Differential Fertility, Human Capital, and Development

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February 2014

Abstract

Using micro-data from 48 developing countries, this paper studies changes in cross-sectional patterns of fertility and child investment over the course of the demographic transition. Before 1960, children from larger families obtained more education, in large part because they had richer and more educated parents. By century's end, these patterns had reversed. Consequently, fertility differentials by income and education historically raised the average education of the next generation, but they now reduce it. While the reversal is unrelated to changes in GDP per capita, women's work, sectoral composition, or health, roughly half is attributable to rising aggregate education in the parents' generation. The results support a model in which rising skill returns lowered the minimum income at which parents invest in education.

*E-mail: tvogl@princeton.edu. For helpful comments, I am grateful to Janet Currie, Partha Deb, Oded Galor, Thomas Fujiwara, Zoë McLaren, Kyle Meng, Omer Moav, Ben Olken, Shing-Yi Wang; seminar participants at Brown, Columbia, Harvard, Hunter, MIT, Princeton, UC Santa Barbara, World Bank, Population Association of America, and NBER Summer Institute; and especially Anne Case and Angus Deaton. Thanks also to Claudia Olivetti for sharing her data on female labor force participation.

1 Introduction

Over the last two centuries, most of the world's economies have seen unprecedented increases in living standards and decreases in fertility. Recent models of economic growth have advanced the understanding of the joint evolution of these economic and demographic processes. Collectively labeled "Unified Growth Theory" (Galor 2011), these models have explored the roles of a variety of factors, including scale effects on technological progress (Galor and Weil 2000), increases in longevity (Kalemli-Ozcan 2002; Soares 2005), changes in gender roles (Galor and Weil 1996; Voigtläender and Voth 2013), declines in child labor (Hazan and Berdugo 2002; Doepke and Zilibotti 2005), and natural selection (Galor and Moav 2002). Central to many of these theories is the idea that a rising return to human capital altered the calculus of childbearing, enabling the escape from the Malthusian trap. Although an abundance of aggregate time series evidence helps to motivate this work, efforts to understand the role of heterogeneity within an economy have been hampered by fragmentary evidence on how cross-sectional patterns of fertility and child investment change over the course of the demographic transition. Using a range of data covering half a century of birth cohorts from 48 developing countries, this paper provides a unified view of how those patterns change, linking them to the canonical theoretical framework for understanding the interplay between demography and economic growth.

Two strands in the theoretical literature relate to this focus on cross-sectional heterogeneity in fertility and skill investment during the process of growth. The first, due to Galor and Moav (2002), analyzes the evolutionary dynamics of a population of lineages that have heterogeneous preferences over the quality and quantity of children.[1] In their model, a subsistence constraint causes fertility to initially be higher in richer, quality-preferring families, but as the standard of living rises above subsistence, fertility differentials flip. Consequently, in the early regime, fertility heterogeneity promotes the growth of quality-preferring lineages, raising average human capital; in the late regime, it promotes the growth of quantity-preferring lineages, dampening the expansion of the human capital stock. A second strand in the literature—including papers by Dahan and Tsiddon (1998), Morand (1999), de la Croix and Doepke (2003), and Moav (2005)—fixes preferences and examines how the initial distribution of income or human capital interacts with

[1] See Clark (2007) and Galor and Michalopoulos (2012) for similar theories of evolution that emphasize different sources of preference heterogeneity.

fertility decisions to affect growth and income distribution dynamics.[2] These authors assume a specific structure of preferences and costs to reproduce two patterns observed in most present-day settings: (1) that wealthy parents have fewer children than poor parents and (2) that they educate their children more. As in Galor and Moav's (2002) late regime, heterogeneity in fertility lowers the average skill level.[3] Indeed, much of this work posits that the higher fertility of the poor can help explain macroeconomic trends in developing countries during the postwar era. Interest in this idea dates back to Kuznets (1973), who conjectured that differential fertility adversely affects both the distribution and the growth rate of income.

But did rich or high skill parents have low relative fertility in developing countries throughout this period? At least since Becker (1960), economists have recognized that although fertility decreases with income or skill in most settings today, the relationships may may have once been positive.[4] Along these lines, in the mid- to late-20th century, some small, cross-sectional studies in mostly rural parts of Africa and Asia showed a positive relation between fertility and parental income or skill (Schultz 1981).[5] Other studies of similar contexts revealed that children from larger families obtained more schooling, again in contrast to most present-day settings (Buchmann and Hannum 2001). Efforts to form a unified view of these results have taken three approaches: (1) combining results from disparate studies that use a variety of methods and measures (Cochrane 1979; Skirrbekk 2008), (2) analyzing survey data collected contemporaneously in several contexts (UN 1987; Cleland and Rodriguez 1988; UN 1995; Mboup and Saha 1998), or (3) studying data from a single country over time (Clark 2007; Maralani 2008). Although informative, these approaches are limited in the extent to which they can shed light on the conditions under which these relationships flip; on how that reversal relates to theories of growth and demographic transition; and on what implications it has for the next generation's human capital distribution.

This paper seeks to fill that gap by analyzing the evolution of two closely-related sets of cross-sectional associations over many decades in many countries: (1) that between parental eco-

[2] Althaus (1980) and Kremer and Chen (2002) consider similar issues in models that assume a specific relationship between parental skill and fertility, rather than allowing it to arise from parental optimization.

[3] Several models also demonstrate how these fertility gaps can give rise to poverty traps, thus widening inequality. Empirically, Lam (1986) shows that the effect of differential fertility on inequality depends crucially on the inequality metric. However, his finding does not overturn the general equilibrium reasoning of recent theories.

[4] Related research, surveyed by Lee (1997), suggests economic growth boosts fertility in pre-industrial economies.

[5] Similar evidence is available for pre-1800 Europe (Weir 1995; Hadeishi 2003; Clark and Hamilton 2006). In the United States, the relationship has been negative for as long as measurement has been possible (Jones and Tertilt 2008).

nomic status (proxied by durable goods ownership or father's education) and fertility and (2) that between sibship size and education. The results show that, in the not-too-distant past, richer or higher-skill parents had more children, and children with more siblings obtained more education. Today, the opposite is true for both relationships. These findings have implications for theories of fertility and the demographic transition, as well as for understanding the role of differential fertility in the process of growth. In particular, until recently, differences in fertility decisions across families promoted the growth of the *per capita* stock of human capital instead of slowing it.

To guide the empirical work, the paper begins by showing how skill differentials in fertility can change sign in the growth literature's standard framework for the study of cross-sectional fertility heterogeneity, due to de la Croix and Doepke (2003) and Moav (2005).[6] Within that framework, both papers impose the assumption that children cost time, while education costs money, which yields the negative gradient that is prevalent today. I demonstrate that with the addition of a subsistence constraint or a goods cost of children, the same framework predicts that fertility increases with income or skill among the poor. As such, in the early stages of development, children with more siblings come from better-off families and obtain more education.

The empirical analysis illustrates these results with two datasets constructed from the Demographic and Health Surveys (DHS). For the first, I treat the survey respondents (who are women of childbearing age) as mothers, using fertility history data to construct two cross-sections of families from 20 countries in the 1986-1994 and 2006-2011 periods. In these data, respondents enumerate all of their children ever born, with information on survival status. Between the early and late periods, (surviving) fertility's relationships with parental durable goods ownership and paternal education flipped from positive to negative in Africa and rural Asia; it was negative throughout in Latin America.[7] I argue that these patterns capture the tail end of a global transition from a positive slope to a negative slope.

For the second dataset, I treat the DHS respondents as siblings, using sibling history data to retrospectively construct a longer panel of families from 42 countries. In these data, respondents report all children ever born to their mothers, again with information on survival status. Among

[6] Jones et al. (2010) discuss related theoretical issues but do not explore how these differentials reverse over time.

[7] I focus on paternal rather than maternal education because of the former's strong link with both income and the opportunity cost of time throughout the sample period. Conditional on durable goods ownership and paternal education, maternal education had a negative association with fertility throughout the sample period. Sections 6-7 discuss gender-specific theories and provide evidence against their role in explaining the main results.

earlier birth cohorts (mostly of the 1940s and 1950s), most countries show positive associations between the number of ever-born or surviving siblings and educational attainment. Among later birth cohorts (mostly of the 1980s), most countries show the opposite. The dates of the transition vary by setting, with Latin America roughly in the 1960s, Asia roughly in the 1970s, and Africa roughly in the 1980s. Taken together, the data suggest that in nearly all sample countries, the relationships between parental economic status and fertility and between sibship size and education both flipped from positive to negative. Indeed, although the DHS offers little data on childhood economic circumstance, three supplementary datasets (from Bangladesh, Indonesia, and Mexico) suggest that one can attribute much of the reversal in the sibsize-education relationship to the reversal of the link between paternal education and fertility.[8]

I then quantify the changing effect of differential fertility on average educational attainment, relative to a thought experiment in which all families are forced to have the same family size. The theoretical framework shows that one can separate this effect into two components. The first reflects how the forced fertility policy would affect the composition of the population, while the second reflects how it would affect the distribution of education investment per child across families. I focus on the first component, which plays a larger role in theories of the aggregate effects of differential fertility, and which one can estimate by means of a simple reweighting procedure. The procedure compares actual average educational attainment with the (reweighted) average that would arise if all families had the same number of children, with no change to their education.

The results of the reweighting procedure are at odds with claims that differential fertility between rich and poor generally depresses average skill. Only in South Africa did differential fertility lower average education throughout the sample period. The remaining countries are split fairly evenly in two groups. In one, differential fertility elevated average education throughout the sample period, due to a consistently positive relationship between surviving sibship size and education. In the other, the influence of differential fertility changed over the sample period, typically starting positive and ending negative. The magnitudes are usually less than half a year of education: moderate in comparison to the nearly four-year increase in average educational attainment over the sample period. But they are meaningfully large relative to the level of average education in early cohorts. For women born during 1950-54, the reweighted average differs from

[8] These supplementary datasets also indicate that the reversal is similar for men and women.

the actual average by 15 percent. Whether these composition effects are large enough to play an important role in endogenous growth is an open question.

To test alternative theories of this reversal, I assemble a country-by-birth cohort panel of sibsize-education coefficients. Net of country and cohort fixed effects, neither women's labor force participation, nor sectoral composition, nor GDP *per capita*, nor child mortality predicts the sibsize-education association. Rather, one variable can account for over half of the reversal of the sibsize-education association: the average educational attainment of the parents' generation. These findings are broadly consistent with the theoretical framework. However, because the reversal is uncorrelated with economic growth, its most likely cause is not a shift of the income distribution over the peak of a stable, hump-shaped income-fertility profile. Instead, a rising return to education spending—which plays an key role in many economic theories of the demographic transition—may have lowered the income threshold at which families begin to invest in education, moving the peak of the income-fertility profile downward and to the left. The fertility history data exhibit exactly this type of shift. Furthermore, the return-to-education theory is consistent with the role of aggregate education; in many endogenous growth models, aggregate human capital raises the individual return to educational investment.

By shedding light on the timing, causes, and consequences of the reversal of differential fertility in the developing world, this paper contributes to several literatures. Most apparent is the connection with two empirical literatures: one on parental socioeconomic status (SES) and fertility, the other on sibship size and education. In these literatures, evidence on positive SES-fertility and sibsize-education associations is scattered, lacking a unifying framework. This paper uncovers a common time path in which both associations flip from positive to negative. Building on a standard model of the growth literature, it provides a theoretical framework that explains the reversal and gives insight into its aggregate implications. Along these lines, the paper shows how cross-family heterogeneity in fertility historically increased average eduction but now largely decreases it. That finding adds to our understanding of how demography interacts with the macroeconomy and calls attention to how cross-sectional patterns can inform models of fertility decline. The basic time-series facts about fertility decline are overdetermined, so a more thorough treatment of changing heterogeneity within populations will help narrow the field of candidate theories of the demographic transition.

2 A Quality-Quantity Framework

This section studies how a subsistence constraint or a goods cost of children affect the growth literature's standard theoretical framework for studying differential fertility. Given the paper's focus, I derive the model's cross-sectional properties and then briefly discuss its dynamic implications.

2.1 Setup

Parents maximize a log-linear utility function over their own consumption (c), the number of children (n), and human capital per child (h):

$$U(c, n, h) = \alpha \log(c) + (1 - \alpha) \left(\log(n) + \beta \log(h)\right) \tag{1}$$

$\alpha \in (0, 1)$ indexes the weight the parents place on their own consumption relative to the combined quantity and quality of children, while $\beta \in (0, 1)$ reflects the importance of quality relative to quantity. Child quality, or human capital, is determined by:

$$h(e) = \theta_0 + \theta_1 e \tag{2}$$

where e denotes education spending per child, and θ_0 and θ_1 are positive. θ_0 is a human capital endowment (e.g., public school), while θ_1 is the return to education spending. One can view $h(e)$ as a child's earnings in adulthood or as some broader measure of human capital.

Irrespective of human capital, each child costs $\tau \in (0, 1)$ units of time and $\kappa \geq 0$ goods. These costs represent the minimum activities (e.g., pregnancy, child care) and goods (e.g., food, clothing) required for each child. Parents are endowed with human capital H, so the budget constraint is:

$$c + \kappa n + ne \leq wH\left(1 - \tau n\right) \tag{3}$$

where w is the wage per unit of parental human capital. They may also face a subsistence constraint, in which case c must exceed $\tilde{c} \geq 0$.

This setup is similar to many others in the literature on the demographic transition, but three features merit further discussion. First, the log-linear utility function with a parameter (β) indexing the relative preference for quality dates to Galor and Moav (2002). The assumption that $\beta < 1$ plays no important conceptual role in the theory, but it guarantees the existence of a solution under a linear human capital production function. If one adds concavity to the production function, for example by setting $h(e) = (\theta_0 + \theta_1 e)^\sigma$ with $\sigma \in (0,1)$ (as in de la Croix and Doepke 2003), then one can obtain a solution so long as β is smaller than $\frac{1}{\sigma} > 1$. I focus on a linear production function to clarify the roles of the human capital endowment and the return to education spending. However, all of the results below hold with this alternative specification of the human capital production function (and therefore also with $\beta \geq 1$). Second, the model implicitly focuses on surviving children, abstracting from child mortality. I return to this issue in Section 6 below, pointing out that the goods cost of (surviving) children, κ, may incorporate the burden of mortality. In both the theory and the data, mortality does not play an important role. Third, the framework allows the child goods cost and the subsistence level to be zero, in which case it reduces to the models of differential fertility by de la Croix and Doepke (2003) and Moav (2005). This section seeks to understand how the framework's predictions change when either of these parameters is nonzero.

2.2 Optimal Fertility and Education Spending

The framework yields closed-form solutions for optimal fertility and education spending. To characterize these solutions, two threshold levels of parental human capital are important. The first is $\widetilde{H} \equiv \frac{1}{\tau w}\left(\frac{\theta_0/\theta_1}{\beta} - \kappa\right)$, above which parents begin to invest in education. If parental human capital is below $\widetilde{H}$, then parents are content with the human capital endowment θ_0, choosing a corner solution with no education spending. For higher skill parents, education spending per child rises linearly in their human capital: $e_H^* = \frac{\beta(\kappa+\tau w H)-\theta_0/\theta_1}{1-\beta}$ if $H \geq \widetilde{H}$.

In addition to $\widetilde{H}$, fertility decisions also depend on the threshold $\frac{\tilde{c}}{\alpha w}$, above which parents cease to be subsistence-constrained:

$$n_H^* = \begin{cases} \frac{wH-\tilde{c}}{\kappa+\tau w H} & \text{if } H < \min\left(\frac{\tilde{c}}{\alpha w}, \widetilde{H}\right) \\ \frac{(1-\alpha)wH}{\kappa+\tau w H} & \text{if } \frac{\tilde{c}}{\alpha w} \leq H < \widetilde{H} \\ \frac{(1-\beta)(wH-\tilde{c})}{\kappa-\theta_0/\theta_1+\tau w H} & \text{if } \widetilde{H} \leq H < \frac{\tilde{c}}{\alpha w} \\ \frac{(1-\alpha)(1-\beta)wH}{\kappa-\theta_0/\theta_1+\tau w H} & \text{if } H \geq \max\left(\frac{\tilde{c}}{\alpha w}, \widetilde{H}\right) \end{cases} \tag{4}$$

In the first line, parents are both subsistence constrained and at an education corner solution. After consuming $\tilde{c}$, they spend all of their remaining full income wH on child quantity, so fertility increases with H. The next two lines deal with the cases in which $\frac{\tilde{c}}{\alpha w} < \widetilde{H}$ and $\widetilde{H} < \frac{\tilde{c}}{\alpha w}$, respectively. In the second line, the subsistence constraint no longer binds, but the parents remain at an education corner solution. They devote αwH to their own consumption and the remainder to child quantity, so fertility is increasing in H if $\kappa > 0$ and constant if $\kappa = 0$. In the third line, the subsistence constraint binds, but the parents now choose an education interior solution, making the comparative static ambiguous: $\frac{dn_H^*}{dH} \gtreqless 0$ if and only if $\kappa \gtreqless \frac{\theta_0}{\theta_1} - \tau\tilde{c}$. It is also ambiguous in the final line, in which the parents are constrained by neither the subsistence constraint nor the lower bound on education spending: $\frac{dn_H^*}{dH} \gtreqless 0$ if and only if $\kappa \gtreqless \frac{\theta_0}{\theta_1}$. If the goods cost is not too large, the substitution effect of a higher wage dominates the income effect.

To summarize, either a subsistence constraint or a goods cost of children guarantees a hump-shaped relationship between parental human capital and fertility, so long as the goods cost is not too large.[9] At low human capital levels, fertility increases with human capital if $\kappa > 0$ or $\tilde{c} > 0$; at high human capital levels, it decreases with human capital if the goods cost is smaller than the ratio θ_0/θ_1. The same hump shape holds for income. Thus, this framework, based on homogenous preferences but heterogeneous initial skill, generates a skill-fertility profile similar to that in Galor and Moav's (2002) model, which combines preference heterogeneity with a subsistence constraint. Because preferences are unobservable, these theories are difficult to distinguish.

Nevertheless, one can can glean insight into the importance of goods costs vis-à-vis subsistence constraints by studying the response of the skill-fertility profile to an increase in the return to education spending. Rising skill returns are crucial to many economic models of the demographic transition, so this comparative static is key. Figure 1 depicts how the relationship between parental human capital and fertility changes after successive increases in the return to education spending (θ_1). The two panels reveal how the framework's predictions depend on whether the hump shape is driven by a goods cost of children or a subsistence constraint. In the left panel, which assumes a positive goods cost of children but no subsistence constraint, increases in θ_1 shift the peak of the hump shape downward and to the left. Fertility declines among all parents that are at an interior

[9] In his analysis of the aggregate demographic transition, Murtin (2013) implicitly discusses the role of a goods cost in generating a hump-shaped income-fertility profile.

solution, and more parents switch from a corner solution to an interior solution as $\widetilde{H}$ falls. In the right panel, which assumes a subsistence constraint but no goods cost, increases in θ_1 still depress fertility among unconstrained parents but have no systematic effect on the location of the peak. This difference arises because changes in θ_1 affect $\widetilde{H}$ but not $\tilde{c}$.

As a result, two mechanisms are likely to flip the sign of the association between parental skill or income, on the one hand, and fertility, on the other. First, the distribution of full income (wH) could shift to the right, over the peak of the hump, because of an increase in the wage return to human capital (w) or a shift in the distribution of parental human capital. In this case, broad-based gains in living standards would tend to flip the association from positive to negative. Second, an increase in the return to education spending could shift the peak of the hump to the left, flipping the association even without changes in the distribution of full income. The second mechanism is unambiguous only under a goods cost of children, not a subsistence constraint.

2.3 Cross-Sectional Implications

To characterize the effect of differential fertility on average human capital, assume a parental human capital distribution $F(H)$ on $\left[\underline{H}, \overline{H}\right]$, and consider a policy forcing all couples to have $\tilde{n}$ children.[10] The effect of differential fertility is the difference between average human capital under free fertility and average human capital under forced fertility. Under forced fertility level $\tilde{n}$, parents with human capital H choose education spending as follows:

$$e_H^{\tilde{n}} = \begin{cases} \frac{wH-\tilde{c}}{\tilde{n}} - \kappa - \tau wH & \text{if } H < \frac{\tilde{c}/\alpha+\kappa\tilde{n}}{w(1-\tau\tilde{n})} \\ \frac{(\beta-\alpha\beta)\left(\frac{w}{\tilde{n}}-\kappa-\tau wH\right)-\alpha\theta_0/\theta_1}{\alpha+\beta-\alpha\beta} & \text{if } H \geq \frac{\tilde{c}/\alpha+\kappa\tilde{n}}{w(1-\tau\tilde{n})} \end{cases} \tag{5}$$

Consistent with a quality-quantity tradeoff, education spending decreases in $\tilde{n}$. Note that $e_H^{n_H^*}$ equals e_H^*, optimal education spending under free fertility.

For parental human capital distribution F and forced fertility level $\tilde{n}$, the total effect of differential fertility on average human capital is thus:

$$\Delta_{tot}\left(F, \tilde{n}\right) = \frac{\int h\left(e_H^*\right) n_H^* dF(H)}{\int n_H^* dF(H)} - \frac{\int h\left(e_H^{\tilde{n}}\right) \tilde{n} dF(H)}{\tilde{n}} \tag{6}$$

[10] Assume $\tilde{n} < \frac{w\underline{H}-\tilde{c}}{w\underline{H}\tau-\kappa}$, so the forced level of fertility does not keep parents from meeting the subsistence constraint.

On the right-hand side of the equation, the first and second expressions equal average human capital under free and forced fertility, respectively. To average across children rather than families, both expressions reweight the parental human capital distribution by the factor $\frac{n}{E[n]}$. In the second expression, all families have the same fertility level, so this factor equals 1. Although $\Delta_{tot}(F, \tilde{n})$ is relevant to interventions like China's one child policy, coercive fertility polices are rare, so it has few real-world applications.

One can decompose $\Delta_{tot}(F, \tilde{n})$ into two quantities, one of which does not depend on a counterfactual policy. To obtain this decomposition, add and subtract $\int h(e_H^*)\, dF(H)$, average human capital *across families*, to the right-hand side of Equation (6):

$$\Delta_{tot}(F, \tilde{n}) = \underbrace{\int \left(\frac{n_H^*}{\int n_{\mathcal{H}}^* dF(\mathcal{H})} - 1 \right) h(e_H^*)\, dF(H)}_{\Delta_{comp}(F)} + \underbrace{\int \left\{ h(e_H^*) - h\left(e_H^{\tilde{n}}\right) \right\} dF(H)}_{\Delta_{adj}(F,\tilde{n})} \tag{7}$$

where $\mathcal{H}$ is a dummy of integration. $\Delta_{comp}(F)$ is the *composition effect* of differential fertility, measuring how average human capital *across children* differs between the free fertility optimum and the counterfactual in which all families have an equal number of children but maintain the per child educational investments that were optimal under free fertility. Because this counterfactual involves no re-optimization, the composition effect is invariant to $\tilde{n}$. $\Delta_{adj}(F, \tilde{n})$ is the *adjustment effect* of differential fertility, measuring how average human capital *across families* changes in response to a policy shift from free fertility to forced fertility level $\tilde{n}$. This component depends crucially on $\tilde{n}$. Under a policy forcing the lowest observed fertility rate on all parents, the adjustment effect would be positive; if the policy instead forced the highest observed fertility rate, the adjustment effect would be negative. The empirical work focuses on the composition effect because it solely reflects the joint distribution of quantity and quality investments, rather than arbitrarily-defined counterfactual policies.

Assuming a positive subsistence level and a small goods cost of children, several properties of the composition effect are apparent. If $\overline{H} < \widetilde{H}$, so that all parents make no educational investments, then $\Delta_{comp}(F) = 0$. Growth in human capital, wages, or the return to education spending causes $\Delta_{comp}(F)$ to turn positive; fertility rates become highest in the small share of parents with positive education spending. As this process continues, more mass accumulates in the domain in which $\frac{dn_H^*}{dH} < 0$, eventually turning $\Delta_{comp}(F)$ negative. Indeed, if $\underline{H} > \max\left(\frac{\tilde{c}}{\alpha w}, \widetilde{H}\right)$, so that fertility decreases with parental human capital across the entire support of F, then $\Delta_{comp}(F)$ is unambiguously negative. These results suggest that in the early stages of economic development—when most are subsistence constrained or at an education spending corner solution, but the wealthy few educate their children—the composition effect is positive. But with broad-based gains in living standards or increases in the return to education spending, the composition effect turns negative.

2.4 Dynamic Implications

The framework provides insights into how cross-sectional patterns change with the economic environment, but are the resulting composition effects relevant for economic growth? The answer depends on the extent of human capital externalities. Early endogenous growth models (e.g., Lucas 1988; Becker et al. 1990) emphasized the idea that average human capital raised the individual return to human capital. However, literature reviews by Lange and Topel (2006) and Pritchett (2006) find scant empirical evidence for this hypothesis. A less-tested variant of this idea, appearing in the overlapping generations models of Galor and Weil (2000) and Galor and Moav (2002), posits that aggregate human capital fosters technological progress, which in turn raises the return to investment in the next generation's human capital. But most relevant for the current setting is the premise, found for example in the model of de la Croix and Doepke (2003), that aggregate human capital raises the productivity of the education sector (i.e., teachers). This hypothesis finds partial support in recent evidence that the quality of schooling is as important as the quantity of schooling in explaining cross-country variation in output per worker (Schoellman 2012).

This type of intergenerational human capital externality plays an especially interesting role in the current theoretical framework if it affects the return to the human capital endowment (θ_0) and the return to education spending (θ_1) differentially. If one assumes (as in de la Croix and Doepke 2003) that the externality raises both parameters by the same proportion, then it does not affect fertility and education decisions. However, if improvements in teacher quality disproportionately raise θ_1, then higher aggregate human capital in one generation causes greater educational investment in the next. With dynamic reinforcement of this type, differential fertility could play an important role in long-run growth. Early in the process, the positive composition effects of differential fertility raise the return to education spending, speeding both economic growth and the transition to negative composition effects (due to leftward shifts in $\widetilde{H}$). Once negative composition effects set in, differential fertility retards growth (as in de la Croix and Doepke 2003). This potential role for differential fertility in the emergence (and subsequent moderation) of modern growth is similar to the mechanism in Galor and Moav's (2002) model of evolution.

3 Data on Two Generations of Sibships

Using data from the Demographic and Health Surveys (DHS), I construct two generations of sibships by viewing respondents as mothers and daughters. Conducted in over 90 countries, the DHS interviews nationally-representative samples of women of childbearing age (usually 15-49).

3.1 DHS Fertility Histories

The first set of analyses draws on the fertility histories, in which respondents list all of their children ever born, with information on survival. I use these data to study how fertility relates to paternal education and household durable goods ownership, a proxy for household wealth or income. Each of these measures has benefits and drawbacks. Paternal education is attractive because it measures parental human capital and is determined largely before fertility decisions. But its connection to fertility may go beyond the mechanisms in the theoretical framework, and its connection to full income changes with the wage rate.[11] Conversely, durable goods ownership provides a useful gauge of the household's economic status, although it is an imperfect income proxy and may be endogenous to fertility decisions. And as with paternal education, relative price changes may complicate comparisons of durable goods ownership over time.

For a composite measure of durable goods ownership, I take the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. This approach is similar to that of Filmer and Pritchett (2001), except that it does not incorporate

[11] The choice of paternal education is meant to strengthen the link to the theory, not to diminish the role of maternal education. Even more than paternal education, maternal education may affect preferences, beliefs, and bargaining power, and, because of low rates of female labor force participation, its link with income and the opportunity cost of time is tenuous. Footnote 15 describes results for maternal education.

measures of housing conditions (e.g., access to piped water), which may be communally determined. I perform the principal components analysis on the whole sample, so the resulting measure (which is standardized to have mean 0 and standard deviation 1) reflects the same quantity of durable goods in all countries and time periods.

To avoid the complicated task of disentangling cohort effects from changes in the timing of childbearing, I focus on women at least 45 years old and interpret their numbers of children as completed fertility. The focus on older women also has the advantage of capturing cohorts of mothers more likely to be in the early regime in which fertility is increasing in income and skill. I compare results from two time periods, pre-1995 and post-2005, and only include countries with survey data (including the relevant variables) from both periods, leaving 58,680 ever-married women from 46 surveys in 20 countries.[12] Appendix Table 1 lists countries and survey years.

3.2 DHS Sibling Histories

In some surveys, the DHS administers a sibling history module to collect data on adult mortality in settings with poor vital registration. The module asks respondents to list all children ever born to their mothers, with information on sex, year of birth, and year of death if no longer alive. In addition to adult mortality, the sibling histories offer a window into the sibling structure that adult women experienced as children. I relate this information to their educational attainment.

Most DHS surveys with sibling histories are representative of all women of childbearing age, but a few (from Bangladesh, Indonesia, Jordan, and Nepal) include only ever-married women. From these surveys, I minimize concerns about selection by only including age groups in which the rate of ever marriage is at least 95 percent. Therefore, I include women over 30 from the relevant surveys in Bangladesh and Nepal, but I discard surveys from Indonesia and Jordan, where marriage rates are lower.[13] The analysis sample comprises 82 surveys from 42 countries. To exclude respondents who have not finished schooling or whose mothers have not completed childbearing, I drop data on women less than 20 years old, leaving 793,373 women born between 1945 and 1989. Appendix Table 1 lists countries and survey years.

[12]Husband's education is available only for ever-married women. The durable goods results are similar for all women and for ever-married women.

[13]Nepal has two surveys with sibling histories, one of ever-married women in 1996 and one of all women in 2006. I restrict the 1996 sample to women over 30, but I include all respondents to the 2006 survey. I also discard data from the 1989 Bolivia DHS and the 1999 Nigeria DHS due to irregularities in the sibling history data

3.3 Supplementary Surveys

The DHS data are useful in their breadth but suffer from two major shortcomings. The most obvious is their omission of men, for whom the relationship of interest may be different. Additionally, they offer little information on aspects of the respondent's childhood environment, such as the income or education of her parents. To supplement the DHS on these two fronts, I draw on three supplementary surveys in the Appendix: the Indonesia Family Life Survey, the Matlab Health and Socioeconomic Survey, and the Mexico Family Life Survey. All three surveys include questions about surviving siblings and parental characteristics.

4 Changing Cross-Sectional Fertility Patterns

This section documents the evolution of differential fertility in developing countries since the 1940s. It begins with fertility history data, analyzing the socioeconomic determinants of fertility, and then turns to sibling history data, analyzing the association of sibship size with completed education. All analyses use sampling weights, but the results are similar without them.[14]

4.1 Fertility Patterns by Education and Durable Goods Ownership

To assess the changing links between parental socioeconomic characteristics and fertility, I begin with a series of non-parametric estimations. Pooling data from all 20 countries in the fertility history sample, Figure 2 shows local linear regressions completed fertility on the durable goods index and paternal education. The number of surviving children bears the closest link to the theory, but I include plots of ever-born children for completeness.

Figure 2 reveals relationships for surviving fertility that are initially hump-shaped but later become monotonically decreasing. In the early period (1986-1994), surviving fertility first increases and then decreases with durable goods ownership and paternal education. Consistent with a rising return to educational investment, the curves for the late period (2006-2011) are (1) everywhere below those for the early period and (2) everywhere negatively sloped. A concern for this interpretation is that the relative prices of parental skill and of durable goods changed

[14]In the fertility history analyses, which pool multiple countries, the sampling weights are re-scaled to sum to national populations in 1990 (for the pre-1995 sample) and 2010 (for the post-2005 sample).

between the early and late periods. But the relative prices of these variables probably moved in opposite directions. On the one hand, cheaper consumer durables would imply that parents with a given level of durables ownership are poorer, making them more likely to be on the increasing segment of the hump shape. On the other hand, increased skill returns would tend to move parents of a given skill level toward the declining segment of the hump shape. Both variables point to similar changes over time, mitigating concerns about the confounding role of prices.

Estimations for ever-born fertility show less evidence of an initial hump-shape, due to large socioeconomic differences in early-life mortality. Whether these patterns provide a better representation of the demand for children depends on the extent to which parents target surviving fertility. Given that fertility at ages 45-49 reflects sequential childbearing decisions and deaths over three decades, it seems reasonable to interpret surviving fertility as the demand for children. Moreover, only surviving fertility is relevant for the composition effects estimated in Section 5.

The full-sample results mask considerable regional heterogeneity. Figure 3 estimates separate local linear regressions for each world region represented in the sample, ordering the regions by increasing average paternal education. All regions exhibit downward and leftward shifts in the peaks of the relationships between skills or durables and surviving fertility. Moreover, these peaks start furthest to the right in the least-educated regions. To capture how these changing non-monotonic patterns affect the linear association of parental economic status with fertility, Table 1 reports regressions of surviving fertility on either the durables goods index or paternal education, with or without country fixed effects.[15] From the early to late periods, the associations go from significantly positive to significantly negative in Western Africa, go from zero to significantly negative in Eastern/Southern Africa, and are significantly negative in both periods in the three other regions. Appendix Table 3 separates the sample into urban and rural areas, finding that positive coefficients are more likely in rural areas; the coefficients go from weakly positive to significantly negative in rural parts of Eastern/Southern Africa, the Caribbean, and South/Southeast Asia. These results suggest a shared process that operates at different times across and within countries: visiting urban areas before rural, and visiting Latin America before Asia and then Africa.

[15]Table 1 reports univariate regressions because it seeks to document broad associations rather than causal effects. For comparison with the existing literature, Appendix Table 2 includes the durables index, paternal education, and maternal education in the same regression. The main finding is that, conditional on durable goods ownership and paternal education, maternal education is negatively associated with fertility in both periods.

4.2 Sibship Size and Educational Attainment

The fertility history results provide evidence of a reversal in the relationship between parental economic status and surviving fertility in Africa and rural Asia, but they leave several questions unanswered. Did the same reversal occur for counts of ever-born children at some earlier date? Did it occur in Latin America? The sibling histories offer a window onto the answers to these questions for birth cohorts going back to the 1940s. Unfortunately, the DHS collects little data on economic conditions in childhood. However, as the theoretical framework suggests, we can gain some insight into the evolution of the socioeconomic fertility differentials by studying changes in the relationship between sibship size and education. The sibsize-education link is also directly relevant for assessing the effect of differential fertility on the skill distribution. To capture its long-run evolution, I estimate regressions separately by country and 5-year birth cohort (1945-1949 to 1985-1989).[16] For woman i born in country c and cohort t, the regression specification is:

$$highest\, grade_{ict} = \delta_{ct} + \gamma_{ct} sibsize_{ict} + \varepsilon_{ict} \tag{8}$$

where $highest\, grade_{ict}$ denotes her schooling and $sibsize_{ict}$ denotes her sibship size.

Figure 4, which displays estimates of γ_{ct} over time within each country, shows that positive sibsize-education associations were pervasive until recently but have now largely disappeared. Both the ever-born sibling and the surviving sibling coefficients tend to decrease across successive birth cohorts. For earlier birth cohorts, most coefficients are significantly positive, while for the latest birth cohorts, few coefficients are significantly positive, and many are significantly negative. Consistent with the fertility history results, this reversal in the sibsize-education relationship occurs earliest in Latin America, followed soon thereafter by several countries in Asia. Africa's reversal is quite recent; several countries remain in the pre-reversal regime. To put these estimates in context, Appendix Figure 1 plots trends in average education, showing several-year increases in most countries. In absolute value, γ_{ct} is small when average education is low.

These results leave two issues unaddressed: birth order effects and gender heterogeneity. Birth order is a concern because children of high birth orders necessarily come from large families. Given evidence that birth order affects educational attainment (Steelman et al. 2002; Black

[16] For precision, I omit cells with fewer than 200 observations, representing 2.5 percent of all cells.

et al. 2005), researchers often control for birth order in estimating the effect of family size on educational attainment. However, the present paper is concerned not with causal effects but with equilibrium differences between large and small families, making regression adjustment unnecessary. Birth order effects are but one reason for the different outcomes of children from large and small families. On gender heterogeneity, although the DHS only gathers sibling history data from women, the supplementary surveys from Bangladesh, Indonesia, and Mexico interview both genders. In Appendix Table 4, all three supplementary surveys show declining sibsize-education relationships for both genders.

4.3 Connecting the Results

The fertility history results seem to contain the last phases of the global transition to a negative relationship between parental economic status and fertility, while the sibling history results point to a widespread shift of the sibsize-education link from positive to negative. While the two phenomena seem connected, the absence of childhood background characteristics in the DHS prevents examination of this issue. One can examine the connection with the supplementary surveys from Bangladesh, Indonesia, and Mexico, which include data on paternal education. Mirroring the DHS fertility history results, Appendix Figure 2 shows a hump-shaped relationship between paternal education and surviving sibship size in all three countries, with the peak shifting to the left over time. Appendix Table 5 then shows that the evolution of the sibsize-education relationship has much to do with the changing relationship between paternal education and sibship size. Within each country, sibsize-education coefficients decrease across successive birth cohorts, but those controlling for paternal education mutes those decreases by at least one half.

5 Differential Fertility and Average Human Capital

The results so far suggest that differential fertility once promoted human capital accumulation rather than hindering it. This section estimates the changing composition effect of differential fertility on average education.

Recall from the theory section that the composition effect is:

$$\Delta_{comp}(F) = \int \left(\frac{n_H^*}{\int n_{\mathcal{H}}^* dF(\mathcal{H})} - 1 \right) h\left(e_H^*\right) dF(H) \tag{9}$$

This expression integrates over the parental wage distribution, but I only observe siblings, with little information about their parents. Applying the law of iterated expectations, one can rewrite it over the distribution of surviving sibship sizes:

$$\Delta_{comp}(F) = \sum_{k=1}^{K} \left(\eta_k - \frac{\eta_k/k}{\sum_{l=1}^{K} \eta_l/l} \right) \mu_k \tag{10}$$

where K is the maximum possible sibship size, η_k is the share of the individuals from surviving sibships of size k, and μ_k is the mean human capital of individuals from sibships of size k. Inside the parentheses, the term η_k weights the sample to give mean human capital across individuals, while the term $\frac{\eta_k/k}{\sum_{l=1}^{K} \eta_l/l}$ reweights the sample to give mean human capital across families. Importantly, this expression captures *any* composition effect of heterogeneity in fertility and skill investment, not just the heterogeneity specific to the model in Section 2.

I use the empirical analogues of η_k and μ_k to estimate $\hat{\Delta}_{comp}$ and obtain its variance using the delta method. I measure human capital as highest grade completed. For successive 5-year birth cohorts within each country, Figure 5 displays estimates of the composition effect of differential fertility on average educational attainment.[17]

The results overturn the conventional wisdom that variation in fertility over the skill or income distribution tends to lower average education. In some countries, predominantly African, differential fertility increased average educational attainment throughout the sample period. These countries have not transitioned to the regime in which surviving sibship size and education are negatively correlated. Opposite these countries is South Africa, where the effect of differential fertility was negative throughout almost the entire sample period. The remaining countries have undergone a transition from a regime in which differential fertility promoted the growth of human capital to a regime in which differential fertility depressed it. For two compelling examples, con-

[17]To examine whether a single education level drives the results in Figure 5, Appendix Figure 3 estimates composition effects on shares of each cohort with 0, 1-5, 6-8, and 9+ years of education. The shifting composition effects are visible at all levels, from 0 years through 9+ years.

sider the Andean nations of Bolivia and Peru. In the 1945-9 cohort, differential fertility increased average education by 0.3 to 0.5 years in both countries; in the 1985-9 cohort, differential fertility reduced average education by 0.5 years.

Are these magnitudes large or small? The answer depends on whether one evaluates them relative to the *increase* in education over the sample period or relative to the historical *level* of education. On average, the 1985-9 cohorts have 3.7 more years of education than the 1945-9 cohorts.[18] The largest estimated composition effects are ± 0.6, and the average within-country change in these effects between 1945-9 and 1985-9 is -0.2. Therefore, the shift from a positive to a negative sibsize-education relationship did not have a large effect on the evolution of average educational attainment. But relative to the level of average educational attainment, the composition effect is reasonably large for early cohorts. For the 1950-4 cohort, the composition effect was on average 15 percent of mean education. As mean education rose, the relative magnitude of the composition effect shrank: for the 1985-9 cohort, the composition effect was on average 4 percent of the cohort's mean education. It is unclear whether the earlier magnitudes were large enough to play an important role in endogenous growth.

6 Explaining the Reversal

The reversal of differential fertility in the developing world occurred during a half-century with much economic and demographic change. Although Section 2 suggests a compelling theory for the change, the existing literature suggests several alternatives. This section lists forces often associated with the demographic transition and explores their possible roles in the reversal. As its ultimate goal, it aims to identify each theory's implications for the aggregate determinants of γ_{ct}.

Human Capital The rise in the demand for schooling plays a key role in many models of the transition from Malthusian stagnation to growth. Section 2 already discussed how an increase in the return to education spending can move the peak of the fertility hump to the left, which would make γ_{ct} more likely to be negative. This hypothesis is consistent with the disappearance of the hump in Figures 2-3. At the aggregate level, the hypothesis predicts that the decline of γ_{ct} will be

[18]This claim is based on a regression of cohort average education on country and cohort indicators. The coefficient on the 1985-9 cohort indicator is 3.7, indicating a gain of 3.7 years of education relative to the omitted 1945-9 cohort.

associated with rising average educational investment and declining average family size. In the presence of the human capital externalities discussed in Section 2, the decline of γ_{ct} will be also be associated with rising average adult human capital.

Income Growth Although Section 2 emphasizes a rising return to education spending, the theoretical framework also suggests that broad-based income gains (due to increases in parental human capital or wages) can push families over the fertility hump, thus flipping γ_{ct}. This hypothesis is inconsistent with the changing non-parametric estimations in Figures 2-3. However, the hypothesis also has some testable aggregate implications. First, the reversal of γ_{ct} will be associated with rising average educational investment. Second, it will be associated with rising GDP *per capita* and average adult human capital. The relative predictive power of these two variables depends on their associations with income across the income distribution.

Children's Work Another issue is the falling prevalence of child labor, which in the theoretical framework has similar consequences to a rising return to education spending. Some of the decline in child labor may actually be the result of increases in skill returns. Some might also be due to new sanctions against child labor, which one could characterize as increases in the goods cost of children κ. Just as with an increase in the return to education spending, an increase in the goods cost of children decreases the wage threshold at which families start to spend on education, which can shift the peak of the fertility hump to the left. This mechanism is complementary to the return-to-education hypothesis.[19]

Women's Work At least as likely an explanation as children's work is women's work. The reasoning is similar to that of Galor and Weil (1996), who argue that skill-biased technological progress increased women's labor productivity over the long run, eventually inducing greater women's labor force participation and lowering fertility due to the increased opportunity cost of childbearing. They consider neither quality investments nor cross-sectional heterogeneity, but such extensions are natural. In Section 2's framework, one cannot generate a negative association between parental skill and fertility without assuming a positive opportunity cost of childcare time.

[19] In another version of the child labor theory, family labor is cheaper than outside labor, so that landed agricultural households have increased demand for children as laborers. If landed agricultural households are drawn from the center of the income distribution, their demand for child labor can generate a hump-shaped income-fertility relationship.

This explanation runs up against the empirical reality, originally documented by Goldin (1995), that women's labor force participation follows a u-shape over the course of economic development.[20] Rates of women's labor force participation were high in Africa throughout the sample period, despite a positive relationship between income and fertility. But a closer reading of Goldin (1995) suggests that in the early stages of development, when labor is mostly agricultural, women's work is compatible with child rearing. Women's labor force participation then decreases when manufacturing predominates and increases with the emergence of the service sector. Unlike agricultural work, service jobs compete with childbearing. If women's opportunity cost of time explains the reversal, then the emergence of the service sector must also play a key role.

Child Mortality The decline of child mortality is also central to many theories of fertility decline, but it is unlikely to explain the change in fertility regimes observed in this paper. Because the bulk of mortality decline has occurred for children younger than school-starting age, one can think of a it as a reduction in the quantity costs of surviving children. In Section 2, a decline in the goods costs of children can make the slope of the skill-fertility relationship more negative at high wages, although it also moves the peak of the relationship to the right. In any case, as in the Barro-Becker model (1989), reductions either the costs of child quantity lead to higher optimal fertility and lower optimal schooling investment, which appears counterfactual. If child mortality is behind the reversal, then the theoretical framework predicts that the decline of γ_{ct} will be associated with rising average family size, declining education spending, and declining child mortality.

Preference Change In interpreting the changing cross-sectional patterns, many non-economists would think first of preferences. Several theories fertility decline (Caldwell 1980, 1982; Casterline 2001) posit changes in beliefs and norms regarding child-rearing. Some versions of these theories could explain the observed regime change. Consider the introduction of new 'Western' norms that increase the relative importance of child quality in the utility function (β), raising optimal education and lowering optimal fertility. If these norms affect the richest (or most educated) families most strongly, then the relationship between fertility and income (or skill) could flip from positive to negative, starting at the right tail of the income distribution. Caldwell (1980, 1982) assigns

[20] Also see Mammen and Paxson (1998), and Olivetti (2012).

much importance to mass education in altering childbearing norms, thus predicting a relationship between γ_{ct} and average adult human capital. However, without further structure, the theory is otherwise difficult to test.

Other versions of preference-change theory may be more testable. One version associates the diffusion of new norms with the empowerment of women (Duflo 2012). If women have lower β's than men, and if women of higher income or education make the earliest gains in household bargaining power, then richer households will be the first to transition to low fertility. Similar to the women's work hypothesis, this reasoning predicts that measures of female empowerment will be negatively associated with γ_{ct}. Another preference-change theory is that of Galor and Moav (2002), which combines β-heterogeneity with a subsistence constraint. Here too, rising aggregate human capital will be associated with a reversal in γ_{ct}. Because Galor and Moav's model depends crucially on a subsistence constraint, it is complementary to Section 2's framework. But as noted earlier, the subsistence constraint reasoning provides no explanation for the observed shifts in the peak of the fertility hump.

Intergenerational Wealth Transfers A separate class of theories, which does not fit into the framework above, emphasizes upward intergenerational transfers from children to parents, in the form of child labor or old-age support.[21] Caldwell (1982) emphasizes how the expansion of schools alters child-rearing norms, so that parents come to view children as net recipients of, rather than net contributors to, household resources. This model bears similarities with other theories of changing preferences. Following a different thread in Caldwell's work, Boldrin and Jones (2002) study parental behavior when old-age security is the primary motive for childbearing. In their framework, financial deepening could flip the income-fertility relationship if wealthy families substituted other savings vehicles for children. But this reasoning gives no account for why the decreases in quantity investment would be accompanied by increases in quality investment. Additionally, as stressed by Galor (2011), wealthier couples typically have access to a wider variety of savings vehicles before the fertility transition. Finally, Lee (2000) argues that data from no society suggest a net upward flow of resources across generations, unless one counts the pension systems of rich countries.

[21] See Cain (1983), Nugent (1985), Ehrlich and Lui (1991), and Morand (1999).

Contraception Advocates of family planning might instead emphasize the uneven adoption of effective contraceptive technology (Potts 1997). From this perspective, the currently negative relationship between income and fertility is due to an unmet need for contraception among the poor. But a theory of this type fails to account for the early regime during which fertility increases in income. One possibility is that women from richer households have a higher biological capacity to bear children due to their better health. In this case, broad-based health improvements would decrease the relationship between income and fertility.

7 Aggregate Determinants of the Reversal

With an eye to the explanations described in Sections 2 and 6, this section estimates how several economic and demographic aggregates relate to the sibsize-education link. I focus on the sibsize-education link rather than the income-fertility link because the former offers a longer time horizon and is more precisely estimated at the country level. Additionally, I only show results for the surviving sibship size coefficients because they bear a closer link to theoretical framework and because they are directly relevant to the composition effect. Unreported results for the ever-born sibship size coefficients are qualitatively similar but somewhat smaller in magnitude.

The economic and demographic aggregates come from a variety of sources. I use cohort average outcomes from the DHS; GDP *per capita* and the sectoral composition of value added from the Penn World Table (Heston et al. 2012); average adult (ages 25+) educational attainment from Barro and Lee (2010) and Cohen and Soto (2007);[22] urbanization from UNPD (2011); and women's (ages 20-59) labor force participation from ILO (2012). For variables that are not available annually, I first linearly interpolate between observations within each country.

7.1 Cross-Sectional Patterns

Although the main analysis of economic and demographic aggregates takes advantage of the panel structure of the data by controlling for country and birth period fixed effects, cross-sectional analyses serve as a useful starting point. Figure 6 documents the evolution of cross-sectional re-

[22] I use the Barro-Lee estimates when available. For countries that only have Cohen-Soto estimates, I use the Cohen-Soto estimates to generate predicted Barro-Lee estimates, based on a regression of Barro-Lee on Cohen-Soto in the sample of countries with both measures.

lationships between several aggregate variables and γ_{ct}. Three of the four panels—for GDP *per capita*, average education, and urbanization—display a series of local linear regressions, one per period of birth. Data on women's labor force participation are too sparse to estimate cohort-level local linear regressions, so the fourth panel shows a scatter plot.

Throughout the sample period, more educated and more urban places have more negative sibsize-education associations. Although the intercepts shift downward over time, the slopes on these two curves are stable. These patterns suggest that structural transformation or mass education may be linked to the reversal of γ_{ct}. Meanwhile, γ_{ct} shows no consistent relationship with GDP *per capita* or women's labor force participation. The relationship between and log GDP *per capita* goes from flat to significantly negative, at least if one ignores the extreme outlier of Gabon.[23] No discernible pattern emerges in the scatter plot of γ_{ct} and women's labor force participation.

Another noteworthy cross-sectional result, not reported in Figure 6, is that γ_{ct} in polygamous countries exceeds that in monogamous countries by 0.1 to 0.2, both within Africa and across the world. This finding supports Tertilt's (2005) claim that men in polygamous societies have an incentive to invest their wealth in a large number of children. In such societies, a groom typically 'buys' a bride from her father, so men benefit from having many daughters but do not lose from having many sons.[24]

7.2 Panel Analysis

The patterns in Figure 6 lead one to ask whether changes in socioeconomic and demographic aggregate can account for the reversal of the sibsize-education association. One can address this question by including cohort and country fixed effects:

$$\hat{\gamma}_{ct} = Z_{ct}'\lambda + \tau_t + \mu_c + \varepsilon_{ct} \tag{11}$$

where Z_{ct} is a vector of independent variables, and τ_t and μ_c are cohort and country fixed effects, respectively. This specification nets out global trends and time-invariant country characteristics.

[23]Gabon's oil production *per capita* is more than twice that of any other country in the sample, so its GDP *per capita* provides a poor measure of living standards.

[24]Note that the patterns here must be driven by the number of children per wife, not the number of wives per husband. The DHS sibling history asks for siblings with the same biological mother.

If one leaves Z_{ct} out of Equation (12), the resulting cohort effect estimates are flat through the early 1960s, at which point they begin a downward trend, becoming significantly negative in the 1970s. The estimates imply that net of country fixed effects, the sibsize-education association is on average 0.28 lower in 1985-9 than in 1945-9.

7.2.1 Using Cohort Average Outcomes as Covariates

Table 2 presents estimations of Equation (12) in which the covariates Z_{ct} are cohort average outcomes from the DHS: average completed education, average surviving sibship size, and the average fraction of siblings dying before they reach age 5. Because these average outcomes are co-determined with the sibsize-education relationship, one should think of the estimates equilibrium associations rather than causal effects. For this reason, I include only one covariate in each regression (in addition to the cohort and country fixed effects). Also, because the estimates of γ_{ct} and the cohort average outcomes are based on the same data, the table supplements the ordinary least squares results with estimations that correct for correlated measurement errors using Fuller's (1987) method-of-moments technique.

The results in Table 2 give three conclusions: (1) as the sibsize-education association declines, average educational investment increases; (2) as the sibsize-education association declines, average family size declines; and (3) the sibsize-education association has no relation to child mortality rates. These findings are consistent with explanations based on rising incomes, rising returns to education, and declining child labor, but not with those based declining child mortality or an unmet need for contraception.

7.2.2 Using Socioeconomic Aggregates in Early Life as Covariates

Table 3 estimates regressions of $\hat{\gamma}_{ct}$ on three socioeconomic aggregates in the period of birth: log GDP *per capita*, average adult educational attainment, and urbanization. The education measure comes from two datasets that do not completely overlap, so the table presents one regression for the combined sample and one regression for each of the source samples. All three regressions lead to the same conclusion: while aggregate income growth and urbanization do not play a role, the rising educational attainment of the parent generation is intimately connected with the reversal of the sibsize-education relationship among offspring. In fact, the coefficient of -0.1 on average education implies that rising education can account for roughly 60% of the of 1985-9 cohort effect effect for γ_{ct}, as reported at the start of this section. These results best match explanations based on rising returns to education or changing preferences.

Several alternative theories deal with the position of women; these theories are the focus of Table 4.[25] One prominent theory involves the expansion of women's labor market opportunities outside the home. Recall that this explanation predicts a role for both rising women's labor force participation and the emergence of the service sector (which relocates women's work from near the home to far away). Columns (1) and (2) show that neither trend plays a role in the reversal of the sibsize-education association. Another gender-specific theory emphasizes female education over male. Column (3) thus uses gender-disaggregated data from the Barro-Lee education dataset to ask whether the role of average education is due to women or men.[26] While the coefficients on average female education and average male education are jointly significantly different from zero, they are not significantly different from each other; in fact, the coefficient on average male education is larger and individually more significant. Table 4 suggests that the causes of the reversal are not specific to the empowerment of women.

8 Conclusion

Efforts to understand whether and how distributional considerations play a role in the escape from the Malthusian trap have been stymied by fragmentary evidence on how cross-sectional patterns of fertility and child investment change over the demographic transition. With the goal of filling that gap, this paper studies the evolution of these patterns over half a century of birth cohorts in 48 developing countries. The results suggest that the relationships linking income or skill with fertility are initially hump-shaped, with most of the population in the domain in which the relationship is increasing. As the economy develops, the peak of the hump shifts to the left, and the skill distribution shifts to the right, such that the associations of income or skill with fertility flip from positive to negative. Mirroring this reversal, children from larger families initially obtain

[25] To maximize sample size, each regression in Table 4 uses a different sample. In unreported results, average adult education has at least a marginally significant effect on γ_{ct} in each of these samples.

[26] The Cohen-Soto education dataset does not provide gender-specific averages.

more human capital, but this association flips with economic development. Increases in the aggregate education levels of the parents' generation are by far the most important predictor of the reversal; the data show little role for child mortality rates, GDP *per capita*, sectoral composition, urbanization, and women's labor force participation. Given the unique role of rising aggregate education and the shift of the peak of the fertility-durable goods relationship, the data are most consistent with a theory in which a rising return to schooling leads families further and further down the income distribution to invest in education.

Because the reversal has gone largely unrecognized in the literature on the aggregate effects of differential fertility, that literature has missed an important aspect of the interaction between demography and economic growth. In the mid-20th century, fertility differences by parental income increased average education in most of the countries under study. These fertility differences eventually flipped in many countries, so the effects of differential fertility on the *per capita* stock of human capital also reversed later in the century. Fruitful directions for future research include assessing whether the composition effects identified in this paper are large enough to play an important role in endogenous growth and investigating their implications for the evolution of income inequality.

References

Althaus, Paul G. (1980). "Differential Fertility and Economic Growth." *Zeitschrift Für Die Gesamte Staatswissenschaft* 136: 309-326.

Barro, Robert J., and Gary S. Becker (1989). "Fertility Choice in a Model of Economic Growth." *Econometrica* 57: 481-501.

Barro, Robert J., and Jong-Wha Lee. (2010). "A New Data Set of Educational Attainment in the World, 1950-2010." NBER Working Paper 15902.

Becker, Gary S. (1960). "An Economic Analysis of Fertility." In *Demographic and Economic Change in Developed Countries*, no. 11 in Universities-National Bureau Conference Series. Princeton, NJ: Princeton University Press.

Becker, G.S., Murphy, K., and R. Tamura. (1990). "Human Capital, Fertility, and Economic Growth." *Journal of Political Economy* 98: S12-S37.

Black, Sandra, Paul J. Devereux, Kjell G. Salvanes. (2005). "The More the Merrier? The Effect of Family Composition on Children's Education." *Quarterly Journal of Economics* 120: 669-700.

Boldrin, Michele and Larry E. Jones. (2002). "Mortality, Fertility and Saving in Malthusian Economy." *Review of Economic Dynamics* 5(4): 775-814.

Buchmann, C., and E. Hannum. (2001). "Education and Stratification in Developing Countries: A Review of Theories and Research." *Annual Review of Sociology* 27: 77-102.

Cain, M. (1983). "Fertility as an Adjustment to Risk." *Population and Development Review* 9: 688-702.

Caldwell, John C. (1980). "Mass Education as a Determinant of the Timing of Fertility Decline." *Population and Development Review* 6: 225-55.

Caldwell, John C. (1982). *Theory of Fertility Decline*. New York: Academic Press.

Casterline, John B. (2001). "Diffusion Processes and Fertility Transition: Introduction." In John B. Casterline, ed., *Diffusion Processes and Fertility Transition*. Washington, DC: National Academy Press, pp. 1-38.

Clark, Gregory. (2007). *A Farewell to Alms: A Brief Economic History of the World*. Princeton: Princeton University Press.

Clark, Gregory, and Gillian C. Hamilton. (2006). "Survival of the Richest: The Malthusian Mechanism in Pre-Industrial England." *Journal of Economic History* 66(3): 707-736.

Cohen, D., and M. Soto. (2007). "Growth and Human Capital: Good Data, Good Results." *Journal of Economic Growth* 12: 51-76.

Dahan, M., and D. Tsiddon. (1998). "Demographic Transition, Income Distribution, and Economic Growth." *Journal of Economic Growth* 3(1): 29-52.

De la Croix, David and Matthias Doepke. (2003). "Inequality and Growth: Why Differential Fertility Matters." *American Economic Review* 93: 1091-1113.

Doepke, Matthias, and Fabrizio Zilibotti. (2005). "The Macroeconomics of Child Labor Regulation." *American Economic Review* 95(5): 1492-1524. Duflo, Esther. (2012). "Women's Empowerment and Economic Development. *Journal of Economic Literature* 50(4): 1051-1079.

Ehrlich, I., and F.T. Lui. (1991). "Intergenerational Trade, Longevity, and Economic Growth." *Journal of Political Economy* 99: 1029-1059.

Filmer, Deon, and Lant H. Pritchett. (2001). "Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India." *Demography* 38(1): 115-132.

Fuller, Wayne A. (1987). *Measurement Error Models*. New York: Wiley.

Galor, Oded. (2011). *Unified Growth Theory*. Princeton, NJ: Princeton University Press.

Galor, Oded, and Stelios Michalopoulos. (2012). "Evolution and the Growth Process: Natural Selection of Entrepreneurial Traits." *Journal of Economic Theory* 147(2): 759-780. Galor, Oded, and Omer Moav. (2002). "Natural Selection and the Origin of Economic Growth." *Quarterly Journal of Economics* 117: 1133-1192.

Galor, Oded, and David Weil. (1996). "The Gender Gap, Fertility and Growth." *American Economic Review* 86(3): 374-387.

Galor, Oded, and David Weil. (2000). "Population, Technology, and Growth: From the Malthusian Regime to the Demographic Transition and Beyond." *American Economic Review* 90(4): 806-828.

Goldin, Claudia. (1995). "The U-Shaped Female Labor Force Function in Econornic Development and Economic History." In T. Paul Schultz, ed., *Investment in Women's Human Capital*. Chicago: University of Chicago Press.

Hazan, Moshe, and Binyamin Berdugo. (2002). “Child Labour, Fertility, and Economic Growth.” *Economic Journal* 112(482): 810-828.

Hadeishi, Hajimi. (2003). “Economic Well-Being and Fertility in France: Nuits 1744-1792.” *Journal of Economic History* 62(2): 489-505.

Heston, Alan, Robert Summers and Bettina Aten. (2012). *Penn World Table Version 7.1*. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

International Labour Office. (2012). *Economically Active Population Estimates and Projections, 1950-2025: Volume 6*.

Jones, Larry E., and Michèle Tertilt. (2008). “An Economic History of Fertility in the United States: 1826–1960.” In Peter Rupert, ed., *Frontiers of Family Economics (Volume 1)*. Bingley, UK: Emerald Press, pp. 165 - 230.

Jones, Larry E., Alice Schoonbroodt, and Michèle Tertilt. (2010). “Fertility Theories: Can They Explain the Negative Fertility-Income Relationship?” In J.B. Shoven, ed., *Demography and the Economy*. Chicago: University of Chicago Press, pp. 43-100.

Kalemli-Ozcan, Sebnem. (2002). “Does the Mortality Decline Promote Economic Growth?” *Journal of Economic Growth* 7(4): 411-439.

Kremer, Michael, and Daniel L. Chen. (2002). “Income Distribution Dynamics with Endogenous Fertility.” *Journal of Economic Growth* 7: 227-258.

Kuznets, Simon. (1973). *Population, Capital and Growth*. New York: Norton.

Lam, David. (1986). “The Dynamics of Population Growth, Differential Fertility, and Inequality.” *American Economic Review* 76(5): 1103-1116.

Lee, Ronald. (1997). “Population Dynamics: Equilibrium, Disequilibrium, and Consequences of Fluctuations.” In Mark Rosenzweig and Oded Stark, eds., *Handbook of Population and Family Economics*. Amsterdam: North Holland, pp. 1063-1115.

Lee, Ronald. (2000). “A Cross-Cultural Perspective on Intergenerational Transfers and the Economic Life Cycle.” In Andrew Mason and Georges Tapinos, eds., *Sharing the Wealth: Demographic Change and Economic Transfers Between Generations*. Oxford: Oxford University Press, pp. 17-56.

Lange, Fabian, and Robert Topel. (2006). “The Social Value of Education and Human Capital.” In Eric Hanushek and Finis Welch, eds., *Handbook of the Economics of Education, Vol. 1*. Amsterdam: North Holland, pp. 459-509.

Lucas, Robert E. (1988). “On the Mechanics of Economic Development.” *Journal of Monetary Economics* 22(1): 3-42.

Mammen, Kristin, and Christina Paxson. (2000). “Women’s Work and Economic Development.” *Journal of Economic Perspectives* 14(4): 141-164.

Maralani, Vida. (2008). “The Changing Relationship Between Family Size and Educational Attainment over the Course of Socioeconomic Development: Evidence from Indonesia.” *Demography* 45(3): 693-717.

Mboup, G., and T. Saha. (1998). *Fertility Levels, Trends, and Differentials: Demographic and Health Surveys*, Comparative Study No. 28. Calverton, MD: Macro International.

Moav, Omer. (2005). “Cheap Children and the Persistence of Poverty” *Economic Journal* 115(500): 88-110.

Morand, Olivier F. (1999). "Endogenous Fertility, Income Distribution, and G*rowth." Journal of Economic Growth* 4(3): 331-349.

Murtin, Fabrice. (2013). "Long-term Determinants of the Demographic Transition: 1870–2000." *Review of Economics and Statistics* 95(2): 617-631.

Nugent, J.B. (1985). "The Old-Age Security Motive for Fertility." *Population and Development Review* 11: 75-97.

Olivetti, Claudia. (Forthcoming). "The Female Labor Force and Long-run Development: The American Experience in Comparative Perspective." In Leah Platt Boustan, Carola Frydman, and Robert A. Margo, eds., *Human Capital and History: The American Record*. Chicago: University of Chicago Press.

Pritchett, Lant. (2006). "Does Learning to Add up Add up? The Returns to Schooling in Aggregate Data." In Eric Hanushek and Finis Welch, eds., *Handbook of the Economics of Education, Vol. 1*. Amsterdam: North Holland, pp. 635-695.

Potts, Malcolm. (1997). "Sex and the Birth Rate: Human Biology, Demographic Change, and Access to Fertility-Regulation Methods." *Population and Development Review* 23(1): 1-39.

Schoellman, Todd. (2012). "Education Quality and Development Accounting." *Review of Economic Studies* 79(1): 388-417.

Schultz, T. Paul. (1981). *Economics of Population*. Reading, MA: Addison-Wesley.

Skirbekk, Vegard. (2008). "Fertility Trends by Social Status." *Demographic Research* 18(5): 145-180.

Soares, Rodrigo R. (2005). "Mortality Reductions, Educational Attainment, and Fertility Choice." *American Economic Review* 95(3): 580-601.

Steelman, Lala Carr, Brian Powell, Regina Werum, and Scott Carter. (2002). "Reconsidering the Effects of Sibling Configuration: Recent Advances and Challenges." *Annual Review of Sociology* 28: 243-269.

Tertilt, Michèle. (2005). "Polygyny, Fertility, and Savings." *Journal of Political Economy* 113(6): 1341-1371.

United Nations (UN). (1987). *Fertility Behavior in the Context of Development: Evidence from the World Fertility Survey*, Population Study No. 100. New York: United Nations.

United Nations (UN). (1995). *Women's Education and Fertility Behavior: Recent Evidence from the Demographic and Health Surveys*. New York: United Nations.

United Nations Population Division (UNPD). (2011). *World Urbanization Prospects: The 2011 Revision*. New York: United Nations.

Voigtländer, Nico, and Hans-Joachim Voth. (2013). "How the West 'Invented' Fertility Restriction." *American Economic Review* 103(6): 2227-64.

Weir, David R. (1995). "Family Income, Mortality, and Fertility on the Eve of The Demographic Transition: A Case Study of Rosny-Sous-Bois." *Journal of Economic History* 55(1): 1-26.

Figure 1: Changes in the Optimal Fertility Schedule as the Return to Education Spending Increases

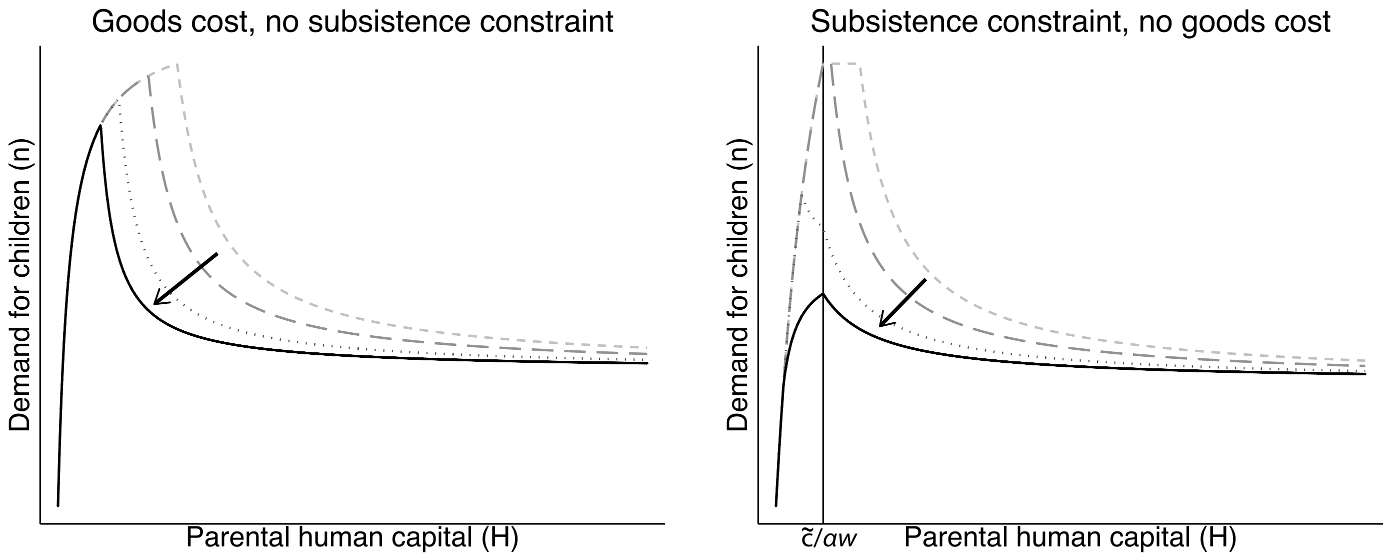
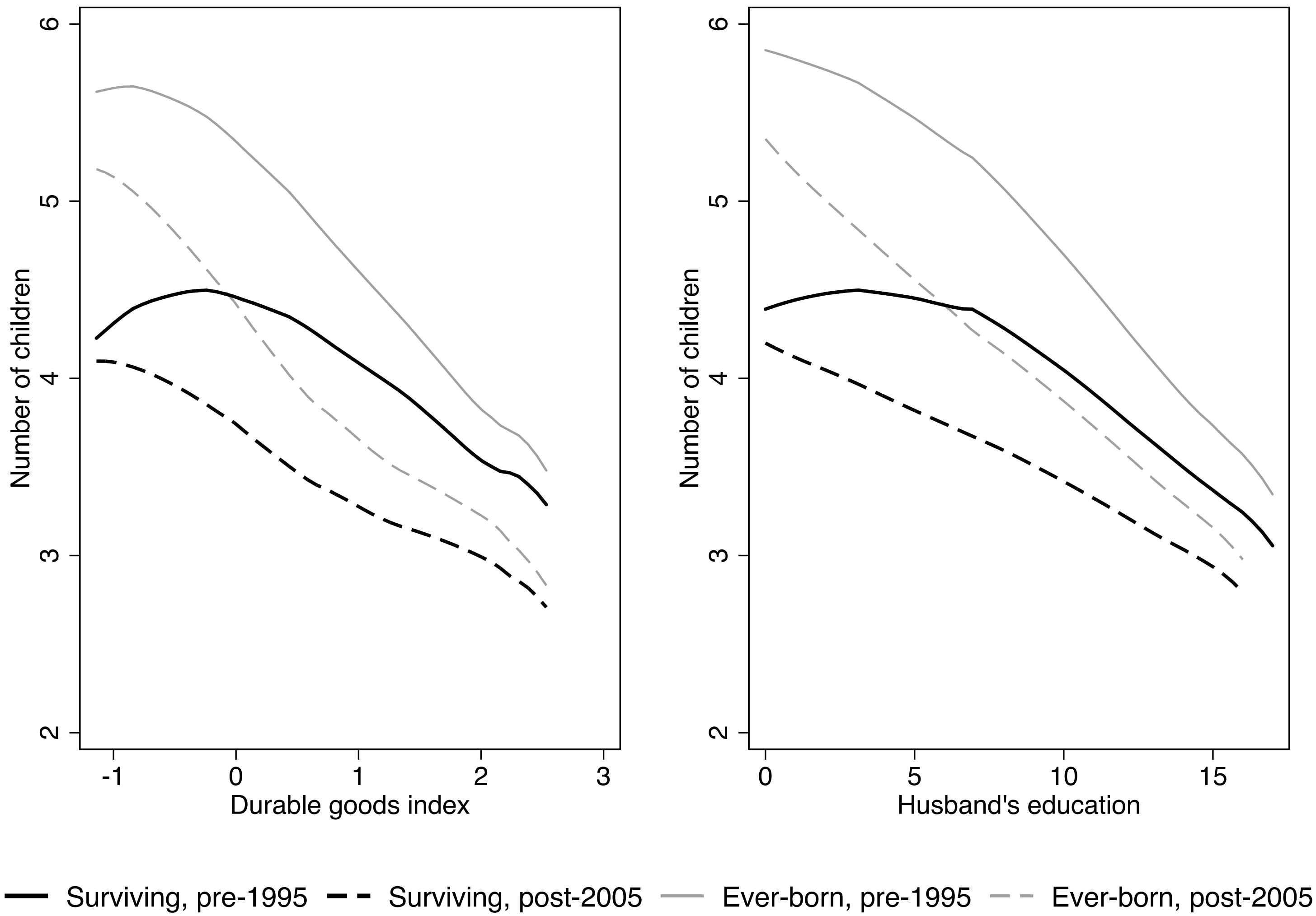
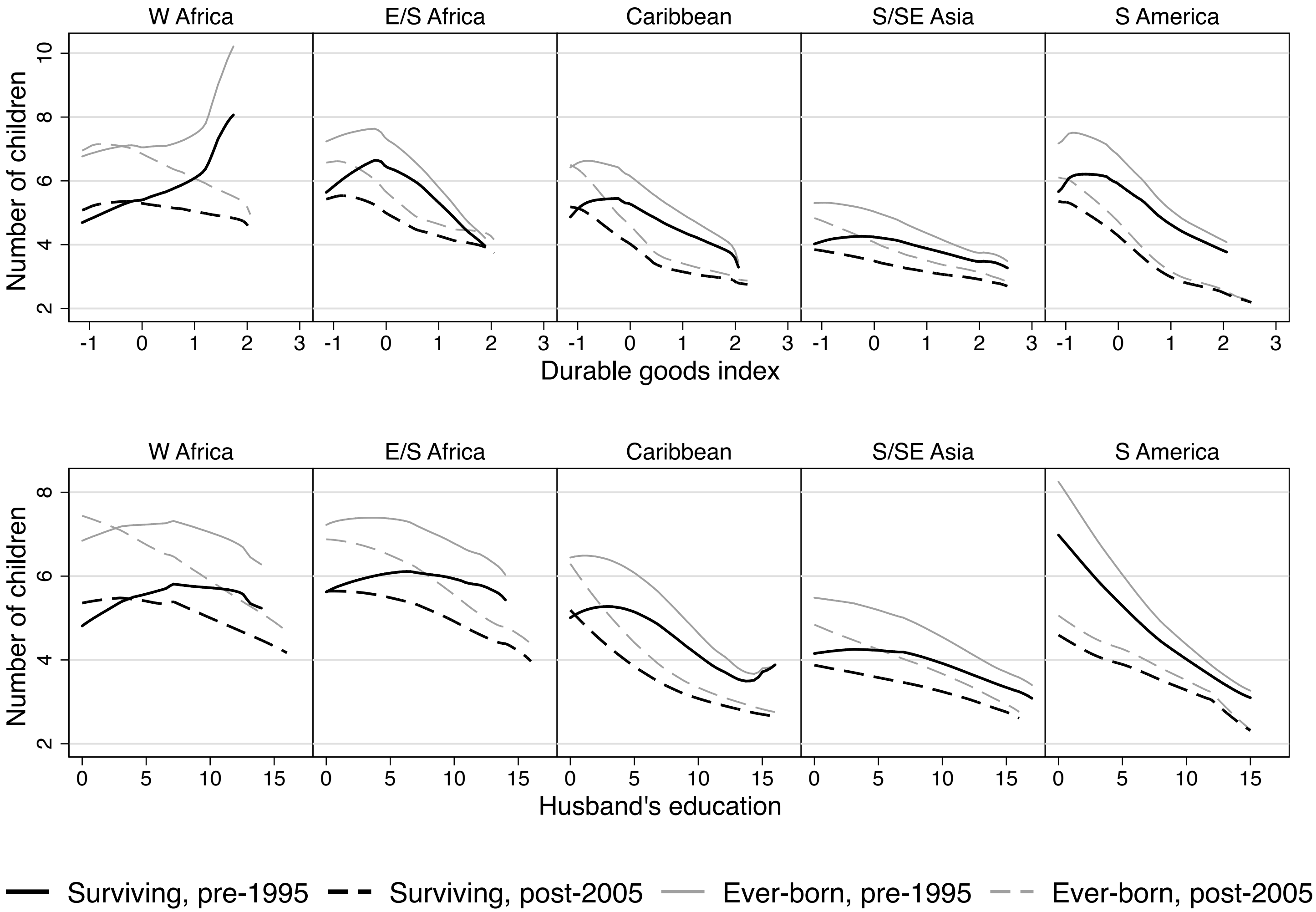


Figure 2: Completed Fertility as a Function of Durable Goods Ownership and Paternal Education, Full Sample



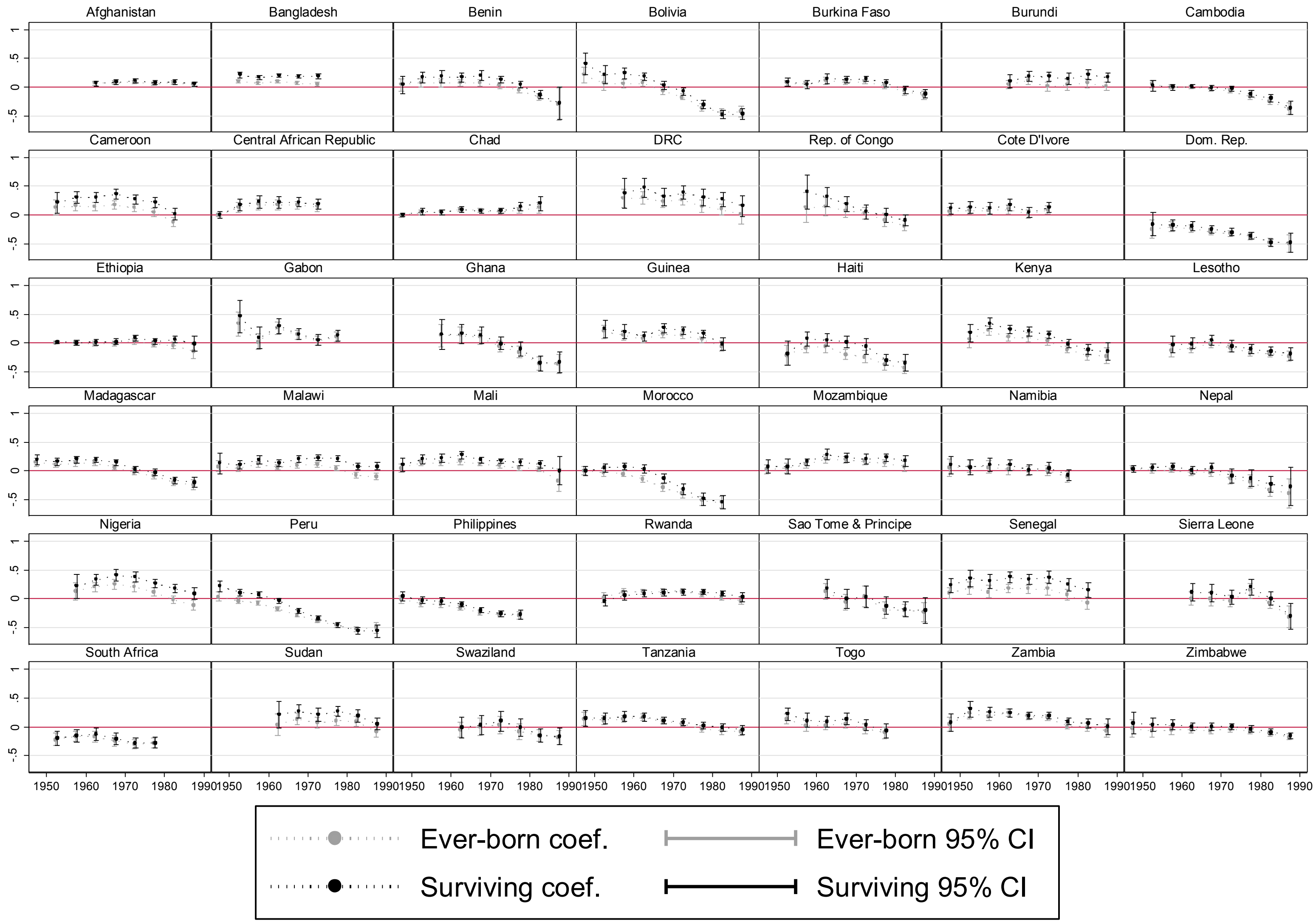
Note: Local linear regressions with bandwidths of 0.5 index units and 3 years of education. Both independent variables have long right tails, the estimation samples trim the top 1% of each independent variable. Sample includes ever-married women in countries with a full durable goods module in both the early and late periods. The durable goods index is the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. Data source: DHS Fertility Histories.

Figure 3: Completed Fertility as a Function of Durable Goods Ownership and Paternal Education, Regional Variation



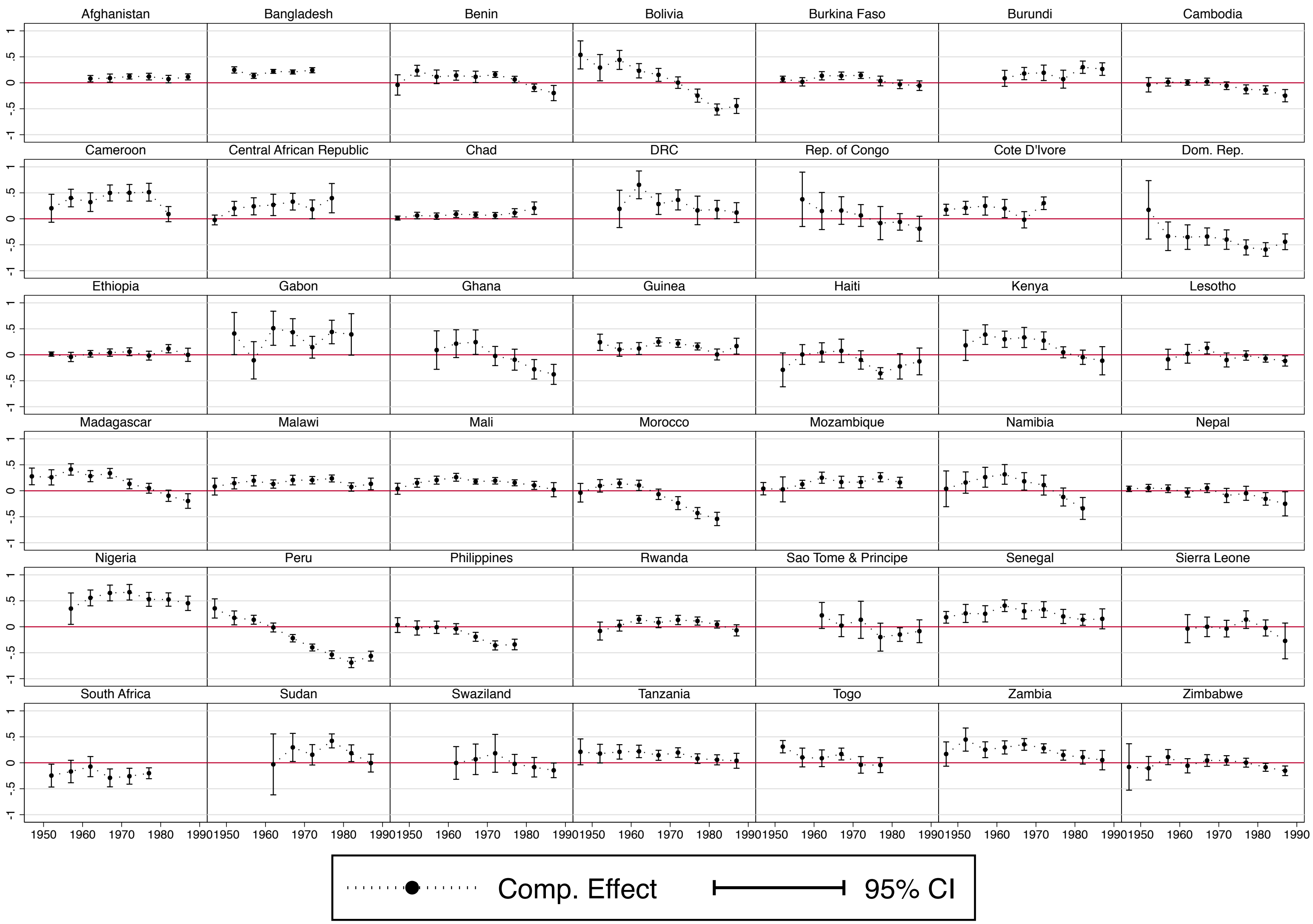
Note: Local linear regressions with bandwidths of 0.5 index units and 3 years of education. Regions are ordered by increasing average paternal education. Both independent variables have long right tails, the estimation samples trim the top 1% of each independent variable. Sample includes ever-married women in countries with a full durable goods module in both the early and late periods. The durable goods index is the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. Data source: DHS Fertility Histories.

Figure 4: Sibship Size-Education Coefficients by Period of Birth



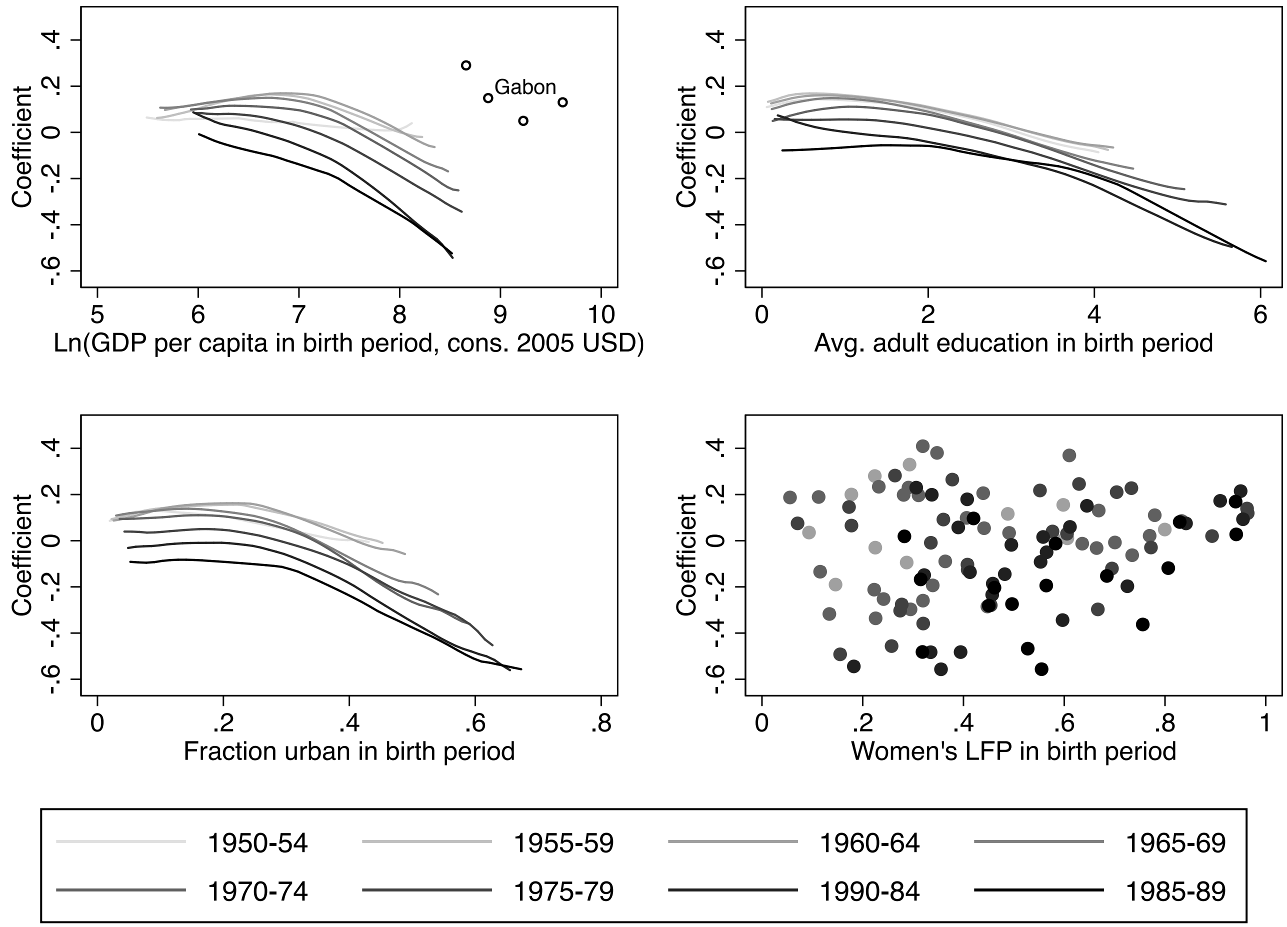
Note: From regressions of years of education on sibship size. Sample includes all women over age 20, except for the 2001 Bangladesh survey and the 1996 Nepal survey, which include ever-married women over age 30. Data source: DHS Sibling Histories.

Figure 5: Composition Effects of Differential Fertility by Period of Birth



Note: The composition effect is the difference between average education and the counterfactual that would arise if all families had the same number of siblings, with no change to their education. CIs are calculated with the delta method. Sample includes all women over age 20, except for the 2001 Bangladesh survey and the 1996 Nepal survey, which include ever-married women over age 30. Data source: DHS Sibling Histories.

Figure 6: Cross-Sectional Determinants of the Sibship Size-Education Relationship



Note: 307 observations from 42 countries. The dependent variable is the coefficient from a regression of education on surviving sibship size. Data source: DHS Sibling Histories.

Table 1: Socioeconomic Characteristics and Surviving Fertility, Women Aged 45-49

	W. Africa		E./S. Africa		Caribbean		S./S.E. Asia		S. America	
	(Burkina Faso, Cameroon, Ghana, Niger, Nigeria, Senegal)		(Burundi, Kenya, Madagascar, Malawi, Namibia, Tanzania, Zambia, Zimbabwe)		(Dominican Republic, Haiti)		(India, Indonesia)		(Colombia, Peru)	
	‘86-'94	‘06-'11	‘86-'94	‘06-'11	‘86-'94	‘06-'11	‘86-'94	‘06-'11	‘86-'94	‘06-'11
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Durable goods index										
Coef. w/o country FE	0.43	-0.124	0.004	-0.60	-0.34	-0.86	-0.10	-0.31	-0.86	-0.95
	[0.15]*	[0.046]*†	[0.102]	[0.07]*†	[0.10]*	[0.06]*†	[0.03]*	[0.02]*†	[0.10]*	[0.04]*
Coef. w/ country FE	0.42	-0.105	-0.119	-0.60	-0.82	-0.68	-0.12	-0.32	-0.87	-0.87
	[0.16]*	[0.046]*†	[0.107]	[0.07]*†	[0.10]*	[0.07]*†	[0.03]*	[0.02]*†	[0.10]*	[0.04]*
Mean index	-0.6	-0.1	-0.8	-0.5	-0.3	0.2	-0.4	0.0	0.4	0.8
B. Husband's education										
Coef. w/o country FE	0.087	-0.057	0.036	-0.09	-0.10	-0.17	-0.034	-0.068	-0.26	-0.13
	[0.026]*	[0.007]*†	[0.019]	[0.01]*†	[0.02]*	[0.01]*†	[0.006]*	[0.005]*†	[0.02]*	[0.01]*†
Coef. w/ country FE	0.083	-0.054	0.003	-0.11	-0.15	-0.13	-0.035	-0.07	-0.27	-0.13
	[0.030]*	[0.008]*	[0.020]	[0.01]*†	[0.02]*	[0.01]*†	[0.006]*	[0.01]*†	[0.02]*	[0.01]*
Mean husb.'s educ.	1.8	4.0	3.3	5.9	3.6	5.4	4.7	6.1	5.5	9.4
Mean num. of kids	5.0	5.2	5.9	5.3	5.0	4.0	4.1	3.5	5.3	3.3
Observations	2,772	8,247	2,777	4,885	1,132	3,112	11,682	13,715	2,356	8,002

Note: Brackets contain standard errors clustered at the PSU level. Sample includes ever-married women in countries with a full durable goods module in both the early and late periods. The durable goods index is the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. Data source: DHS Fertility Histories.

* coefficient significantly different from zero at 5%; † pre-1995 coefficient significantly different from post-2005 coefficient at 5%.

Table 2: Demographic Correlates of the Sibship Size-Education Relationship

	Mean (SD)	OLS	Fuller	OLS	Fuller	OLS	Fuller
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cohort average education	4.2	-0.045	-0.051				
	(2.8)	[0.021]*	[0.024]*				
Cohort average surviving	4.4			0.090	0.096		
sibship size	(0.7)			[0.036]*	[0.047]*		
Cohort average fraction of	0.10					0.42	0.63
siblings dying under 5	(0.04)					[0.82]	[1.52]
Number of observations	307	307	307	307	307	307	307
Number of countries	42	42	42	42	42	42	42

Note: All regressions include birth cohort and country fixed effects. The dependent variable is the coefficient from a regression of education on surviving sibship size. Brackets contain standard errors clustered at the country level. The Fuller GMM estimates are block-bootstrapped. Data source: DHS Sibling Histories.
* significant at the 5% level.

Table 3: Development and the Sibship Size-Education Relationship

	OLS	OLS	OLS
	(1)	(2)	(3)
Ln(GDP per capita in birth period)	0.038	0.022	0.012
	[0.091]	[0.094]	[0.094]
Avg. adult yrs. ed. in birth period	-0.093	-0.106	-0.110
	[0.025]*	[0.029]*	[0.032]*
Fraction urban in birth period	-0.633	-0.556	-0.284
	[0.441]	[0.468]	[0.393]
Number of observations	217	193	142
Number of countries	38	34	27
Education dataset	Combined	Barro-Lee	Cohen-Soto

Note: All regressions include birth cohort and country fixed effects. The dependent variable is the coefficient from a regression of education on surviving sibship size. Brackets contain standard errors clustered at the country level. The "combined" measure uses the Barro-Lee data if available and otherwise projects the Cohen-Soto data onto the Barro-Lee scale.
* significant at the 5% level.

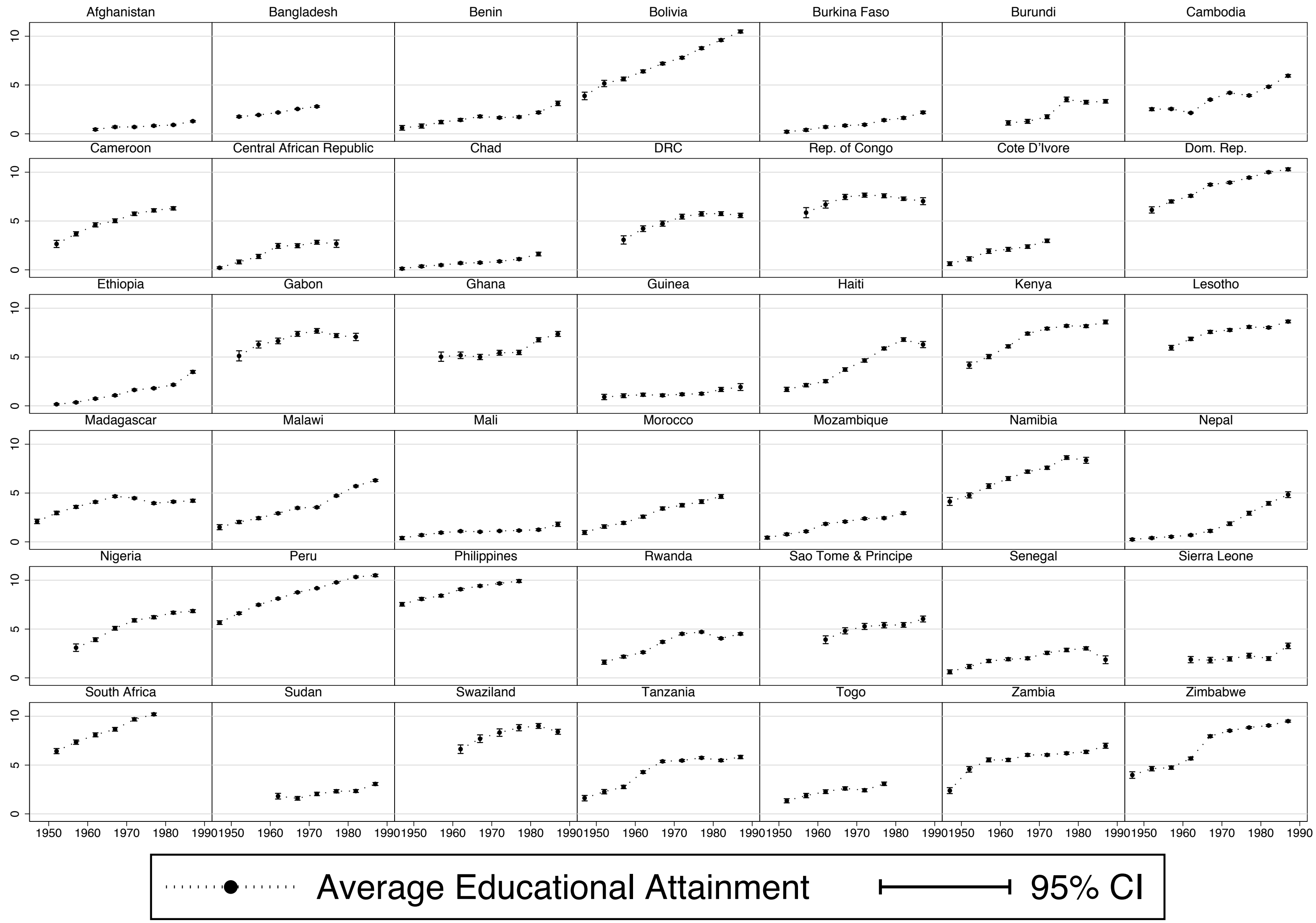
Table 4: Female Empowerment and the Sibship Size-Education Relationship

	OLS	OLS	OLS
	(1)	(2)	(3)
Women's labor force participation rate in birth period	0.113		
	[0.111]		
Manufacturing fraction of value added in birth period		-0.001	
		[0.002]	
Services fraction of value added in birth period		0.001	
		[0.002]	
Avg. adult male yrs. ed. in birth period			-0.065
			[0.022]*
Avg. adult female yrs. ed. in birth period			-0.056
			[0.037]
p-value: joint test of education coefficients			0.002
p-value: difference of education coefficients			0.851
Number of observations	112	137	234
Number of countries	34	41	34

Note: All regressions include birth cohort and country fixed effects. The dependent variable is the coefficient from a regression of education on surviving sibship size. Brackets contain standard errors clustered at the country level. The education measures in column (3) are from the Barro-Lee dataset.
* significant at the 5% level.

Appendix Tables and Figures — Not for Publication

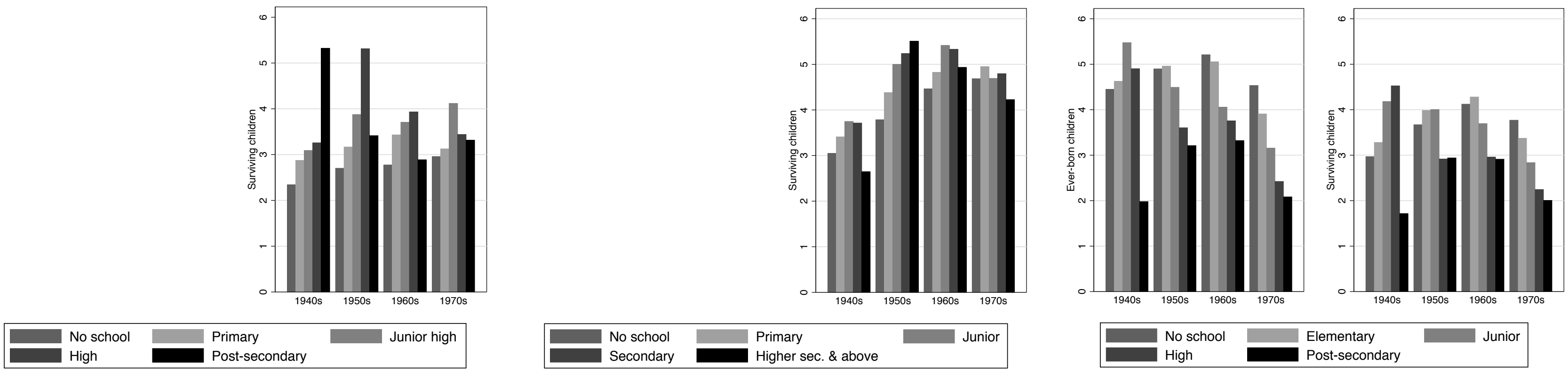
Appendix Figure 1: Mean Education by Period of Birth



Data source: DHS Sibling Histories.

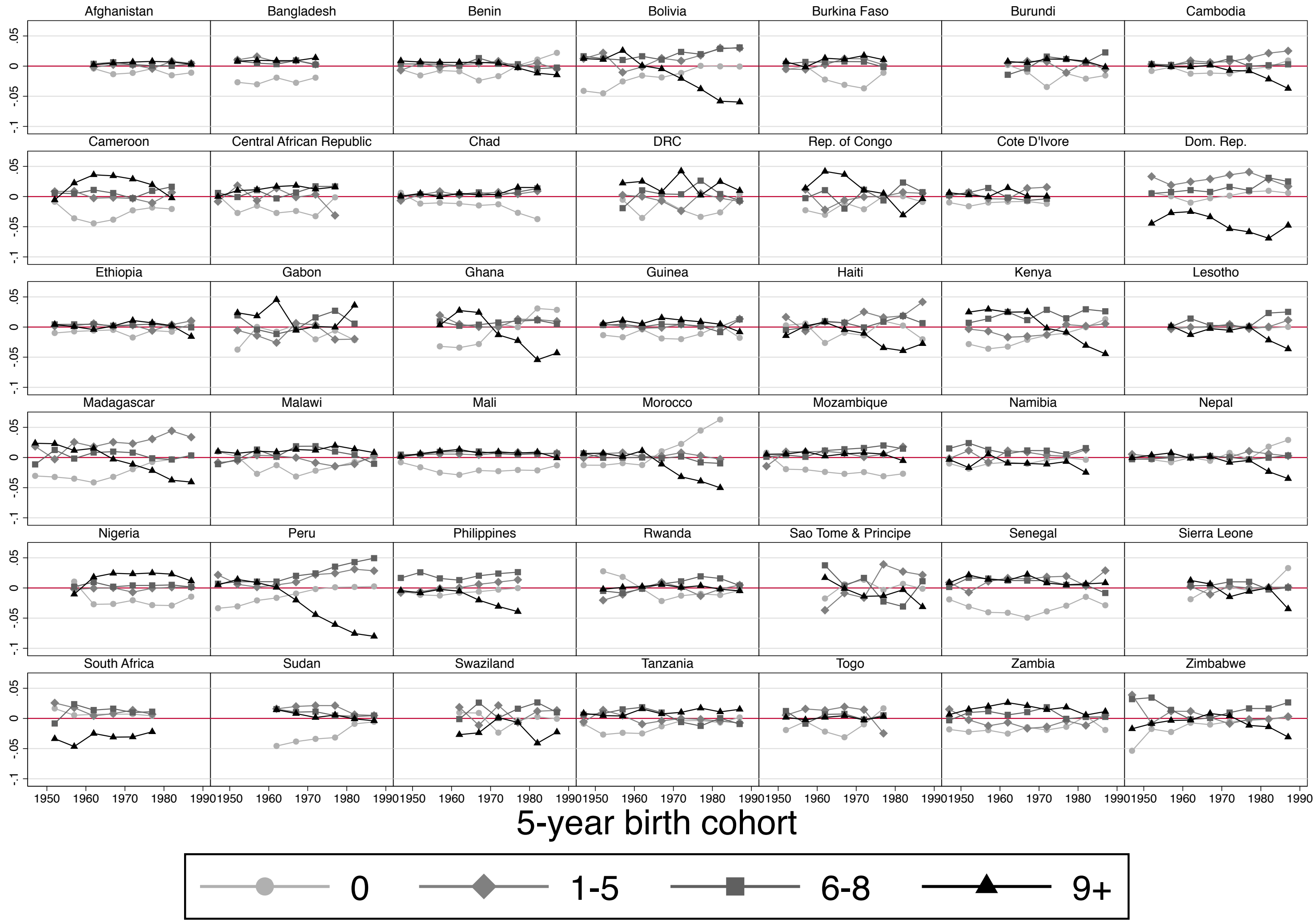
Appendix Figure 2: Father's Education and Sibship Size in the Family Life Surveys

Indonesia *Matlab, Bangladesh* *Mexico*



Note: Means are weighted by the survey weight divided by the surviving sibship size to make them representative of the families of surviving children. Only the Mexico sample contains data on siblings who died in childhood, so the plot for ever-born sibship size is only possible for Mexico. Data source: adults born from 1940-1982 in the Indonesia Family Life Survey (1993, 1997 waves), Matlab Health and Socioeconomic Survey (1996), and Mexico Family Life Survey (2002 wave).

Appendix Figure 3: Composition Effects on Education Shares by Period of Birth



Note: The composition effect is the difference between actual average education and the counterfactual that would arise if all families had the same number of siblings, with no change to their education. Data source: DHS Sibling Histories.

Appendix Table 1: DHS Countries and Survey Years

Fertility Histories

Burkina Faso 1992-3, 2010; Burundi 1987, 2010; Cameroon 1991, 2011; Colombia 1986, 1990. 2009-10; Dominican Republic 1986, 1991, 2007; Ghana 1988, 1994, 2008; Haiti 1994-5, 2005-6; India 1992-3, 2005-6; Indonesia 1994, 2007; Kenya 1988-9, 2008-9; Madagascar 1992, 2008-9; Malawi 1987, 2006; Nigeria 1990, 2008; Niger 1992, 2006; Namibia 1992, 2006-7; Peru 1986, 1992, 2006-8; Senegal 1986, 1993, 2010-11; Tanzania 1991-2, 2010; Zambia 1992, 2007; Zimbabwe 1988, 1994, 2010-11.

Sibling Histories

Afghanistan 2010; Bangladesh 2001; Benin 1996, 2006; Bolivia 1994, 2003, 2008; Burkina Faso 1999, 2010; Burundi 2010; Cambodia 2000, 2005, 2010; Cameroon 1998, 2004; Central African Republic 1995; Chad 1996, 2004; Congo, Dem. Republic 2007; Congo, Republic 2005; Cote d'Ivore 1994; Dominican Republic 2002. 2007; Ethiopia 2000, 2005, 2010; Gabon 2000; Ghana 2007; Guinea 1992, 2005; Haiti 2000, 2005-6; Kenya 1998, 2003, 2008-9; Lesotho 2004, 2009; Madagascar 1992, 1997, 2004, 2008-9; Malawi 1992, 2000, 2004, 2010; Mali 1995, 2001, 2006; Morocco 1992, 2003; Mozambique 1997, 2003; Namibia 1992, 2000; Nepal 1996, 2006; Nigeria 2008; Peru 1992, 1996, 2000, 2003-8; Philippines 1993, 1998; Rwanda 2000, 2005, 2010; São Tomé & Príncipe 2008; Senegal 1992, 2005; Sierra Leone 2008; South Africa 1998; Sudan 2010; Swaziland 2007; Tanzania 1996, 2004, 2010; Togo 1998; Zambia 1996, 2001, 2007; Zimbabwe 1994, 1999, 2005, 2010-11.

Appendix Table 2: Socioeconomic Characteristics and Surviving Fertility, Women Aged 45-49

	W. Africa		E./S. Africa		Caribbean		S./S.E. Asia		S. America	
	(Burkina Faso, Cameroon, Ghana, Niger, Nigeria, Senegal)		(Burundi, Kenya, Madagascar, Malawi, Namibia, Tanzania, Zambia, Zimbabwe)		(Dominican Republic, Haiti)		(India, Indonesia)		(Colombia, Peru)	
	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. No country fixed effects										
Durable goods index	0.33	0.12	-0.09	-0.29*	-0.14	-0.37	0.14	-0.028	-0.31	-0.56
	[0.15]*	[0.050]*	[0.13]	[0.08]	[0.13]	[0.06]*	[0.04]*	[0.025]	[0.11]*	[0.04]*
Husband's education	0.087	-0.015	0.054	-0.012	-0.085	-0.050	-0.009	-0.003	-0.17*	-0.040
	[0.028]*	[0.011]	[0.023]	[0.016]	[0.033]*	[0.013]*	[0.007]	[0.006]	[0.03]	[0.006]*
Own education	-0.062	-0.082	-0.028	-0.096	0.002	-0.11	-0.08	-0.10	-0.098*	-0.11
	[0.043]	[0.013]*	[0.027]	[0.019]*	[0.039]	[0.01]*	[0.01]*	[0.006]*	[0.025]*	[0.007]*
B. Country fixed effects										
Durable goods index	0.34	0.13	-0.125	-0.25	-0.54	-0.28	0.13*	-0.039	-0.30	-0.40
	[0.16]*	[0.050]*	[0.130]	[0.08]*	[0.12]*	[0.07]*	[0.04]*	[0.025]	[0.11]*	[0.04]*
Husband's education	0.080	-0.012	0.020	-0.028	-0.055	-0.053	-0.004	-0.001	-0.171	-0.042
	[0.032]*	[0.011]	[0.023]	[0.017]	[0.033]*	[0.013]*	[0.007]	[0.006]	[0.027]*	[0.005]*
Own education	-0.062	-0.084	-0.021	-0.10	-0.072	-0.10	-0.09	-0.11	-0.097	-0.122
	[0.043]	[0.013]*	[0.027]	[0.02]*	[0.036]	[0.01]*	[0.01]*	[0.006]*	[0.025]*	[0.0067]
Observations	2,771	8,243	2,773	4,883	1,131	3,111	11,659	13,710	2,356	8,002

Note: Brackets contain standard errors clustered at the PSU level. Sample includes ever-married women in countries with a full durable goods module in both the early and late periods. The durable goods index is the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. Data source: DHS Fertility Histories.
* significant at the 5% level.

Appendix Table 3: Socioeconomic Characteristics and Surviving Fertility by Sector, Women Aged 45-49

	W. Africa		E./S. Africa		Caribbean		S./S.E. Asia		S. America	
	(Burkina Faso, Cameroon, Ghana, Niger, Nigeria, Senegal)		(Burundi, Kenya, Madagascar, Malawi, Namibia, Tanzania, Zambia, Zimbabwe)		(Dominican Republic, Haiti)		(India, Indonesia)		(Colombia, Peru)	
	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11	'86-'94	'06-'11
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Durable goods index										
Rural	0.43	0.079	0.82	-0.15	0.18	-0.85	0.143	-0.27	-0.36	-0.89
	[0.22]*	[0.065]†	[0.22]*	[0.12]†	[0.20]	[0.083]*†	[0.051]*	[0.03]*†	[0.30]	[0.06]*†
Urban	0.41	-0.077	-0.15	-0.49	-0.37	-0.58	-0.2	-0.26	-0.67	-0.67
	[0.19]*	[0.068]†	[0.14]	[0.08]*†	[0.14]*	[0.08]*	[0.04]*	[0.03]*	[0.13]*	[0.05]*
B. Husband's education										
Rural	0.12	-0.017	0.09	-0.05	0.051	-0.23	-0.001	-0.045	-0.28	-0.09
	[0.03]*	[0.010]†	[0.02]*	[0.02]*†	[0.053]	[0.02]*†	[0.007]	[0.006]*†	[0.06]*	[0.01]*†
Urban	0.033	-0.08	-0.003	-0.09	-0.12	-0.09	-0.072	-0.083	-0.21	-0.10
	[0.033]	[0.01]*†	[0.035]	[0.02]*†	[0.03]*	[0.01]*	[0.010]*	[0.007]*	[0.02]*	[0.01]*
Rural observations	1,912	5,639	2,208	3,593	577	1,509	8,038	7,615	669	2,341
Urban observations	860	2,608	569	1,292	555	1,603	3,644	6,100	1,687	5,661

Note: Brackets contain standard errors clustered at the PSU level. No country fixed effects. Sample includes ever-married women in countries with a full durable goods module in both the early and late periods. The durable goods index is the first principal component of a vector of ownership indicators for car, motorcycle, bicycle, refrigerator, television, and radio. Data source: DHS Fertility Histories.

* coefficient significantly different from zero at 5%; † pre-1995 coefficient significantly different from post-2005 coefficient at 5%.

Appendix Table 4: Sibship Size-Education Coefficients by Gender and Period of Birth

	1940-1949	1950-1959	1960-1969	1970-1982
	(1)	(2)	(3)	(4)
Indonesia				
Men	0.399	0.427	0.303	0.179
	[0.074]*	[0.063]*	[0.070]*	[0.156]
N	949	1,450	1,133	132
Women	0.418	0.383	0.295	0.085
	[0.065]*	[0.046]*	[0.056]*	[0.098]
N	1,076	1,614	1,762	479
Matlab, Bangladesh				
Men	0.309	0.274	0.172	0.143
	[0.086]*	[0.070]*	[0.076]*	[0.077]
N	751	920	894	780
Women	0.123	0.249	0.141	0.062
	[0.028]*	[0.039]*	[0.039]*	[0.067]
N	968	1,130	1,481	967
Mexico				
Men	0.05	-0.023	-0.186	-0.29
	[0.088]	[0.086]	[0.067]*	[0.045]*
N	845	1,256	1,644	2,154
Women	0.017	-0.038	-0.127	-0.29
	[0.066]	[0.068]	[0.052]*	[0.044]*
N	966	1,574	2,222	3,053

Note: OLS coefficients. Brackets contain standard errors clustered at the PSU level. Each coefficient is from a separate regression. Data source: adults born from 1940-1982 in the Indonesia Family Life Survey (1993, 1997 waves), Matlab Health and Socioeconomic Survey (1996), and Mexico Family Life Survey (2002 wave).
* significant at the 5% level.

Appendix Table 5: Sibship Size-Education Coefficients with and without Controlling for Father's Education

	1940-1949	1950-1959	1960-1969	1970-1982
	(1)	(2)	(3)	(4)
Indonesia				
Unadjusted for dad's ed.	0.344	0.415	0.328	0.074
	[0.061]*	[0.051]*	[0.058]*	[0.103]
Adjusted for dad's ed.	0.189	0.225	0.119	-0.012
	[0.056]*	[0.040]*	[0.043]*	[0.088]
N	1,430	2,049	2,009	460
Matlab, Bangladesh				
Unadjusted for dad's ed.	0.191	0.264	0.160	0.093
	[0.040]*	[0.038]*	[0.037]*	[0.052]
Adjusted for dad's ed.	0.102	0.138	0.071	0.119
	[0.037]*	[0.036]*	[0.034]*	[0.046]*
N	1,678	2,007	2,317	1,705
Mexico				
Unadjusted for dad's ed.	0.032	-0.037	-0.162	-0.301
	[0.080]	[0.067]	[0.057]*	[0.037]*
Adjusted for dad's ed.	0.071	0.0002	-0.045	-0.154
	[0.070]	[0.057]	[0.048]	[0.034]*
N	1,376	2,261	3,166	4,393

Note: OLS coefficients. Brackets contain standard errors clustered at the PSU level. Each coefficient is from a separate regression. The samples include both men and women, and all regressions control for a gender indicator. Data source: adults born between 1940 and 1982 in the Indonesia Family Life Survey (1993, 1997 waves), Matlab Health and Socioeconomic Survey (1996), and Mexico Family Life Survey (2002 wave). The Mexico Family Life Survey only contains data on broad education categories, but for ease of comparison across settings, I convert them to a measure of years of education. Using data from the 2000 Mexico census, I determine the mean years of education among adults in each education level, and I then assign that mean to the corresponding parents in the Mexico Family Life Survey.
* significant at the 5% level.