converge to replacement. In fact, when fertility rates plummeted below replacement, there was little if any resistance at TFR=2.1. In 2002 there were already 17 European countries with TFR below 1.3, and over half of the European population lived in countries with TFR below 1.5

Countries with very high development, measured by any conventional development index, were the first to experience below replacement fertility. In Europe, Denmark, Netherlands, and United Kingdom entered below replacement regime already in late 1960s or early 1970s. Most other developed countries followed suit, and now the lowest fertility levels among developed countries are in the Eastern Europe and Mediterranean countries (Kohler et al. 2006).

In both Eastern and Western Europe the fall of fertility has been accompanied by a progressive postponement of childbearing (Andersson and Neyer 2004). Therefore part of the low contemporary fertility may be attributable to postponement of fertility, in contrast to decreasing quantity of fertility. However, in many countries, for example Scandinavian and Mediterranean countries, low fertility has persisted so long that there is not doubt about the fact that also the level of fertility is below replacement.

The historical fertility decline, which occurred during the first demographic transition, was associated with increasing levels of development. The first demographic transition first started in Western World, and less developed countries lagged behind. Recent research has also established a strong inverse link between fertility and development in contemporary developing countries (Bryant 2007).

The inverse link between development and fertility raises the question what will happen to fertility in the long run. If inverse link holds everywhere, the answer is obvious. But prior research has shown that that the association between fertility and many societal variables has changed signs during the last 10-15 years. These include the correlations between fertility and female labor force participation (Ahn and Mira 2002), mean age at first birth, mean age at first marriage, and total divorce rate (Prskawetz et al. 2006). Few studies, however, have considered the association between development and fertility in the developed world. This study attempts to fill this gap in knowledge by analyzing the link between development and fertility with focus on low fertility and developed world.

3 Data

We use data on total fertility rate TFR, *absolute* human development index aHDI, and components of aHDI. The data source is World Bank World Development Indicators Online Database (World Bank 2008). The data is yearly, covering period 1975-2005 for 100 countries.

Both TFR and *standard* human development index HDI are readily available in the Development Indicators Database. The period total fertility rate TFR, which is the sum of age-specific fertility rates in a given period, suits well for the purposes of this paper: it is a simple, easy-to-interpret measure of the quantum of fertility, describing in a single figure the average number of children women would have if they lived through the reproductive years. Because TFR ignores mortality, a slightly higher TFR value than 2 is needed for reproduction. We use TFR=2.1 as an approximation to replacement level fertility.

TFR is subject to tempo effects, that is changes in the timing of childbearing (e.g. Bongaarts and Feeney 1998). Thus in some situations changes in TFR may reflect more changes in timing than changes in level. Therefore we adjust the fertility rates for changes in mean age at childbearing. This adjustment is possible for only a handful of countries for which good data on mean age at childbearing is available. Our focus, however, is in the most developed countries for which the data *is* available. This it is unlikely that the results would be biased because adjustment is not possible for all the countries.

To measure development, we use a modified measure of the standard human development index HDI called absolute HDI (aHDI). This is because the standard HDI is not comparable over time, whereas aHDI is. The standard HDI measures the average achievements in a country in three basic dimensions of human development: i) mortality conditions, as measured by life expectancy at birth, ii) knowledge, as measured by adult literacy rate (with two-thirds weight) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weight), and iii) standard of living, as measured by gross domestic product (GDP) per capita at purchasing power parity (PPP) in USD. For every year all three indicators are scaled, or standardized, between 0 and 1. In the standardization, component x of HDI is standardized to s(x) using the formula $s(x) = [x - \min(x)]/[\max(x) - \min(x)]$, where max(x) and min(x) are the maximum and minimum of x in all countries in that year. HDI is then calculated as the arithmetic mean of the three standardized components.

Because of the way HDI is calculated, individual country's HDI level and HDI ranking depend both on the country itself and on the minimum and maximum values of all countries. Therefore country's development index and development ranking may change even if there are no changes in any of the HDI components. Moreover, individual country's HDI may increase (decrease) even if all the components of HDI decrease (increase). To overcome this problem, we calculate an absolute human development index aHDI. In aHDI, the scaling values (minimum and maximum of HDI components) change from year to year, but in aHDI they are fixed. We use the minimum and maximum values of year 2000 in the sample of 100 countries as the scaling values.

To calculate aHDI, individual components of HDI, or proxies of the components, are required. For many countries, data on all components is not available in the World Development Indicators database on an annual basis. Therefore we use linear interpolation to impute the missing data.

The data was almost complete for TFR, life expectancy and GDP per capita at purchasing power parity. We decided not to impute GDP or TFR values because these are subject to unpredictable fluctuation. Life expectancy, on the other hand, evolves relatively slowly, so we used linear interpolation to impute missing values. For enrollment ratios and literacy rates the proportion of missing data was much larger. However it is unlikely that the imputation has any large effect on the results, since both enrollment ratio and literacy rate evolve very slowly and are not subject to large variation, unlike GDP per capita. Therefore linear interpolation is a reasonable imputation method.

Originally, there were 226 countries or country groups in the World Development Indicators database. For some countries the total amount of missing data was so large that these countries could not be included in the analyses. Specifically, country was not included in the analyses if there was no information at all for some of the aHDI components or TFR, or if either the response variable TFR or life expectancy or GDP per capita – the dominating components of aHDI – had more than 30 % of the observations missing. In the final data set there were 100 countries whose data was considered complete enough to be used in the analyses.

To summarize, the data was subject to missingness. Some countries were discarded from the data because of very large proportion of missing data. For those countries that were included in the analyses, linear interpolation was used to impute the data. The imputation method reduces variation and imposes structure on the data. Thus imputation may affect results and conclusions.

However the data was most complete for developed countries and for time period 1990-2005, and the focus of this paper is in these observations. Therefore it is unlikely that imputation would have a large effect on our findings. The same reasoning applies also when considering whether country selection might bias the results: the focus of this study is in developed countries, and none of these countries was discarded because of large proportion of missing data.

4 Results

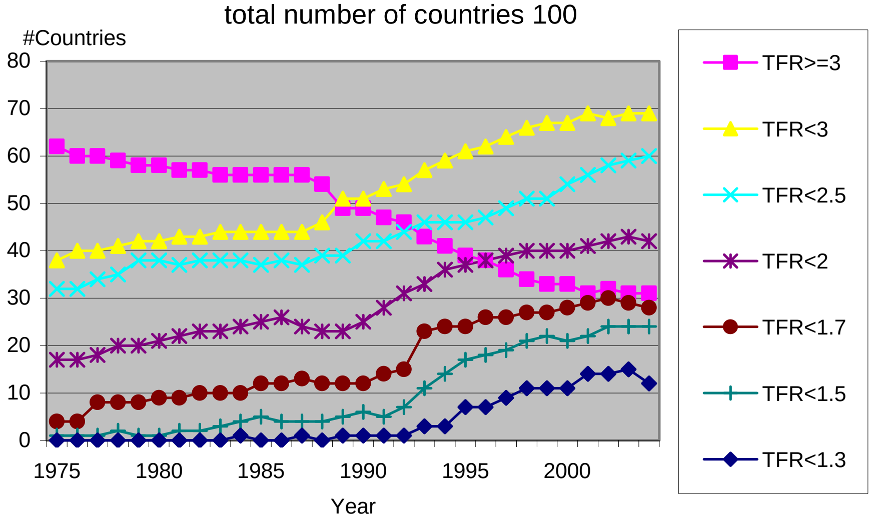
The empirical analyses are divided into three sections: trends in fertility, trends in development, and analysis of the covariation between development and fertility.

4.1 Trends in low fertility

Fertility trends in the developing world have been discussed in Bongaarts and Watkins (1996), and fertility trends in developed countries have been reviewed in Billari and Kohler (2004). There is no need to repeat the findings of these studies here. However some review on fertility trends with focus on low fertility is useful in setting the background for the empirical analyses.

Figure 4.1.1 shows the number of countries by fertility level and year. The figure shows that the number of countries with TFR above 3 has been decreasing fast, and the number of countries with low fertility (TFR<2) has been steadily increasing. The number of countries with lowest-low fertility (TFR<1.3) started increasing since early 1990s.

Figure 4.1.1. Number of countries by TFR in 1975-2004; total number of countries 100



4.2 Trends in development

Figure 4.2.1 shows the distribution of absolute human development index aHDI in the sample of 100 countries for years 1975, 1990 and 2004. The figure shows that during the 30 years this study covers, the distribution of development has shifted to the right, with mean of aHDI increasing from .478 in 1975 to .545 in 1990 and .603 in 2004, but the pace of development has not been equal for all countries. This can be seen from the emerging second mode in the distribution. Already in 1975 there are some signs of two modes, one close to sHD1=.40 and another close to aHDI=.70. In 2004 the second mode is evident at about aHDI=.90.

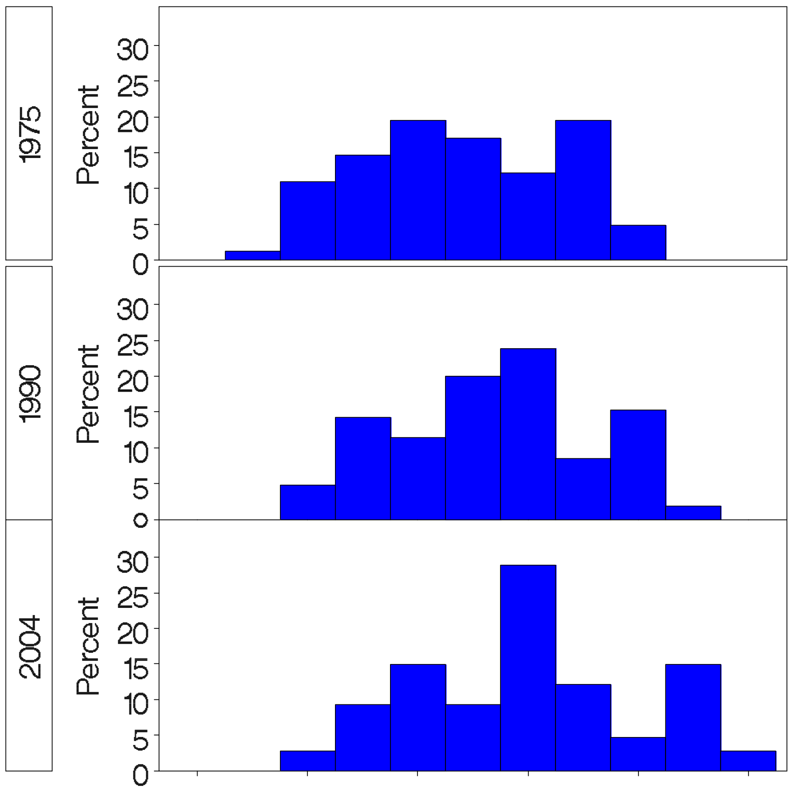


Figure 4.2.1. Distribution of absolute human development index aHDI in the sample of 100 countries for years 1975, 1990 and 2004.

Figures 4.2.2 and 4.2.3 show the time paths of aHDI for countries which ranked highest in development in 1975 and 2004, respectively. The figures show that none of the top ten countries of 1975 or 2004 has experienced notable declines in development. The top ten countries in 1975 and 2004 also overlap; six countries with highest development in 1975 are in the top ten also in 2004. Thus countries which were doing well three decades ago seem to be doing well also now.

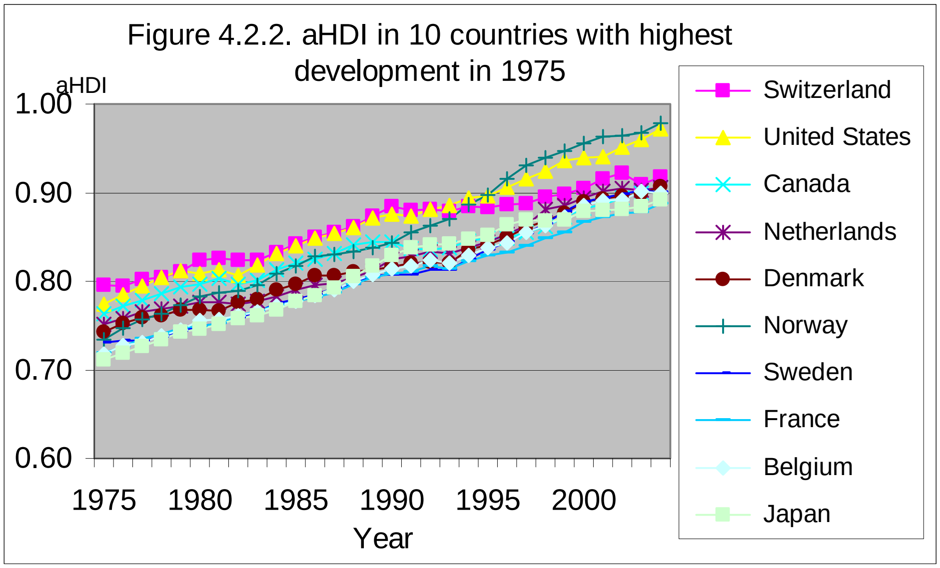


Figure 4.2.2. aHDI in 10 countries with highest development in 1975
aHDI
1.00
0.90
0.80
0.70
0.60
1975
1980
1985
1990
1995
2000
Year
Switzerland
United States
Canada
Netherlands
Denmark
Norway
Sweden
France
Belgium
Japan

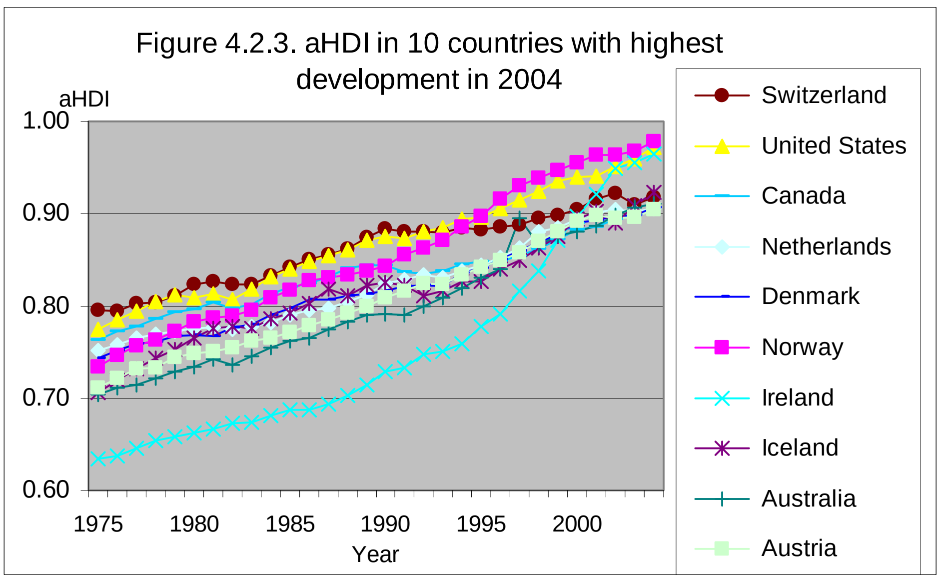


Figure 4.2.3. aHDI in 10 countries with highest development in 2004
aHDI
1.00
0.90
0.80
0.70
0.60
1975
1980
1985
1990
1995
2000
Year
Switzerland
United States
Canada
Netherlands
Denmark
Norway
Ireland
Iceland
Australia
Austria

4.3 The changing correlation between fertility and development

In this section we study the bivariate relationship between TFR, aHDI. We start with graphical and non-parametric representations of TFR-aHDI relationship (section 4.3.1), and then model the relationship using difference-in-differences regression models with time fixed effects (section 4.3.2).

4.3.1 Graphical and non-parametric analyses

Figure 4.3.1 shows absolute human development index aHDI and total fertility rate TFR for 1975 and 2004. In the figure, squares are for 1975, and triangles are for 2004. Country names are indicated for most countries with aHDI>.8. The outlier for year 2004, with aHDI .83 and TFR 2.90, is Israel.

To better see what is happening in the countries with highest development, the scale of aHDI has been stretched by using transformation aHDI → -log(1-aHDI). This transformation does not change the ranking of observations and preserves all the patterns – all it does is that it makes changes in the association between development and fertility more visible. A non-parametric smoothed spline has also been fitted to the graph for years 1975 and 2004 separately. The change of scale and smoothed spline is used also in figure 4.3.2.

The Figure 4.3.1 shows that for every level of development observed in 1975, fertility was lower in 2004 than in 1975. Thus it is clear that development is not the only force affecting fertility. Second, in 1975, the statistical association between development and fertility was inverse and close to linear. Third, the association has changed dramatically during the period 1975 – 2004: in 1975, countries with highest development had lowest fertility, but in 2004, countries with highest development (aHDI>.9) had higher fertility than countries with aHDI between .75 and .85.

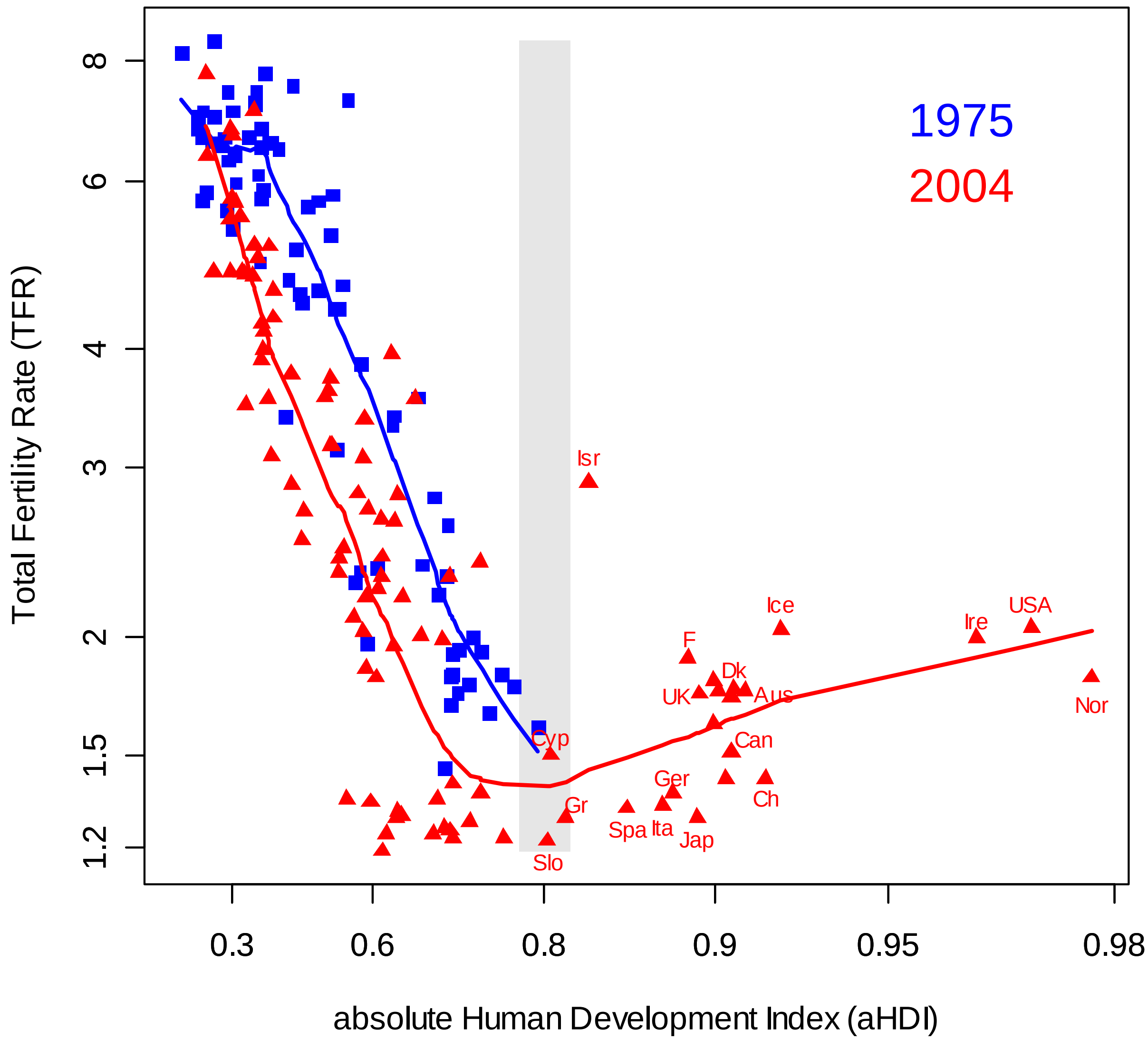


Figure 4.3.1. Absolute human development index aHDI and total fertility rate TFR in 1975 and 2004, and non-parametric smoothed spline regression.

Figure 4.3.2 shows how the positive association between aHDI and TFR emerges. The figure shows that until about aHDI=.80, fertility level is inversely and linearly associated with development (1975-1985). But when aHDI further increases, fertility does not systematically decrease, but first stays approximately on the same level and then starts to increase (1985-1995). Starting from year 1997, there is a clear positive relationship between aHDI above .80 and total fertility rate.

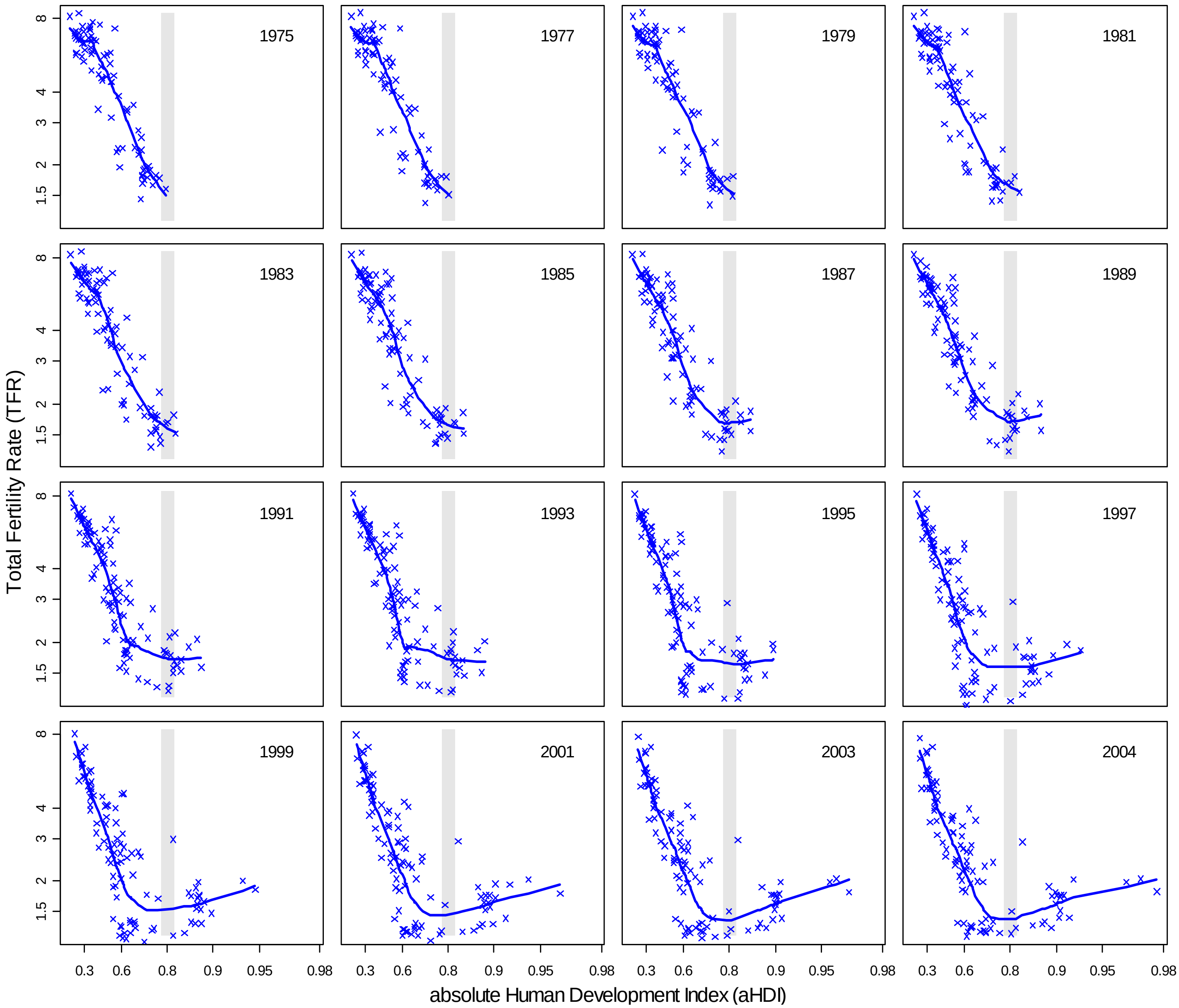


Figure 4.3.2. Absolute human development index aHDI and total fertility rate TFR for selected years and a non-parametric smoothed spline regression.

Figures 4.3.1 and 4.3.2 describe the association between fertility and development from the cross-sectional point of view. Figure 4.3.3 shows the time-path of aHDI-TFR for selected countries. Note that in figure 4.3.3 aHDI axis is not scaled. The figure supports the hypothesis that until certain level of development, which can be approximated by aHDI=.80, fertility and development are negatively correlated. But once absolute human development index aHDI crosses this threshold, at least in some countries the negative correlation breaks down, and the association may even turn to positive.

Figure 4.3.3. Time path of aHDI-TFR for selected countries, 1975-2004. aHDI on horizontal axis, TFR on vertical axis.

Figure 4.3.4 focuses on the developed countries that attain an aHDI of at least .85 at the end of the observation period. Figure 4.3.4 then depicts the TFR in 1975 and 2004 *relative* to the lowest TFR that was observed while a country's aHDI was within the window .78--.82. The (first) year in which this TFR is observed is denoted *reference year*. The figure then draws for all countries that attain an aHDI of at least .85 the line connecting the aHDI—TFR combinations for the three years 1975. For four particularly interesting and relevant countries – the United States, Norway, the Netherlands and Japan – the graph shows not only the aHDI—TFR combination for 1975, the reference year and 2004, but the full path of the aHDI—TFR development during 1975—2004 (plotting the full time path for all countries would have unnecessarily cluttered the graph).

The motivation for comparing the 1975 and 2004 TFR values to the TFR of the reference year (the lowest TFR observed while a country's aHDI was within the window .78--.82) is the hypothesis that at aHDI around .8 there is a "turning point" for the long-term trends in TFR. If this was true, the lines connecting the aHDI—TFR combinations for 1975, the reference year and 2004 should exhibit a "kink": both the 1975 and 2004 aHDI—TFR points for a specific countries should be above the aHDI-TFR point for the reference year, which for all countries is within the grey circle (by definition, aHDI for the reference year is within the .78--.82 range, and the relative TFR equals 1). Country paths supporting the hypothesis should then begin in the top-left quadrant of Figure 4.3.4, pass through the grey circle, and end in the top right quadrant of the figure.

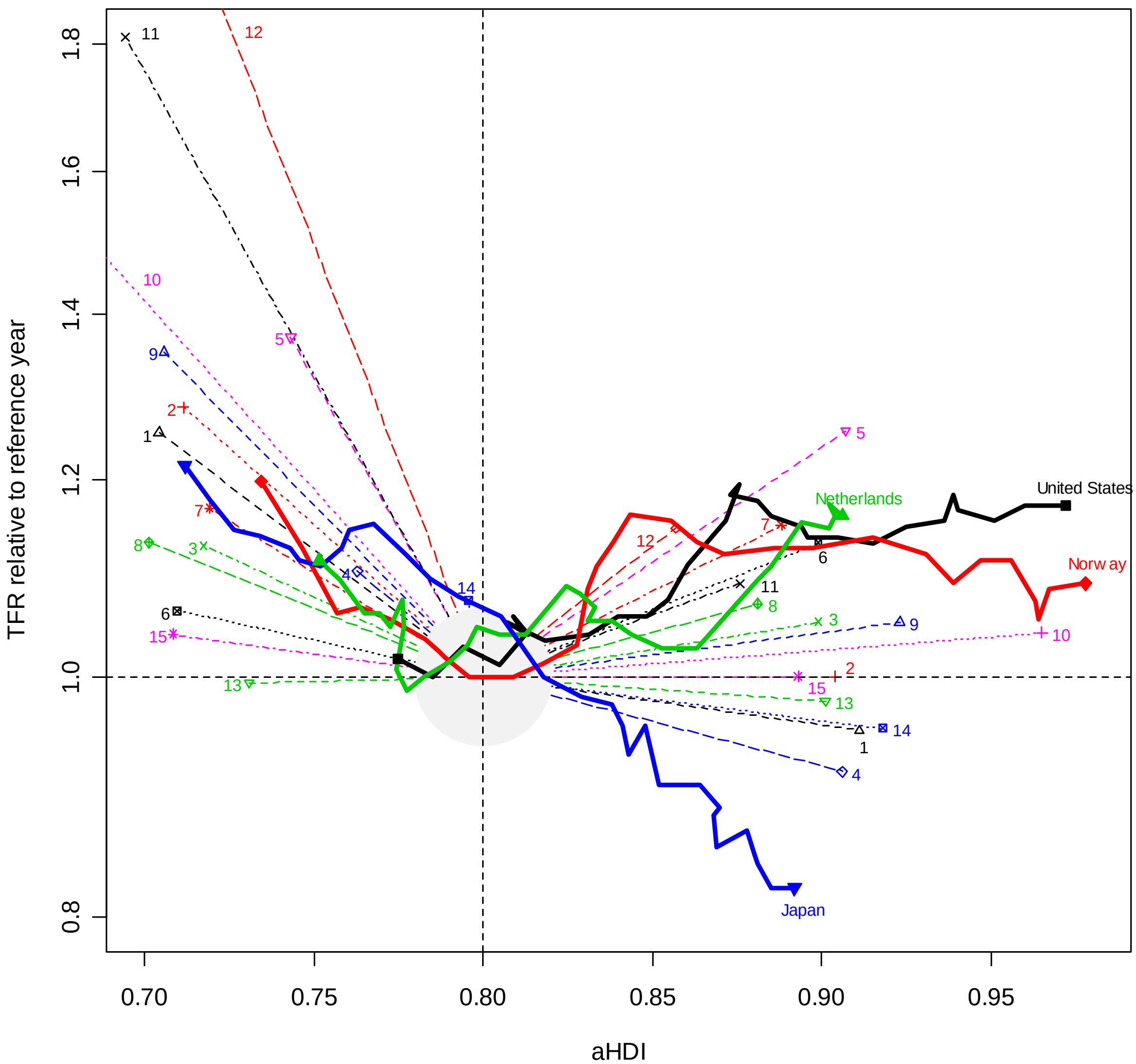


Figure 4.3.4. TFR relative to reference year (year with lowest TFR while a countries aHDI was within the range .78--.82)

The most important insight of Figure 4.3.4 is that for the vast majority of countries, the lines connecting aHDI—TFR combinations for the three years 1975, the reference year and 2004 (or the full time paths in the case of the US, Norway, the Netherlands and Japan) do indeed exhibit a kink. In particular, the lines for 14 countries – the United States, Norway, the Netherlands, Austria (line #2 in Fig 4.3.4), Belgium (line #3), Denmark (line #5), Finland (line #6), France (line #7), Germany (line #8), Iceland (line #9), Ireland (line #10), Italy (line #11), Spain (line #12) and the United Kingdom (line #15) – all begin the top left quadrant as fertility was higher in 1975, and aHDI lower than in the reference year; and consistent with our hypothesis of a TFR reversal around an aHDI level of .8, the lines for these countries end in the top right quadrant as *both* the aHDI and the TFR were higher than in the reference year. Only the lines for five countries in Figure 4.3.4 – Japan Australia (line #1), Canada (line #4), Sweden (line #13) and Switzerland (line #14) – however, do not confirm with the hypothesis of a TFR reversal around an aHDI level of .8: in these five countries, the final year of our observation period, 2004, is characterized by a higher aHDI as compared to the reference year, but a *lower* TFR.

4.3.2 Parametric statistical analyses

We use difference-in-differences models with time fixed effects and spline restriction (e.g. Wooldridge 2002) to test whether the break in development – fertility association stays after adjusting for potentially confounding factors[1]. The model controls for country-specific time invariant factors and time-specific factors that do not vary across countries. The country-level fixed effects are taken into account by differencing, and time-fixed effects are explicitly incorporated in the model. The model equation is

$$(1) \qquad \Delta TFR_{it} = \Delta[(\beta_0^{pre} + \beta_1^{pre} aHDI_{it})B_{it}] + \Delta[(\beta_0^{post} + \beta_1^{post} aHDI_{it})B_{it}] + \Delta\gamma_t + \Delta\varepsilon_{it},,$$

where Δ is the difference operator, TFR_{it} and $aHDI_{it}$ are total fertility rate and absolute human development index for country *i*, time *t*, B_{it} is the breakpoint indicator for country *i*, time *t*, and γ_t is the time fixed effect. Note that because of differencing the country fixed effect vanishes, but the model still controls for these effects. The models is are estimated using OLS.

We use three different criteria to define the breakpoint in the aHDI – TFR association. The first criteria is based on aHDI, the second is based on changes in TFR, and the third one uses time as the criteria for change. The aHDI based breakpoint rule defines the breakpoint B so that for $aHDI \geq .80$, B=1, otherwise B=0[2]. The TFR based breakpoint rule defines B so that B=1, otherwise B=0. The TFR based breakpoint rule defines the breakpoint so that B changes from 0 to 1 if TFR i) is below 3 and ii) rises for three consecutive years[3]. The time base breakpoint rule finds a common year B for all countries which minimizes mean squared error. Year 1990 turned out to provide best fit.

Table 1 shows parameter estimates for the coefficients of interest, β_1^{pre} and β_1^{post}. Negative values for β_1^{pre} and positive values for β_1^{post} would support the hypothesis that the statistical association between development and fertility has broken down and changed signs.

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[1] We use differencing because preliminary analyses indicated that there is an unit root in the residual. We use spline restriction to guarantee that the pre- and post-break lines $\beta_0^{pre} + \beta_1^{pre} aHDI_{it}$ and $\beta_0^{post} + \beta_1^{post} aHDI_{it}$ match at the defined breakpoint level.

[2] This threshold was chosen because it maximizes the fit of the model in terms of minimizing the mean squared error MSE. The results were not sensitive to small changes in the threshold.

[3] The results were robust to the TFR based breakpoint definition: none of the estimates of interest changed sign or lost significance if the rule i) was discarded and breakpoint was defined using 1, 2, 3, 4, or 5 years of consecutive TFR increase.

Table 1. Pre- and post-break estimates for aHDI from Model (1) by breakpoint rule.

Breakpoint rule based on	*Coefficient*	*Parameter estimate*	*P-value (two-tailed hyp.)*
aHDI	β_1^{pre}	-.657	<0.001
	β_1^{post}	2.28	<0.001
TFR	β_1^{pre}	-.343	<0.001
	β_1^{post}	.980	<0.001
Time	β_1^{pre}	-.404	<0.001
	β_1^{post}	.114	0.118

Table 1 indicates that there has indeed been a change in the aHDI-fertility association, and the results are in line with the graphical and non-parametric results of section 4.3.1. When the breakpoint is based on $aHDI \geq .80$, there is statistically strong evidence that the association between fertility and development has changed signs. The coefficient 20.3 is for aHDI implies that a change from aHDI level .80 to .90 is associated with a .10*2.28 = 0.228 unit change in TFR.

If the breakpoint is defined using changes in TFR, we observe the same statistically strong change in the sign of aHDI. However, the magnitude of the coefficients drops markedly compared to what was observed when breakpoint was defined using aHDI. This indicates that the aHDI based rule captures the moment of change better than TFR based rule. When the breakpoint is defined using only time, the estimate for β_1^{post} is not significantly positive. This indicates that changes in the aHDI-TFR association are more likely driven by development, not by time.

Overall, the estimates of Table 1 indicate that once countries reach a high enough level of development – possibly aHDI=.80 – the association between development and fertility turns from negative to positive. Results were robust to the definition of breakpoint: the signs of coefficients stayed the same and significance was lost when breakpoint values .70, .71, .72, …, .89, .90 were used. Results were also robust to outlying countries: if three countries with highest aHDI in 2004 were excluded – these countries are Norway, United States and Ireland, and they are partly responsible for the positive association in the smoothed spline regression in figure 4.3.2 – results in table 1 stayed practically the same.

4.4 Sensitivity of the results on changes in mean age at childbearing

To be done.

5 Discussion

In this paper we studied the association between development, as measured by absolute human development index aHDI, and fertility, as measured by total fertility rate TFR, with focus on developed countries. Previous studies, focusing on developing world, have established a strong link between fertility and development: the higher the development level, the lower the fertility. Studies on low fertility in developed countries have also shown that many variables that just a couple of decades ago were inversely associated with low fertility, such as female labor force participation (Ahn and Mira 2002) and divorce rates (Prskawetz 2006), are now positively associated with fertility. But studies on the association between development and fertility in developed world are rare.

Data on 100 countries from 1975 to 2004 suggest that the association between fertility and development is not constant across observed levels of development. Until 1980, observed aHDI levels ranged from .25 to .80, and with aHDI values within this range, fertility was linearly and negatively associated with aHDI. But as countries cross the aHDI threshold .80, the inverse association between development and fertility breaks down: once countries cross this threshold, fertility and development are not anymore negatively correlated, and the association seems to change sign from negative to positive.

The finding that development and fertility are positively correlated among most developed countries was supported by visual graphical analyses and formal statistical analyses which employed both non-parametric regressions and parametric difference-in-differences fixed-effects regressions. Various breakpoint rules were used to define when the association changes from negative to positive, and results were robust to the definition of breakpoint. The strongest results, however, were obtained when the breakpoint rule was based on absolute human development index crossing the threshold .80. This indicates that the aHDI based rule captures the moment of change better than TFR or calendar year based rules. Our results were also robust to outlier countries.

There are at least three different explanations for the fact that development and fertility are positively correlated among countries with highest development. First, the observed positive correlation may be an artifact caused by tempo effects: During the last two decades mean age at childbirth for most parities has increased markedly in developed countries. But it is unlikely that results as robust as ones obtained in this study would be driven only by tempo changes. However in future studies it would be important to take changes in timing into account.

Second, observed positive association between fertility and development may be caused by rapid fertility declines in countries whose development level is close to most developed countries. For example in many eastern European countries fertility has recently plummeted below the levels observed in most developed countries. These countries could be responsible for turning cross country correlation from negative to positive, but within country correlation could still be negative. However both graphical analyses and regression results suggest that there has been a change in the development – fertility association also within countries.

Third, development itself, or changes closely associated with development, such as institutional and value changes, may be either changing fertility preferences or making it easier for individuals to realize their fertility desires. If this is true, it would be important to study more the mechanisms through which these changes might happen.

To summarize, this study suggests that the statistical association between development and fertility turns from negative to positive once countries reach high enough level of development. The most developed countries led also the first and second demographic transitions, so it might not be that surprising that they are again leading the transition by entering a new of regime where development and fertility are positively correlated.

This study did not answer two important questions: First, which exactly is the mechanism through which development feeds fertility, and second, which dimensions of development contribute most to the positive association and/or timing of the change in the association. One potential explanation for the change in the development-fertility association might be the following. Development indicators mirror societal changes which may make childbearing more feasible (e.g. by introducing institutions which make it easier to combine parenthood and career). This is important, since one of the many explanations for modern fertility decline is that women entering the labor market find it difficult to find time to raise children. Also, there is increasing pressure for men to participate in childrearing, and countries with highest development are the first to introduce policies which make it possible for men to combine career and involved parenthood. Countries with high development also have relatively high supply of child care services, and relatively inexpensive high school and college education. These factors effectively reduce the costs of having children and may thus be increasing fertility.

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