Fertility Decline and Educational Progress in African Women and Children

Tom Vogl*

April 2024

Abstract

Theories linking fertility decline to rising education among women and children have featured prominently in discussions of African fertility change. Using survey data from 33 countries, this paper leverages cross-place and cross-cohort variation to assess the theories' relevance to the continent's fertility transition. Across countries and subnational regions, lower fertility is associated with higher education in both generations. But across cohorts within a country or region, fertility decline has at most a weak relationship with children's educational progress, although it remains associated with that of women. Within-place, cross-cohort variation thus corroborates existing evidence that women's education drives fertility change in Africa, but it indicates a more limited role for the interplay of the number of children and their education. Reductions in desired fertility more consistently predict children's educational progress, suggesting that this interplay may become more relevant to African fertility change as implementation of desired fertility improves.

*Department of Economics, University of California San Diego, BREAD, and NBER. An earlier draft of this paper served as a framework paper for the Project on Human Capital Development in Africa at the African Economic Research Consortium, with funding from the Bill and Melinda Gates Foundation. I thank Francis Baye, Jishnu Das, Shoshana Grossbard, Lant Pritchett, Emily Smith-Greenaway, and audiences at AERC, AHHCES, Columbia, Georgetown, PAA, SDSU, UC Berkeley, Williams College, and World Bank for comments. Akanksha Arora and Frances Lu provided exceptional research assistance.

1 Introduction

Sub-Saharan Africa is the only world region with a total fertility rate in excess of four children per woman, the result of later and slower fertility decline (Appendix Figure A1). On top of timing and pace, several African countries stand out for having fertility rates that "stalled" after a period of sustained decline (Bongaarts 2017). Educational progress too has lagged other regions, such that the region now places last in educational attainment among prime-age adults (Appendix Figure A2). A number of demographic and economic theories propose that these phenomena are linked, with education growth among adults and children acting as either a driver or byproduct of fertility decline. This paper studies patterns of fertility and education across places and cohorts in Africa to shed light on the relevance of these theories to the region's fertility transition.

The theories propose two classes of links between falling fertility and rising education. A first class emphasizes how *children's* education expands as families shrink, with causality running in both directions. Since Becker and Lewis (1973) and Willis (1973), economists have noted that investing in the average child is more expensive when children are more numerous, leading to a 'quality-quantity tradeoff.' Social demographers have instead stressed Caldwell's (1980) theory that mass primary education must precede fertility decline, due to its effects on childrearing costs, the extent of child labor, dependency norms, the pace of cultural change, and the spread of Western values. A second class of links centers on how the expansion of *women's* education reduces fertility, through women's opportunity cost of time, autonomy, knowledge, and attitudes (Cochrane 1979; Jejeebhoy 1995; Diamond et al. 1999). The two classes of links are interconnected, suggesting a triangle connecting fertility with the education of both generations. I use data on the early cohorts of Africa's fertility transition to quantify each leg of the triangle, asking how cross-cohort variation within places compares with cross-place variation.

Existing research has applied these theories to Africa's fertility transition, but my focus on cohort variation is novel, and it provides a coherent framework for jointly studying fertility's association with education in both generations. On fertility decline and *children's* schooling, the canonical reference on Africa is Lloyd et al. (2003), who document that early fertility declines were concentrated in countries that had extensive primary schooling. However, they associate the *level* of child schooling with the *change* in fertility, and cross-sectional variation in schooling may be correlated with other determinants of fertility change.[1] I build on their influential work by studying within-place changes in both variables: a new check on applications

[1]Studies of individual-level variation in these variables have muddled results in Africa, documenting positive, negative, and null relationships between sibship size and education (Buchmann and Hannum 2001; Eloundou-Enyegue and Williams 2006; Vogl 2016).

of Becker's and Caldwell's theories to the context. Caldwell (1980) himself cites examples of how schools spread Western ideas about family in Africa. And research on demographic-economic dynamics in Africa emphasizes the Beckerian mechanism despite limited context-specific evidence (Ashraf et al. 2013). As free primary education policies have proliferated, with large gains in attendance but more limited school progression and learning (Bold et al. 2017), how have fertility and children's education outcomes coevolved?

More research has explored the connection between *women's* schooling and the ebbs and flows of African fertility change. Kebede et al. (2019) argue that slowdowns in the growth of women's education across cohorts explain "stalls" in fertility decline in several countries. Despite their focus on cohorts, they rely on the cross-sectional education-fertility association to project cohort fertility under counterfactual cohort education trends, so their quantitative exercise mixes two types of variation.[2] Bongaarts (2020) complements this approach by leveraging within-country variation between rounds of the Demographic and Health Surveys, finding that—net of country fixed effects—the total fertility rate falls as average women's education rises. Because his method focuses on aggregate changes rather than cross-sectional differences, it better suited to assess theories of fertility decline, an aggregate concept. I follow a similar approach but use cohort rather than period variation. Cohort variation underlies several quasi-experimental studies of universal primary education policies, which estimate negative effects of women's education on fertility in Nigeria (Osili and Long 2008) and Uganda (Keats 2018), as well as on ideal family size in Ethiopia, Malawi, and Uganda (Behrman 2015).[3] Relative to these studies, I take a broader geographic scope and consider both women's and children's schooling.

The cohort orientation is key to relating fertility decline to educational progress in both generations. In aggregate period data, some children in an average of child schooling outcomes will have mothers outside the age range of a typical fertility rate. The fertility rate may also weight families differently from the educational average. In contrast, if one divides women into cohorts and then takes cohort averages of their fertility, education, spousal attributes, and children's education, then one characterizes the resources and decisions of well-defined groups of families. My analysis asks whether places with more cross-cohort fertility decline have experienced relatively more cross-cohort educational progress among women and their children.

To this end, I assemble a continent-wide dataset from 112 Demographic and Health Surveys, in which women from 33 African countries report their own educational attainment, their spouses' attributes, their

[2]Schoumaker and Sánchez-Páez (forthcoming) dispute Kebede et al.'s conclusion on the role of women's education in fertility "stalls," but they too rely on cross-sectional variation in education and fertility.

[3]The findings on realized fertility are corroborated by randomized controlled trials of education subsidies in Kenya (Duflo et al. 2015) and Ghana (Duflo et al. 2021), as well as a regression discontinuity design on secondary school admissions in Kenya (Ozier 2018). The Ghanaian trial does not confirm an effect on deired fertility, however.

fertility histories and desires, and the school outcomes of their children. I compare pooled cross-sectional analyses with fixed-effect analyses of national or regional cohorts: groups of women born in the same year and residing in the same country or subnational region. The national fixed-effect analyses include country fixed effects and women's birth year fixed effects, thus isolating variation across cohorts within countries, net of continent-wide cohort trends. The regional fixed-effect analyses include region fixed effects and country-by-birth year fixed effects, thus isolating variation across cohorts within regions, net of country-specific cohort trends. Each level of aggregation has benefits and drawbacks. Confounding national policies and trends pose concerns for the national analyses, while selective migration poses a concern for the regional analyses.

Despite their different strengths and weaknesses, analyses at both levels of aggregation find that declining fertility is robustly associated with rising women's education but has a weak and fragile relationship with rising children's education. Higher women's education systematically predicts fewer ever-born and surviving children, with similar magnitudes in all cases. For children's schooling, however, the fixed-effect results are much weaker than the pooled cross-sectional results. In the cross-section, higher fertility is associated with lower school enrollment and grade attainment. But with fixed effects, the enrollment results either flip sign or fall to zero, while the attainment results shrink substantially. The slightly stronger attainment results line up with differences in the roles of women and their husbands in the final leg of the fertility-education triangle, linking adult education with child education.[4]

Overall, one must squint to see evidence that child schooling systematically rises as fertility falls. But women's reports of desired fertility provide a saving grace for Becker and Caldwell. Desired fertility may respond to changing educational conditions more immediately and precisely than realized fertility. Indeed, lower desired fertility is associated with higher child enrollment and attainment, with and without fixed effects. Desired fertility follows Becker's and Caldwell's predictions more closely than realized fertility.

The paper does not seek to disentangle the causal pathways underlying these results but instead to contribute new facts on changing cohort fertility and its relation to educational progress in two generations. Demographic and economic theory predict a coevolution of fertility with both women's and children's schooling. Data on cohorts of African women born in the mid-20^{th} century find a prominent link with the former but a substantially weaker link with the latter. Nevertheless, as deviations of realized from desired fertility narrow, the child schooling link may yet become a more systematic feature of Africa's fertility transition.

[4]Specifically, rising husbands' education predicts rising child enrollment *and* grade attainment, whereas rising women's education predicts only the latter. These results are consistent with Zimbabwean evidence that father's education raises both child outcomes, but mother's education raises only attainment (Agüero and Ramachandran 2020).

2 A Cohort Framework for the Fertility-Education Triangle

Parents' own education levels interact with their decisions over fertility and the education of their children. As a consequence, the three legs of the fertility-education triangle—linking fertility with child education, fertility with adult education, and adult education with child education—are intertwined. Axinn and Barber (2001) set a precedent for jointly considering multiple legs of the triangle in their seminal work on Nepal, which connects women's contraceptive use to their own schooling experiences and those of their children. Their conceptual framework draws together one set of hypotheses linking adult education and fertility with another set linking child education and fertility. This section briefly reviews both sets of hypotheses alongside a third set linking adult education with child education. It then discusses how a cohort framework is uniquely suited for studying the three legs of the fertility-education triangle simultaneously.

Fertility and Child Education The Caldwellian theory concerns effects running from schooling to fertility, while the Beckerian theory features effects in both directions, but both generally predict that children's schooling rises as fertility falls. Caldwell (1980) notes how the rise of schooling alters wealth flows between generations and changes parents' thinking about their fertility. Schooling may increase child costs, reduce income from child labor, and raise children's expectation of independence from their parents. It may also spread new cultural values regarding ideal family size and children's independence. Caldwell thus characterizes mass education as the "primary determinant of the timing of the onset of the fertility transition" (p. 225). Economists' 'quality-quantity' theory (Becker and Lewis 1973; Willis 1973) focuses on the first set of forces in Caldwell's theory—child costs and returns—but highlights bidirectionality. More educational investment per child makes children more expensive; equivalently, a greater number of children raises the cost of investing in the average child. In a standard economic model of this type, most policies and structural changes that reduce fertility raise investment in children, and vice-versa.[5]

The application of these theories African context must confront at least two issues. First, the expansion of formal schooling in Africa is undoubtedly intertwined with colonialism and efforts to spread Western ideology, as both Caldwell (1980) and Lloyd et al. (2003) note. But does fertility change diffuse to families contemporaneously, as wealth flows shift and children hear new ideas in school, or must one wait a generation for those children to grow up and start families of their own? Second, the way schooling reorganizes chil-

[5] Perhaps most prominently, Becker and Lewis (1973) conjecture that the income elasticity of the demand for education is larger than that for children, so that income growth leads to rising educational investment and declining fertility.

dren's time undoubtedly transforms the family economy. But when schools are free and underresourced, with variable learning outcomes, is school enrollment best interpreted as a costly investment in children's human capital? Attainment, which also captures school progression, may more closely reflect active investment by families. For younger children, even the time cost of schooling is unclear, as young children contribute little to family production and require care when they are not in school.

Adult Education and Fertility One cannot think about parents' decisions regarding the number and education of their children without first thinking about their own education. This interconnection features prominently in Kasarda et al.'s (1986) status-enhancement framework, in which parents choose fertility in pursuit of social mobility. It also plays a role in economic explanations for the lower fertility of more educated women, which suggest that more educated mothers may be more effective at investing in their children or have higher opportunity costs of time (see Schultz 1997 and references therein). Demographers propose a broader set of mechanisms linking women's education to fertility, including access to and knowledge of family planning methods (Cochrane 1979), autonomy (Jejeebhoy 1995), and ideas about fertility and family (Cleland and Wilson 1987). In the African context, the way schools promote Western ideas about independence and family structure may shape fertility trends not just through children, as Caldwell (1980) emphasized, but also through women, who were exposed to these ideas in childhood. Many of these mechanisms are specific to women's rather than men's education, and indeed the empirical literature has focused disproportionately on women. However, some may apply to men's education too, and part of the relationship for women's education may be mediated by marriage outcomes.

Adult Education and Child Education To close the triangle, one also needs to quantify the link between the education of parents and children. Large literatures in economics and sociology explore mechanisms that could explain an effect of parental education on child education, which include socialization, financial constraints, heterogeneity in schooling returns, and cultural capital (Torche 2021). Mothers and fathers tend to have similar education levels (Pesando 2021), but their relative importance for children's education is unclear. Any differences in the extent to which women's and men's education predict fertility vis-à-vis child education will influence the strength of the association between fertility and child education. Women's and husbands' education are both relevant for the analysis.

Timing Axinn and Barber (2001) note that the interplay of fertility and child education could be simultaneous, with parents formulating fertility and education plans before they commence, or sequential, with parents updating their plans as their older children experience schooling. These issues of lag structure are vexing if one studies the evolution of outcomes over a woman's life course, but they become less so if one studies cross-cohort changes in outcomes measured at the end of her reproductive period. Analyzing the education, marriage, child, and fertility outcomes of women from the same place and birth year sheds light on the choices of a well-defined group of families, after the sequence of decisions has concluded. The research questions thus necessitate a cohort orientation. Additionally, if parents are unsuccessful in perfectly implementing their fertility desires, then fertility outcomes may change less than fertility desires in response to changes in education. Both realized and desired fertility are of interest.

3 African Demographic and Health Surveys

3.1 Sample

The Demographic and Health Surveys (ICF 1986-2021) interview nationally-representative samples of women of childbearing age, typically 15-49, with survey modules on the respondents' reproductive histories, their characteristics and those of their spouses, and the survival and education of their children. I assemble data from all DHS in sub-Saharan Africa that (i) are in standard format and in the public domain; (ii) contain data on husbands' and children's schooling outcomes; and (iii) allow linkage of children to their mothers in the household roster. Because the analysis focuses on cross-cohort changes, I restrict to countries with multiple surveys. The final sample contains 112 surveys in 33 countries.[6] All calculations apply sampling weights.

The measurement of education differs between adults and children. For women's and husbands' education, I use the number of grades completed. For children's education, I use enrollment and grades completed among coresident children aged 7 to 14: old enough to exceed every country's school-starting age and young enough to be included in every survey's education module.[7] At these ages, most children have not yet completed their schooling, so the number of grades completed measures school progression rather than lifetime attainment.

[6] The countries include Benin, Burkina Faso, Burundi, Cameroon, Chad, Comoros, Côte d'Ivoire, Democratic Republic of Congo, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. Angola, Central African Republic, and Eswatini are excluded because each had exactly one survey.

[7] The DHS asks whether the child is currently in school or whether the child attended during this academic year. In surveys that include both questions, answers differ in 1.6 percent of children, presumably due to summer vacation. I rely on the 'academic year' answer when available (80 surveys) and supplement with the 'current' answer when necessary (32 surveys).

The preferred regression models include child age fixed effects, in which case this variable can be interpreted as a child's grade-for-age.[8] Research on schooling in low- and middle-income countries commonly uses data on grade-for-age to complement data on enrollment (Grant and Behrman 2010). It distinguishes being engaged with school from simply being present in school.

The analyses rely on three measures of fertility. To capture realized fertility, I use counts of children ever born and surviving children. To capture desired fertility, I use women's responses to the question: "if you could go back to the time you did not have any children and could choose exactly the number of children to have in your whole life, how many would that be?" (Rutstein and Rojas 2006).[9] A woman's answer may in part reflect *ex post* rationalization, but it offers a window into her current thinking about children. It may also be subject to social desirability bias, although the implication for its association with education is not clear.

I include women aged 40-49 in the study sample and use cumulative fertility at age 40 to proxy for completed fertility. Two tradeoffs underlie these decisions. First, most women were interviewed before the end of the reproductive period, precluding the study of completed realized fertility. Lowering the age of fertility measurement allows greater sample size and cohort coverage. Both DHS and United Nations data suggest that cumulative fertility at age 40 is a good proxy for completed fertility.[10] Second, the oldest women have fewer 7-14 year-old children than slightly younger women, and those children have higher birth order and later maternal age at birth (Appendix Table A1). Including somewhat younger women makes the sample of children more representative. Sample children were born when their mothers were in their 20s, 30s, and 40s; sample women were born between the late 1940s and early 1980s. All of these cohorts could bear children after 1980, when United Nations data indicate that age-specific fertility rates started declining across the continent (Appendix Figures A4-A5).

3.2 Aggregation

Motivated by Section 2, I aggregate women and their children into cells defined by women's birth years and places of residence. I use place of residence because the data lack detailed information on place of birth. Aggregations using national boundaries are *national cohorts*, while aggregations using subnational regional boundaries are *regional cohorts*. Analysis of national cohorts minimizes risk of bias from migration, since

[8]Following similar logic, the enrollment variable can be interpreted as enrollment-for-age in the preferred regression models.

[9]I top code ideal family size at 20. Following DHS guidelines, I exclude women who did not respond (2 percent) or gave non-numeric responses (10 percent) from the analysis of desired fertility (Rutstein and Rojas 2006).

[10]The oldest women in the study sample, age 49, bore 91 percent of their children before turning 40. United Nations data similarly indicate that African women give birth to 90 percent of their children by age 40 (Appendix Figure A3).

external migration is rarer than internal. At the same time, it raises risk of bias from confounding national trends and policies. In contrast, analysis of regional cohorts raises risk of bias from migration but eliminates risk of bias from nationwide confounders.

To form regional cohorts, I create temporally consistent region boundaries. Successive surveys for the same country often rely on different region classifications. Although most recent surveys are georeferenced, many older surveys are not. I harmonize boundary files across survey waves and, when necessary, superimpose cluster coordinates from one survey on the boundary file from another. This effort leads to 198 subnational regions across the 33 countries.[11]

3.3 Summary Statistics

Table 1 reports summary statistics, with column (1) listing means and standard deviations for the 211,045 women aged 40-49. These women average 5.7 children ever born at age 40, 4.7 surviving children at age 40, and an ideal number of children of 5.9.[12] Marriage rates are high, with 79 percent currently married and 97 percent ever married. Schooling is low, with women averaging 3.5 grades completed, their husbands 4.6.[13]

Column (2) turns to the children of these women. Data are available for 283,330 children, who coreside with 144,004 mothers. By construction, this sample overrepresents families with children: mothers have 6.8 children ever born and 5.8 surviving children by age 40, roughly one child more than the woman sample in column (1). Families with children are more disadvantaged than families without; the educational attainment of both mothers and their husbands is lower than in column (1). Three-quarters of children are enrolled in school, and the average child has completed 2.5 grades.

Sample-wide averages mask age variation in children's educational outcomes. Figure 1 unpacks this age variation by plotting the enrollment rate (Panel A) and average grade attainment (Panel B) by age. To aid visual interpretation, Panel B includes 45-degree grid lines. If all children were enrolled and progressed to the next grade annually, then the grade attainment curve would be parallel to these grid lines.

Figure 1 reveals a modest hump shape in enrollment and a rising pattern in grade attainment. The hump in enrollment partly reflects variation in the ages of starting and finishing primary school, since dropout

[11]Burundi's 1987 survey and Côte d'Ivoire's 1998 survey had unmappable regions, so I treat these entire countries as single regions. In regional analyses that include country-by-birth year fixed effects, the fixed effects aborb all variation from these countries.

[12]Desired fertility exceeds realized, reflecting my measurement of realized fertility before childbearing is complete, coupled with African women's tendency to report similar desired and realized fertility on average (Casterline and Agyei-Mensah 2017).

[13]All never-married women, 60 percent of formerly married women, and 5 percent of currently married women lack data on husbands' schooling, summing to 12 percent of the sample. I include these women but control for missing husband data.

accelerates after the latter. The positive slope in attainment reflects the accumulation of grades with age. The enrollment rate starts from 61 percent at age 7, grows to 82 percent at age 11, and then trails off to 75 percent at age 14. Average attainment starts from 0.5 grades at age 7 and steadily grows to 4.5 grades at age 14.

The slope of the age-attainment relationship suggests that children progress through the education system slower than by design. The start and end points of the "all children" curve imply that grades rise 0.57 with each year of age, less than the 1-for-1 relationship that would obtain if all children were enrolled and progressing to higher grades annually. Even more strikingly, the slope is substantially less than 1 among currently enrolled children. Average attainment rises from 0.8 grades at age 7 to 5.4 grades at age 14, implying a slope of 0.66. This pattern, reflecting both enrollment churn and grade repetition, suggests that grade attainment conveys more information than enrollment about the extent of educational engagement.

4 Methods

The analysis seeks to compare associations of fertility and education levels with associations of fertility and education changes. As a first step toward that goal, I map levels and rates of change in both domains across African countries and subnational regions. The maps are graphically illuminating but have two limitations. First, they do not account for differences in DHS cohort coverage across countries. Second, they do not account for differences in child age structure across cells.

The regression models address these limitations while allowing me to parse within-place variation from pooled cross-sectional variation. Both first-difference and fixed-effect models can estimate associations of within-place change. The first-difference approach explicitly models change, while the fixed-effect approach does so implicitly, by differencing out the unit mean. The fixed-effect approach is more attractive here because it easily accommodates the unbalanced nature of the place-cohort panels, with some respondent birth years not observed in some places and varying observation counts for those observed. I thus compare fixed-effect models with pooled cross-sectional models.

I specify two fixed-effect models, one for national cohorts and one for regional cohorts, each of which conditions on a place fixed effect and a woman's birth year fixed effect. The place fixed effect absorbs place-specific differences in the levels of the dependent and independent variables, so that the coefficients are estimated based on within-place changes. The birth year fixed effect absorbs continent-wide cohort trends, so that the coefficients are estimated based on differential within-place changes. In the regional fixed-effect model, I allow the birth year fixed effect to vary across countries, so that the regional model only compares regional changes within the same country. As a result, the regional fixed-effect model is nested within the national fixed-effect model. When the dependent variable is a child outcome, I further allow the place and birth year fixed effects to vary by child age. This interaction helps rule out spurious correlations between covariates and the age composition of children in the cell.

To allow flexibility in the specification of fixed effects and to maintain a constant sample across regressions, I run regressions at the individual level, but with independent variables averaged at either the national cohort level or the regional cohort level. An individual-level regression with cell-averaged independent variables is equivalent to a cell-level regression with cell-averaged dependent and independent variables. Women's observations are indexed by individual i, birth year b, region of residence r, and country c. Children's observations are indexed by individual i, maternal birth year b, region of residence r, country c, and age at survey a. I write all regression specifications with age indices, but age is only relevant for children's outcomes.[14]

The national model regresses outcome y^a_{ircb} on a vector of national cohort average covariates $\bar{X}_{cb}$:

$$y^a_{ircb} = \bar{X}'_{cb}\beta + \tau^a_b + \delta^a_c + \varepsilon^a_{ircb}$$

where the a superscript applies only to child schooling outcomes. The pooled cross-sectional version of the model excludes τ^a_b and δ^a_c, while the fixed-effect version of the model includes them: τ^a_b is a women's birth year fixed effect, while δ^a_c is a country fixed effect. For child schooling outcomes, both of these fixed effects vary with child age. In practice, the fixed-effect regression for child schooling outcomes includes woman birth year indicators, country indicators, and both interacted with child age indicators.

The regional model adapts the national model to the subnational level by averaging covariates $\bar{X}_{rcb}$ at the regional cohort level:

$$y^a_{ircb} = \bar{X}'_{rcb}\beta + \tau^a_{cb} + \delta^a_{rc} + \varepsilon^a_{ircb}$$

where again the a superscript applies only to child schooling outcomes. As before, the pooled cross-sectional version of the model excludes τ^a_b and δ^a_c, while the fixed-effect version of the model includes them. The fixed effects in the regional model differ from those in the national model in two respects. First, the place effect is now a region fixed effect δ^a_{rc}. Second, the birth year fixed effect τ^a_{cb} now varies by country, so that the regression restricts to within-country comparisons of regional change. As before, both fixed effects vary with

[14]Realized fertility is measured at the same age for all women. Desired fertility is measured at varied ages but always in the 40s.

child age when the dependent variable is a child schooling outcome.

For each model, we will be interested in whether the pooled cross-sectional version and the fixed-effect version produce similar estimates of β. In the pooled cross-sectional version, β measures the association between average X and average y in levels, reflecting three sources of variation: cross-place variation within a cohort, continent-wide cross-cohort variation, and place-specific cross-cohort variation. The fixed-effect version focuses on the last source of variation, such that β measures the extent to which places that experienced greater changes in average X also experienced greater changes in average y. For child schooling outcomes, the child age interactions imply that the fixed-effect regressions compare children of the same age.

The analysis proceeds in three steps, each corresponding to a different leg of the fertility-education triangle. The first defines y as fertility and X as women's education; the second defines y as child schooling and X as fertility; the third defines y as child schooling and X as women's education. When women's education is on the right-hand side, β represents an association between resources and outcomes. To assess the role of marriage and marital sorting in mediating the relationship between resources and outcomes, I run these regressions with and without marital covariates. Husbands' education is of primary interest, but because selection into marriage may affect the distribution of husbands, I also include never marriage and current marriage. When fertility is on the right-hand side, β represents an association between jointly determined outcomes. In this case, estimations that control for parental characteristics do not have a clear conceptual interpretation. I do not report them in the main results but do in the Appendix.

To account for survey design and error correlations within units of aggregation, I compute cluster-robust standard errors. The DHS design requires clustering at the primary sampling unit level, while the averaging of covariates requires clustering at the level of aggregation. For simplicity, I conservatively cluster standard errors at the country level throughout. The resulting standard errors are robust to error correlations within countries, regions, and primary sampling units, thus adjusting for both survey design and aggregation.

5 Results

5.1 The Geography of Fertility and Education in Levels and Trends

This section develops intuition for the regression analysis with two sets of maps that describe cross-place variation in levels and rates of change of key variables: realized fertility, desired fertility, women's education, and children's education. The maps of levels will confirm the unsurprising pattern that the places with the lowest fertility have the most educated women and children. However, the maps of trends will have a more complicated takeaway. The places with the largest fertility declines have the largest increases in women's education, but the geography of trends in children's education is markedly different, with no immediately discernable relation to trends in women's outcomes.

Figure 2 maps the levels of average children ever born, surviving children, ideal children, women's educational attainment, children's enrollment, and children's grade attainment across countries and regions. Coverage of birth cohorts varies by country and region, so the map restricts to a decadal birth cohort that appears in every country and region: women born in 1965-74. Places are classified into quartiles of each variable, and darker colors correspond to higher quartiles. For reference, Appendix Table A2, Panel A, details the quantiles of each variable across countries and regions.

Both the national maps and the regional maps in Figure 2 plainly suggest an inverse relationship between fertility and the education of women and children. Panel A displays the national maps. Countries in the lowest quartile of children ever born, surviving children, and ideal children are concentrated in Southern Africa and coastal Central Africa. The same countries tend to be in the highest quartile for women's education and children's education. Conversely, countries of the Sahel and the Horn of Africa tend to be in the highest fertility quartile and lowest education quartile. The regional maps in Panel B of Figure 2 suggest the same. Regions in Southern Africa and along the Central and West African coast have the lowest fertility and highest women's and children's education, while regions in the Sahel and the Horn of Africa have the opposite.

The geography of changes differs from the geography of levels. Figure 3 maps cross-cohort rates of change in the same five variables that appeared in Figure 2. The rates of change are computed as slope coefficients from place-specific regressions of each outcome on the woman's year of birth. Places are classified into quartiles of the cohort trend in each variable. Darker colors imply faster fertility decline and faster educational progress. For reference, Appendix Table A2, Panel B, details the quantiles of each trend across countries and regions. In all cases, the median rate of change is negative for fertility variables and positive for education variables. In all but one case, the same signs apply at the 25^{th} percentile.[15] In most African countries and regions, fertility has trended downward, while education has trended upward in both generations.

Figure 3 illuminates which places experienced more fertility decline and which experienced more educational progress. The dark areas are similar to Figure 2 for fertility and women's education but not children's education. Southern Africa and coastal areas of West, Central, and East Africa have seen greater declines in

[15]The exception is surviving fertility at the regional level, which trended upward at the 25^{th} percentile.

ever-born and surviving fertility, as well as greater increases in women's education. Trends in desired fertility have a slightly different geography, with decline somewhat less concentrated in Southern Africa and somewhat more concentrated in East Africa and the Sahel. Meanwhile, gains in children's education are concentrated in the interior, particularly the Democratic Republic of Congo and Ethiopia. The child schooling maps show more overlap with the desired fertility maps than with the realized fertility maps.

The geographic patterns in Figure 3 suggest that the drivers of progress in child education may be different from the drivers of fertility decline. However, the rates of change are estimated using different sets of birth cohorts for each country, depending on the coverage of the DHS. Furthermore, the procedure for computing rates of change does not account for age in analyzing child outcomes, despite the pronounced age patterns documented in Figure 1. The flexible regression frameworks of Section 4 make progress on both issues.

5.2 Women's Fertility and Children's Schooling

Table 2 reports regressions of children's schooling on averaged realized or desired fertility. School enrollment and grade attainment serve as measures of children's schooling. As Figure 1 demonstrated, the outcomes are related, but only grade attainment detects variation in student progression. Ever-born, surviving, and ideal children serve as measures of realized and desired fertility. Although the pooled cross-sectional regressions will find an inverse relationship between fertility and children's schooling, this relationship will largely dissipate upon the inclusion of place and cohort fixed effects.

Because both sets of variables in part reflect parental choices, these regressions have a nuanced interpretation. The results do not speak to the effects of family size on educational outcomes. Instead, they assess whether fertility decline coincides with rising children's education, and whether the magnitude of the within-place association matches that of the pooled cross-sectional association.

Table 2 has four columns, corresponding to the cross-sectional and fixed-effect national models (columns [1]-[2]) and the cross-sectional and fixed-effect regional models (columns [3]-[4]). To flexibly absorb age patterns in child schooling, all fixed effects are interacted with child age indicators. Panel A focuses on school enrollment, and Panel B on grade attainment. I relate each outcome to each of the three fertility measures in a separate regression. In other words, each coefficient and standard error pair comes from a different regression.

The pooled cross-sectional estimations in columns (1) and (3) find a large, negative relationship between fertility and children's schooling, confirming the cross-sectional pattern in Figure 2. For both measures of realized fertility, an additional child per woman is associated with 7-10 percentage point lower enrollment

(Panel A) and 0.5-grade lower attainment (Panel B) among children. The results for desired fertility are more variable in magnitude but qualitatively similar. Children are more engaged with school in places that have lower realized and desired fertility, across both countries and regions.

The fixed-effect results in columns (2) and (4) are much weaker than the cross-sectional results, at least for realized fertility. Cohort declines in children ever born and surviving children are not associated with cohort increases in child enrollment (Panel A). Most of the coefficients are statistically non-significant and close to zero; one is significant but unexpectedly positive. For child attainment (Panel B), the fixed-effect estimates are more promising but still small relative to the aggregate cross-sectional results. Declining realized fertility does not significantly predict rising grade-for-age at the national level.[16] It does at the regional level, but the coefficients from the fixed-effect model are one-tenth the magnitude of those from the cross-sectional model. A one-child decline in realized fertility predicts a $\frac{1}{20}$-grade increase in attainment.

Table 2 has more promising results for desired fertility than for realized fertility. Both children's schooling outcomes negatively covary with average ideal family size, even with fixed effects. Comparing inter-cohort changes across countries, a one-child decline in average ideal family size is associated with a 2.8 percentage point increase in school enrollment and a 0.25 grade increase in attainment. Comparing inter-cohort changes across regions within countries, the same decline in desired fertility is associated with a 0.7 percentage point enrollment increase and a 0.07 grade attainment increase.

Overall, Table 2 fails to provide consistent evidence that fertility decline and rising educational investment go hand in hand. One can find glimpses of this pattern, but one must focus on attainment rather than enrollment, on regional rather than national aggregates, or on desired rather than realized fertility.

Are the weak fixed-effect results in Table 2 artifacts of nonlinearities or outliers? To investigate this issue, Figure 4 presents partial regression plots, which display relationships between fertility and education after partialling out the intercepts or fixed effects from the pooled cross-sectional or fixed-effect models. To reduce clutter, I present them as binned scatterplots. Estimation proceeds in three steps. First, I run separate regressions of each fertility variable and each education variable on either an intercept (for the pooled cross-sectional plots) or fixed effects (for the fixed-effect plots). Second, I obtain residuals, average them by national or regional cohort cell, and bin the cells into deciles of the fertility residual. Third, I plot the average education residual against the average fertility residual across deciles.

The binned partial regression plots in Figure 4 appear linear, ruling out the possibility that the null fixed-

[16] The national attainment association approaches statistical significance for children ever born ($p = 0.065$) but is close to zero and non-significant for surviving children ($p = 0.922$).

effect results in Table 2 reflect nonlinearities or outliers. For all pairs of dependent and independent variables, the pooled cross-sectional plots at both the national and regional levels display pronounced negative slopes. In contrast, the fixed-effect plots have far more muted slopes, typically indistinguishable from zero. One can see the weakness of the fixed-effect results across the entire distribution of (residual) fertility.

In the Appendix, analyses of heterogeneity by child age and sex, as well as of robustness to adjustment for cohort average parental characteristics, also do not change the conclusions from Table 2. Appendix Figure A6 re-estimates the fixed-effect models separately for boys and girls, by single year of age, and with and without average parental covariates. Both the national and regional associations between fertility change and children's education change are similar for boys and girls. They also are similar across ages when the outcome is enrollment, but they grow with age when the outcome is attainment, likely reflecting the cumulation of attainment with age. Regression adjustment for average parental characteristics—women's education, husbands' education, and marriage rates, the same covariates as in Tables 3 and 4 below—does not meaningfully change the results either. Wherever the fertility-child schooling association is negative, controlling for average parental characteristics modestly shrinks it.

5.3 Adult Educational Attainment and Women's Fertility

The other legs of the fertility-education triangle can shed light on the mechanics of the weak association between fertility change and children's education change. Analyzing them can also clarify whether the fixed-effect models absorb too much variation to detect the associations of interest. Is the well-known inverse relationship between women's education and fertility detectable in the fixed-effect models? If it is, then one cannot attribute the weak fixed-effect results in Table 2 to low power.[17] The finding would also contribute to the literature on women's education and fertility, which currently lacks a cohort-level estimate spanning sub-Saharan Africa.

Table 3 turns to the relationship between the education of adults, particularly women, and realized or desired fertility. Regressions with and without fixed effects will find that women's schooling is associated with lower ever-born (Panel A), surviving (Panel B), and desired (Panel C) fertility. Although the magnitude of the relationship varies slightly across outcomes and sources of variation, the range is small.

In Table 3, columns (1)-(4) use covariates averaged at the national cohort level, while columns (5)-(8)

[17] In Table 2, the standard errors in the fixed-effect models are generally smaller than the standard errors in the pooled cross-sectional models, which already suggests that the weak results are not due to low power.

use covariates averaged at the regional cohort level. Columns (1)-(2) and (5)-(6) omit fixed effects so reflect pooled cross-sectional variation. Columns (3)-(4) and (7)-(8) include fixed effects to isolate within-place variation. Odd columns include only women's average schooling, while even columns add marital covariates.

National cohort variation indicates a robust inverse association between women's education and fertility, both within and across countries. In the pooled cross-section, an extra grade of women's average education is associated with 0.24 fewer children ever born per woman, 0.12 fewer surviving children per woman, and 0.23 fewer desired children per woman (column [1]). Controlling for husbands' education and marital status does not change the coefficients on women's education for realized fertility but weakens that for desired fertility (column [2]). With the addition of country and birth year fixed effects, the women's education coefficients for realized fertility stabilize at roughly -0.20 (columns [3]-[4]). As women's average educational attainment rises across cohorts by one grade, realized fertility falls by one-fifth of a child. The result is similar for ever-born and surviving fertility, implying that any child survival benefits of rising maternal education do not offset fertility reduction. The coefficient for desired fertility is similar in column (3) but falls somewhat in column (4) because rising husbands' education is associated with falling ideal family size.

The association of adult education with fertility at the regional level is similar to that at the national level. In the pooled cross-section of regional cohorts, an extra grade of women's average education is associated with 0.27 fewer children ever born per woman, 0.14 fewer surviving children per woman, and 0.29 fewer desired children (column [5]). These magnitudes are slightly larger than their national analogues in column (1). With the addition of region and country-by-birth year fixed effects, the coefficients again stabilize at roughly -0.2. Across cohorts within a region, a one grade increase in women's average educational attainment predicts a 0.21-0.23 reduction in children ever born, a 0.17 reduction in surviving children, and a 0.14-0.18 reduction in ideal family size (columns [7]-[8]). As in the national case, the regional fixed-effect regressions indicate that husbands' education negatively predicts women's desired but not realized fertility.[18] Despite relying on an entirely separate source of variation—differential cohort change across regions within countries, rather than differential cohort change across countries within the continent—the national and regional fixed-effect regressions have the same takeaways.

Columns (1)-(2) and (5)-(6) serve as a useful point of comparison, but columns (3)-(4) and (7)-(8) are of principal interest because they focus on within-place change. These estimations suggest that rising women's education predicts falling fertility, while rising husbands' education has far less predictive power, and in most

[18]The link between rising husbands' education and declining desired fertility is unexpected. Because rising husbands' education has a weak positive association with fertility change, it implies that rising husbands' education predicts rising unwanted fertility.

cases none at all. Whether we prefer the national or regional estimates depends on the magnitude of bias stemming from time-varying country-level confounders (favoring regional estimates) and internal migration (favoring national estimates). Fortunately, either aggregation leads to similar estimates for women's schooling.

Depending on the level of aggregation and the regression specification, the association of women's education with either realized or desired fertility ranges from -0.12 to -0.29. Within-place estimates for both measures of realized fertility are tighter still, from -0.17 to -0.23. The consistency across sources of variation, with and without controlling for marital outcomes, supports arguments that women's education plays a key role in African fertility decline. It also contrasts the nuanced takeaways from Table 2, which found that falling realized fertility has at most a weak relationship with progress in children's schooling.

5.4 Adult Educational Attainment and Children's Schooling

The final leg of the triangle, between the education of parents and children, can help mechanically reconcile the weak fixed-effect results in Table 2 with the strong fixed-effect results in Table 3. Table 4 analyzes the same right-hand side variation as Table 3, but with the same children's outcomes and children's sample as Table 2. The column structure of the table mirrors Table 3, with four columns devoted to national cohort variation and four to regional cohort variation. The panels mirror Table 2, with child enrollment in Panel A and child grade attainment in Panel B.

As in earlier tables, pooled cross-sectional variation displays the strongest relationships. Across both countries and regions, a one grade increase in women's average educational attainment predicts a 5.7-5.8 percentage point higher child school enrollment rate and a 0.28-0.31 grade higher child average attainment (columns [1] and [5]). Fixed effects shrink this association by half or more. In the fixed-effect regressions, a one grade increase in women's attainment predicts a 0.4-1.3 percentage point increase in child enrollment and a 0.12-0.13 grade increase in child attainment (columns [3] and [7]).

Unlike earlier tables, husbands' education is at least as relevant as women's. In the fixed-effect models, rising child enrollment loads onto rising husbands' education, not women's, while rising child attainment loads onto both. A one grade increase in husbands' average schooling predicts a 1-2 percentage point increase in child enrollment (Panel A, columns [4] and [8]). Net of changes in husbands' average schooling, changes in women's average schooling are not associated changes in child enrollment. Meanwhile, a one grade increase in women's *or* husbands' average attainment predicts a 0.05-0.14 grade increase in child average attainment.[19]

[19] In Panel B, column (4), the coefficient on women's average attainment is positive but not significantly different from zero.

Table 4 helps to reconcile the divergent fixed-effect results in Tables 2 and 3, at least in mechanical terms. Rising husbands' education predicts rising child enrollment *and* attainment, while rising women's education predicts only the latter, mainly in the regional analysis. Rising women's education consistently predicts falling realized fertility, while rising husbands' education does not. These patterns combine to produce a detectable (though small) relationship between regional fertility decline and regional attainment progress, a statistically weak relationship between national fertility decline and national attainment progress, and a null relationship between fertility decline and enrollment progress at either level of aggregation. Meanwhile, increases in both women's and husbands' education predict falling desired fertility, so decreases in desired fertility consistently predict rising child enrollment and attainment.

This reconciliation is mechanical in the sense that it relies on regression algebra, not theory. The regression results do not provide a conceptual reason for the gender discordance. The positive link between men's and children's education—particularly enrollment—may reflect economic resources, while the negative link between women's education and fertility may reflect separate domains like female empowerment and information.

6 Discussion

A number of demographic and economic theories predict the coincidence of fertility decline and educational progress among women and children. Variation across national and regional cohorts in sub-Saharan Africa unambiguously supports a link between rising *women's* education and declining fertility. However, the association of declining fertility with rising *children's* education is weak. Rising *enrollment* is entirely unrelated to changes in the number of children per woman. Rising children's *attainment* is significantly associated with declining fertility in some analyses, but the association is much smaller than its cross-sectional counterpart.

In the early cohorts of Africa's fertility transition, then, declining fertility and rising child schooling have not gone hand in hand. Interestingly, declines in *desired* fertility are more strongly linked with progress in children's schooling than are declines in *realized* fertility. If future parents narrow deviations of realized from desired fertility, then the latter may become more systematically linked with expansions in children's schooling, as Becker and Caldwell predicted.

Beyond regression mechanics, the particular weakness of the enrollment results has two potential explanations. First, enrollment and attainment have diverged in Africa, with unprecedented shares of children in school but low progression and completion rates (Lewin 2009; Bold et al. 2017). Enrollment gains may primarily reflect expansions in school access, while attainment may more closely proxy for the intensity of human capital investment (as in Becker) or socialization (as in Caldwell). Second, as children face less competition from other children in their own families, they may face more competition from children in other families. Due to population momentum, cohort size peaks decades after average family size (Lam and Marteleto 2008). Even as their families shrink, children's access to public resources may decline due to a rising number of children in the population. Enrollment may be more sensitive to public resources per child, while attainment may be more sensitive to family resources per child.

The study has three limitations. First, relying on place of residence rather than place of birth—the DHS does not have data on the latter—raises risk of bias from migration, especially in the regional analyses. The national analyses are less susceptible to migrant selection but raise separate concerns about confounding national policies and trends. Second, restricting to older women and their coresident children implies a sample of younger, later-born children, whose education may not be complete. An analysis of completed education among all children might have different results. Third, the study does not speak to the causal pathways underlying the associations.

Instead, the study contributes a coherent set of facts on changing fertility and education among women, their husbands, and their children. The cohort orientation is key to the simultaneous analysis of both generation. The cohort facts cast doubt on the extent of contemporaneous linkages between family planning and education policy in the world region destined to become the world's most populous by the end of this century (UN 2022).

References

Agüero, Jorge M., and Maithili Ramachandran. (2020). "The Intergenerational Transmission of Schooling among the Education-Rationed." *Journal of Human Resources* 55(2): 504-538.

Ashraf, Quamrul H., David N. Weil, and Joshua Wilde. (2013). "The Effect of Fertility Reduction on Economic Growth." *Population and Development Review* 39(1): 97-130.

Axinn, William G., and Jennifer S. Barber. (2001). "Mass Education and Fertility Transition." *American Sociological Review* 66(4): 481-505.

Becker, Gary S., and H. Gregg Lewis. (1973). "On the Interaction between the Quantity and Quality of Children." *Journal of Political Economy* 81(2): S279-S288.

Behrman, Julia Andrea. (2015). "Does Schooling Affect Women's Desired Fertility? Evidence from Malawi, Uganda, and Ethiopia." *Demography* 52(3): 787-809.

Bold, Tessa, Deon Filmer, Gayle Martin, Ezequiel Molina, Brian Stacy, Christophe Rockmore, Jakob Svensson, and Waly Wane. (2017). "Enrollment Without Learning: Teacher Effort, Knowledge, and Skill in Primary Schools in Africa." *Journal of Economic Perspectives* 31(4): 185-204.

Bongaarts, John. (2017). "Africa's Unique Fertility Transition." *Population and Development Review* 43: 39-58.

Bongaarts, John. (2020). "Trends in Fertility and Fertility Preferences in Sub-Saharan Africa: The Roles of Education and Family Planning Programs." *Genus* 76(32).

Buchmann, Claudia, and Emily Hannum. (2001). "Education and Stratification in Developing Countries: A Review of Theories and Research." *Annual Review of Sociology* 27(1): 77-102.

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

Casterline, John B., and Samuel Agyei-Mensah. (2017). "Fertility Desires and the Course of Fertility Decline in Sub-Saharan Africa." *Population and Development Review* 43: 84-111.

Cochrane, Susan. (1979). *Fertility and Education: What Do We Really Know?* Baltimore: Johns Hopkins University Press.

Cleland, John, and Christopher Wilson. (1987). "Demand theories of the Fertility Transition: An Iconoclastic View." *Population Studies* 41: 5-30.

Diamond, Ian, Margaret Newby, and Sarah Varle. (1999). "Female Education and Fertility: Examining the

Links." In Caroline H. Bledsoe, John B. Casterline, Jennifer A. Johnson-Kuhn, and John G. Haaga, eds., *Critical Perspectives on Schooling and Fertility in the Developing World*. Washington, DC: National Academy Press, pp. 23-48.

Duflo, Esther, Pascaline Dupas, and Michael Kremer. (2015). "Education, HIV, and Early Fertility: Experimental Evidence from Kenya." *American Economic Review* 105(9): 2757-2797.

Duflo, Esther, Pascaline Dupas, and Michael Kremer. (2021). "The Impact of Free Secondary Education: Experimental Evidence from Ghana." NBER Working Paper No. 28937.

Eloundou-Enyegue, Parfait, and Lindy Williams. (2006). "Family Size and Schooling in Sub-Saharan African Settings: A Reexamination." *Demography* 43(1): 25-52.

Grant, Monica J., and Jere R. Behrman. (2010. "Gender Gaps in Educational Attainment in Less Developed Countries." *Population and Development Review* 36(1): 71-89.

ICF. (1986-2021). Demographic and Health Surveys (various) [Datasets]. Funded by USAID. Rockville, Maryland: ICF [Distributor].

Jejeebhoy, Shireen J. (1995). *Women's Education, Autonomy, and Reproductive Behaviour: Experience from Developing Countries*. Oxford: Clarendon Press.

Keats, Anthony. (2018). "Women's Schooling, Fertility, and Child Health Outcomes: Evidence from Uganda's Free Primary Education Program." *Journal of Development Economics* 135: 142-159.

Kebede, Endale, Anne Goujon, and Wolfgang Lutz. (2019). "Stalls in Africa's Fertility Decline Partly Result from Disruptions in Female Education." *Proceedings of the National Academy of Sciences* 116(8): 2891-2896.

Lam, David, and Leticia Marteleto. (2008). "Stages of the Demographic Transition from a Child's Perspective: Family Size, Cohort Size, and Children's Resources." *Population And Development Review* 34(2): 225-252.

Lewin, Keith M. (2009). "Access to Education in Sub-Saharan Africa: Patterns, Problems and Possibilities." *Comparative Education* 45(2): 151-174.

Osili, Una Okonkwo, and Bridget Terry Long. (2008). "Does Female Schooling Reduce Fertility? Evidence from Nigeria." *Journal of Development Economics* 87(1): 57-75.

Ozier, Owen. (2018). "The Impact of Secondary Schooling in Kenya: A Regression Discontinuity Analysis." *Journal of Human Resources* 53(1): 157-188.

Pesando, Luca Maria. (2021). "Educational Assortative Mating in Sub-Saharan Africa: Compositional

Changes and Implications for Household Wealth Inequality." *Demography* 58(2): 571-602.

Rutstein, Shea and Guillermo Rojas. (2006). *Guide to DHS Statistics*. Calverton, Maryland: ORC Macro.

Schoumaker, Bruno D., and David A. Sánchez-Páez. (Forthcoming). "Disruptions in Educational Progress and Fertility Dynamics by Educational Level: Unraveling the Link between Education and Fertility Stalls in Sub-Saharan Africa." *Population and Development Review*.

Schultz, T. Paul. (1997). "Demand for Children in Low Income Countries." In Mark R. Rosenzweig and Oded Stark, eds., *Handbook of Population and Family Economics*, pp. 349-430.

Torche, Florencia. (2021). "Educational Mobility in the Developing World." In Vegard Iversen, Anirudh Krishna, and Kunal Sen, eds., *Social Mobility in Developing Countries*. Oxford: Oxford University Press, pp. 139-171.

United Nations Department of Economic and Social Affairs, Population Division. (2022). *World Population Prospects 2022: Summary of Results*. UN DESA/POP/2022/TR/NO. 3.

Vogl, Tom S. (2016). "Differential Fertility, Human Capital, and Development." *Review of Economic Studies* 83(1): 365-401.

Table 1: Summary Statistics

	Women 40-49	Children 7-14
	(1)	(2)
A. Woman/mother variables		
Children ever born at age 40	5.69 (2.76)	6.84 (2.36)
Surviving children at age 40	4.71 (2.33)	5.84 (2.01)
Ideal number of children*	5.92 (2.99)	6.33 (3.07)
Grades completed	3.53 (4.39)	3.06 (4.07)
Currently married	0.79 (0.41)	0.86 (0.35)
Never married	0.03 (0.17)	0.01 (0.10)
Husband's grades completed*	4.56 (5.05)	4.17 (4.79)
B. Child variables		
School enrollment		0.75 (0.43)
Grades completed		2.45 (2.34)
Number of women/mothers	211,045	144,004
Number of children		283,330
Number of surveys	112	112
Number of regions	198	198
Number of countries	33	33

Notes: Means with standard deviations in parentheses. Column (1) includes all women aged 40-49, both mothers and non-mothers. Column (2) includes children aged 7-14 with mothers aged 40-49 and reports the mothers' characteristics in Panel A. * ideal family size and husband's grades completed are available only for 88 percent subsamples.

Table 2: Fertility and Child Education

	National cohort averages		Regional cohort averages	
	(1)	(2)	(3)	(4)
A. Child enrollment				
Children ever born at 40 (N = 283,330)	-0.113**	0.003	-0.097**	0.0038
	[0.023]	[0.019]	[0.014]	[0.0047]
Surviving children at 40 (N = 283,330)	-0.106**	0.040*	-0.084**	0.0073
	[0.036]	[0.018]	[0.021]	[0.0047]
Ideal number of children (N = 247,097)	-0.075**	-0.028*	-0.073**	-0.0074*
	[0.010]	[0.014]	[0.006]	[0.0028]
B. Child grades completed				
Children ever born at 40 (N = 283,330)	-0.595**	-0.167	-0.562**	-0.057**
	[0.082]	[0.087]	[0.050]	[0.017]
Surviving children at 40 (N = 283,330)	-0.583**	0.0085	-0.534**	-0.052**
	[0.122]	[0.086]	[0.083]	[0.018]
Ideal number of children (N = 247,097)	-0.220*	-0.246**	-0.285**	-0.070**
	[0.085]	[0.066]	[0.046]	[0.016]
Mother year of birth × child age FE		X		
Country × child age FE		X		
Country × mother year of birth × child age FE				X
Region × child age FE				X

Notes: Each coefficient is from a separate regression of the specified fertility outcome on the specified child education covariate and the specified fixed effects. Brackets contain standard errors clustered by country. Columns (1)-(4) use national cohort averages as covariates; columns (5)-(8) use regional cohort averages as covariates. FE refers to fixed effects. * p<0.05, ** p<0.01

Table 3: Adult Education and Fertility

	National cohort averages				Regional cohort averages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Children ever born at 40 (N = 211,045)								
Woman highest grade	-0.243**	-0.276**	-0.195**	-0.205**	-0.272**	-0.289**	-0.230**	-0.214**
	[0.044]	[0.085]	[0.036]	[0.036]	[0.026]	[0.050]	[0.049]	[0.058]
Husband highest grade		0.123		0.049		0.083		-0.005
		[0.067]		[0.031]		[0.046]		[0.016]
B. Surviving children at 40 (N = 211,045)								
Woman highest grade	-0.116**	-0.150*	-0.195**	-0.209**	-0.141**	-0.160**	-0.172**	-0.170**
	[0.035]	[0.063]	[0.048]	[0.036]	[0.023]	[0.039]	[0.039]	[0.046]
Husband highest grade		0.093		0.063		0.065		0.014
		[0.052]		[0.037]		[0.035]		[0.016]
C. Ideal number of children (N = 185,996)								
Woman highest grade	-0.225**	-0.141	-0.184**	-0.087	-0.294**	-0.236*	-0.175**	-0.141**
	[0.078]	[0.128]	[0.044]	[0.044]	[0.045]	[0.087]	[0.024]	[0.028]
Husband highest grade		0.125		-0.119**		0.053		-0.040*
		[0.108]		[0.040]		[0.032]		[0.019]
Marital covariates		X		X		X		X
Woman year of birth FE			X	X				
Country FE			X	X				
Country × woman year of birth FE							X	X
Region FE							X	X

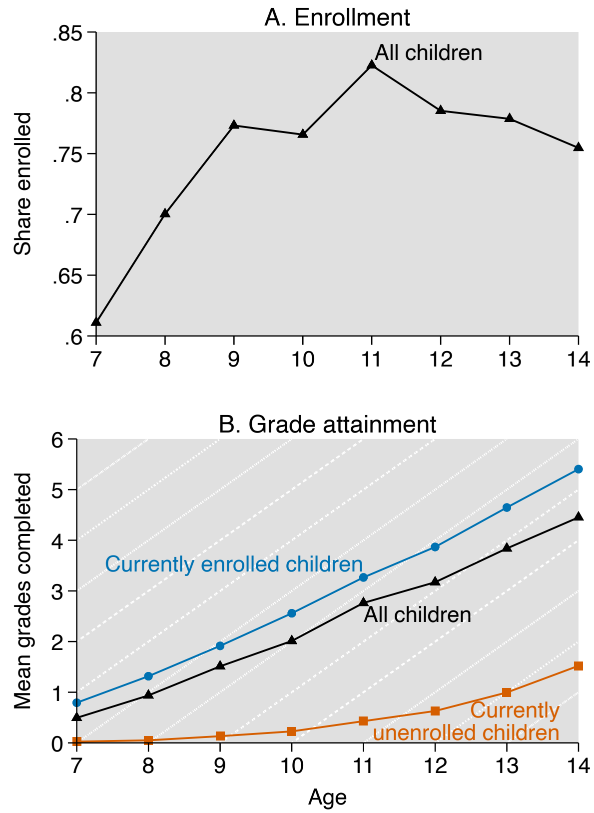
Notes: Brackets contain standard errors clustered by country. Columns (1)-(4) use national cohort averages as covariates; columns (5)-(8) use regional cohort averages as covariates. Marital covariates are cohort shares of women currently married, never married, and missing husband's education. FE refers to fixed effects. * p<0.05, ** p<0.01

Table 4: Adult Education and Child Education

	National cohort averages				Regional cohort averages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Child enrollment (N = 283,330)								
Woman highest grade	0.057**	0.012	0.004	-0.014	0.058**	0.018*	0.013**	0.005
	[0.007]	[0.011]	[0.008]	[0.011]	[0.005]	[0.008]	[0.005]	[0.005]
Husband highest grade		0.028**		0.024*		0.030**		0.012**
		[0.010]		[0.009]		[0.008]		[0.002]
B. Child grades completed (N = 283,330)								
Woman highest grade	0.284**	0.270*	0.128*	0.047	0.310**	0.244**	0.122**	0.079**
	[0.031]	[0.084]	[0.053]	[0.054]	[0.023]	[0.059]	[0.014]	[0.013]
Husband highest grade		0.036		0.135**		0.071		0.063**
		[0.060]		[0.040]		[0.045]		[0.011]
Marital covariates		X		X		X		X
Woman year of birth FE			X	X				
Country FE			X	X				
Country × woman year of birth FE							X	X
Region FE							X	X

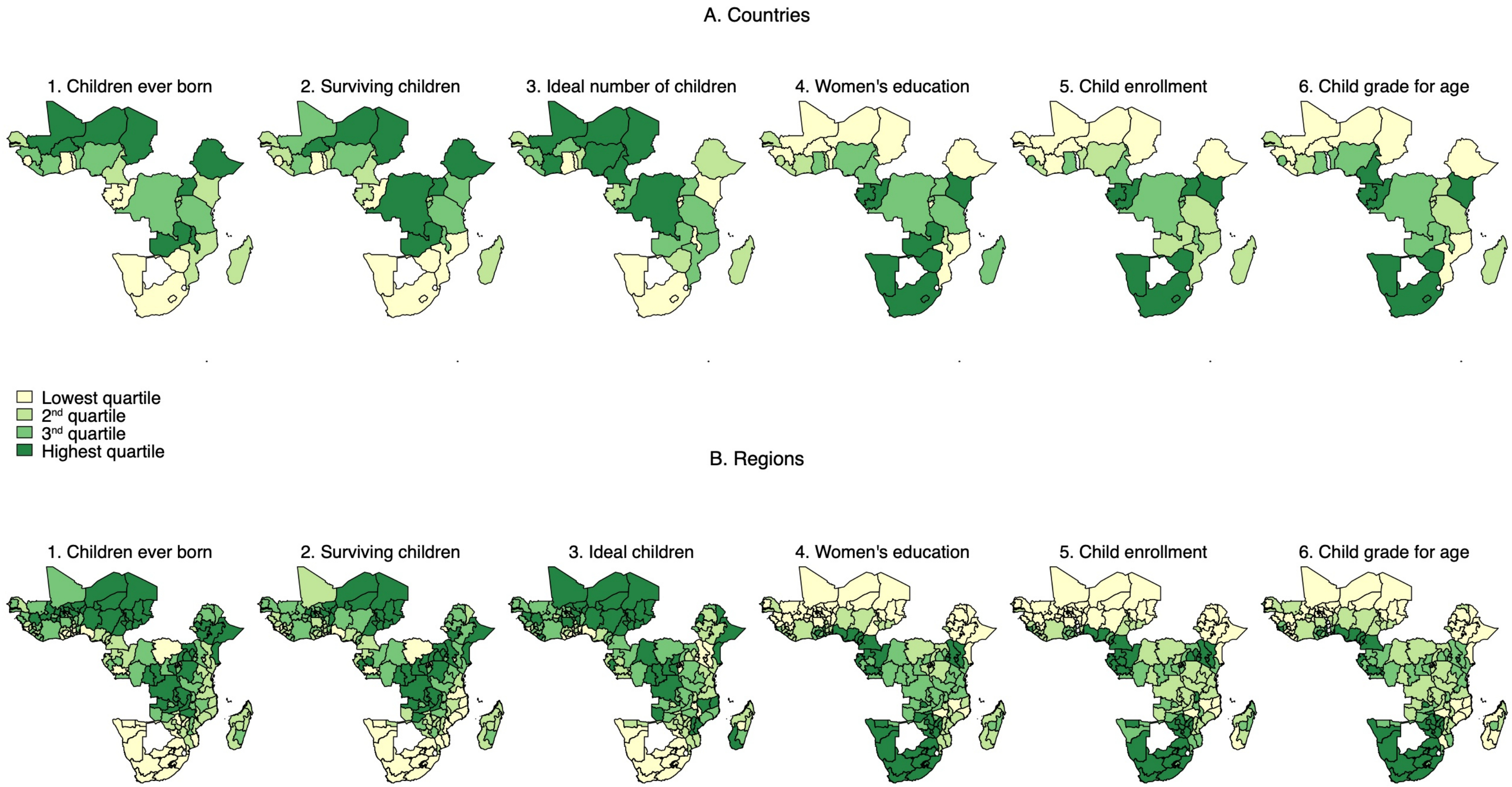
Notes: Brackets contain standard errors clustered by country. Columns (1)-(4) use national cohort averages as covariates; columns (5)-(8) use regional cohort averages as covariates. Marital covariates are cohort shares of women currently married, never married, and missing husband's education. FE refers to fixed effects. * p<0.05, ** p<0.01

Figure 1: Enrollment and Attainment by Age



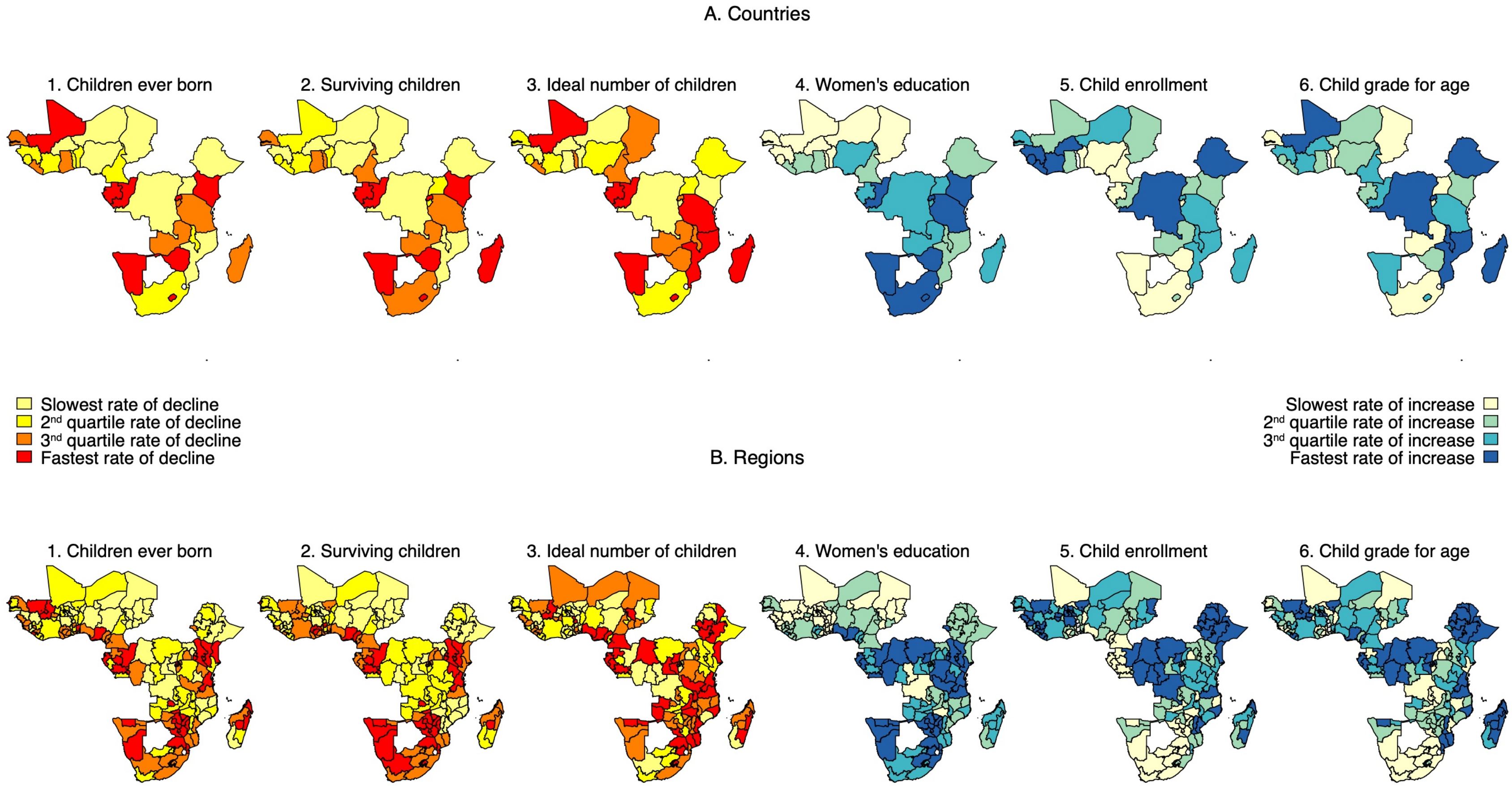
Notes: In Panel B, 45 degree lines are indicated in white.

Figure 2: Levels of Fertility and Education in Women Born 1965-74 and Their Children



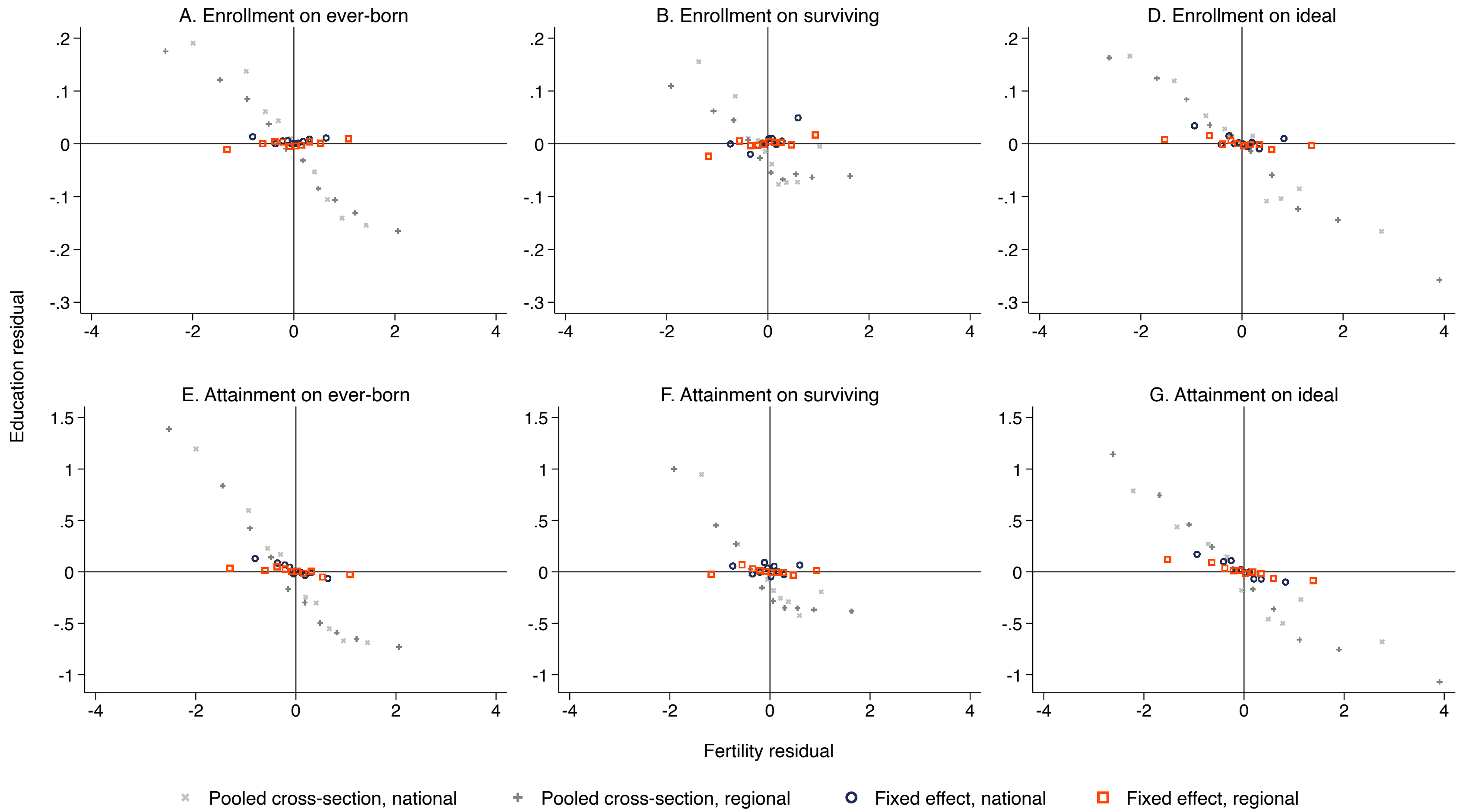
Notes: The 1965-74 decadal cohort is used to maximize cross-sectional coverage. The only birth years observed for all countries and regions are 1967 and 1968.

Figure 3: Cross-Cohort Rates of Change in Fertility and Education in Women Born 1940-80 and their Children



Notes: Rates of change computed in country- or region-specific regressions of the outcome on the woman's year of birth.

Figure 4: Partial Regression Plots for Fertility and Child Education



Notes: Binned scatterplots of residualized average child education on residualized average fertility. First, the education or fertility variable is regressed on an intercept or fixed effects (as specified in equations [1] and [2]). Second, residuals from these regressions are averaged into national or regional cohort cells, which are then binned into deciles of the cell-averaged fertility residual. Third, average education residuals are plotted against average fertility residuals across deciles.

Table A1: Sample Size, Fertility, and Child Coresidence by Age of Respondent

Age	# women	At least one child ever born (1)	Children ever born (2)	Living children (3)	At least one 7-14 YO (4)	7-14 YOs (5)	Avg. age when 7-14 YOs born (6)	Avg. birth order of 7-14 YOs (7)	At least one coresident 7-14 YO (8)	Coresident 7-14 YOs (9)
20-24	242,197	0.67	1.24	1.11	0.07	0.08	15.42	1.12	0.05	0.06
25-29	224,128	0.88	2.57	2.27	0.49	0.72	18.44	1.39	0.38	0.57
30-24	179,426	0.94	3.85	3.35	0.79	1.59	21.76	2.06	0.67	1.29
35-39	152,065	0.96	4.97	4.24	0.85	1.86	26.22	3.24	0.75	1.57
40-44	115,575	0.97	5.77	4.81	0.81	1.72	30.87	4.65	0.73	1.48
45-49	95,574	0.97	6.33	5.09	0.7	1.37	35.68	6.08	0.63	1.18

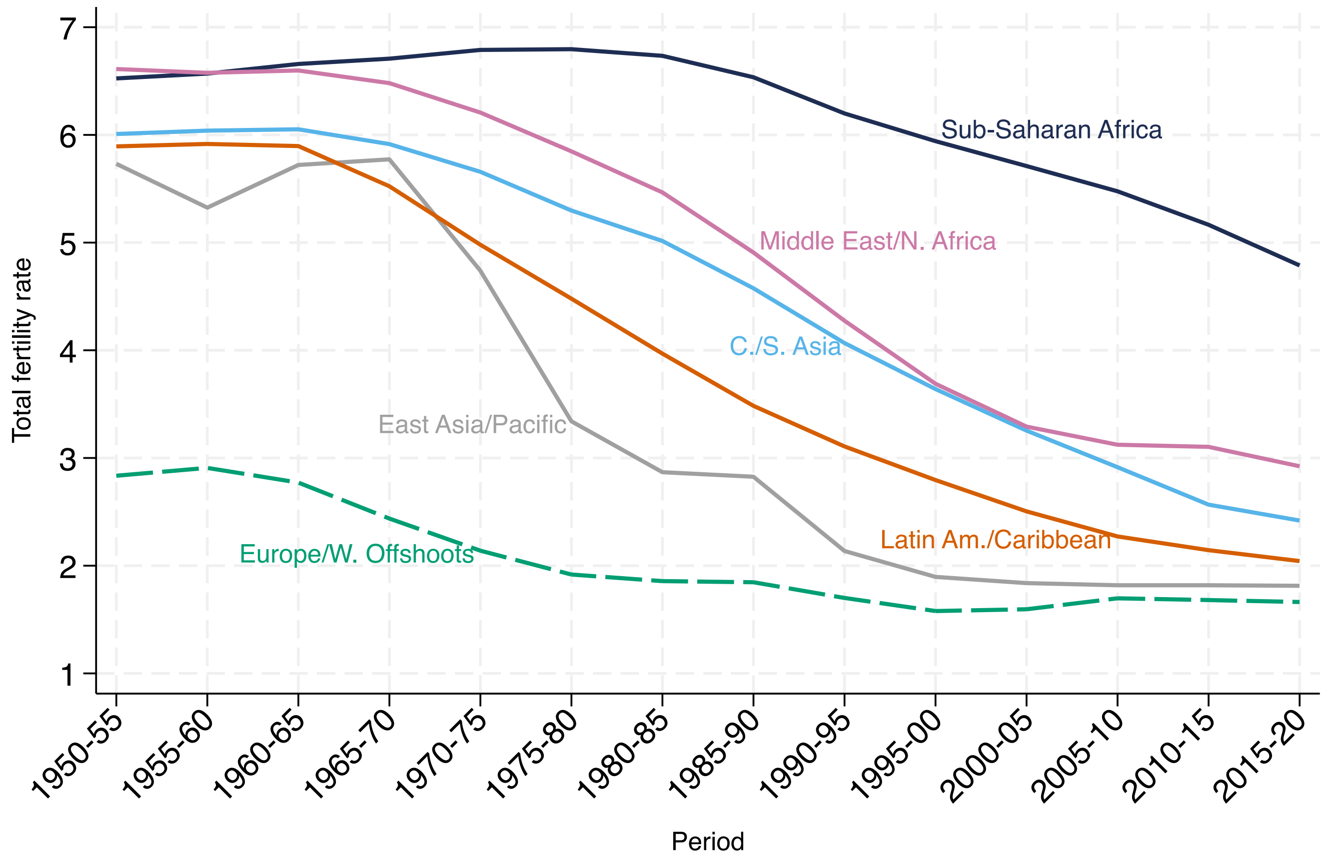
Notes: In columns (6)-(7), child characteristics are first averaged by mother and then averaged across mothers.

Table A2: Distribution of Levels and Rates of Change in Key Variables

	Countries				Regions			
	Mean	p25	p50	p75	Mean	p25	p50	p75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Levels, women born 1965-74 and their children								
Children ever born at age 40	5.61	5.27	5.58	5.99	5.67	5.14	5.76	6.45
Surviving children at age 40	4.67	4.42	4.74	4.96	4.71	4.26	4.78	5.23
Ideal number of children	5.99	6.02	5.23	6.58	6.20	5.25	6.14	6.95
Woman grades completed	3.54	1.64	3.05	5.06	3.46	1.00	3.24	5.47
Child school enrollment	0.76	0.67	0.79	0.89	0.75	0.63	0.81	0.91
Child grades completed	2.48	1.84	2.38	3.06	2.48	1.67	2.35	3.18
B. Rates of change, all women and their children								
Children ever born at age 40	-0.049	-0.030	-0.048	-0.075	-0.042	-0.017	-0.047	-0.075
Surviving children at age 40	-0.021	-0.002	-0.021	-0.036	-0.017	0.012	-0.021	-0.045
Ideal number of children	-0.040	-0.021	-0.042	-0.061	-0.039	-0.013	-0.042	-0.064
Woman grades completed	0.093	0.049	0.097	0.137	0.091	0.024	0.088	0.148
Child school enrollment	0.008	0.003	0.007	0.011	0.008	0.003	0.006	0.013
Child grades completed	0.037	0.016	0.036	0.046	0.035	0.014	0.032	0.056

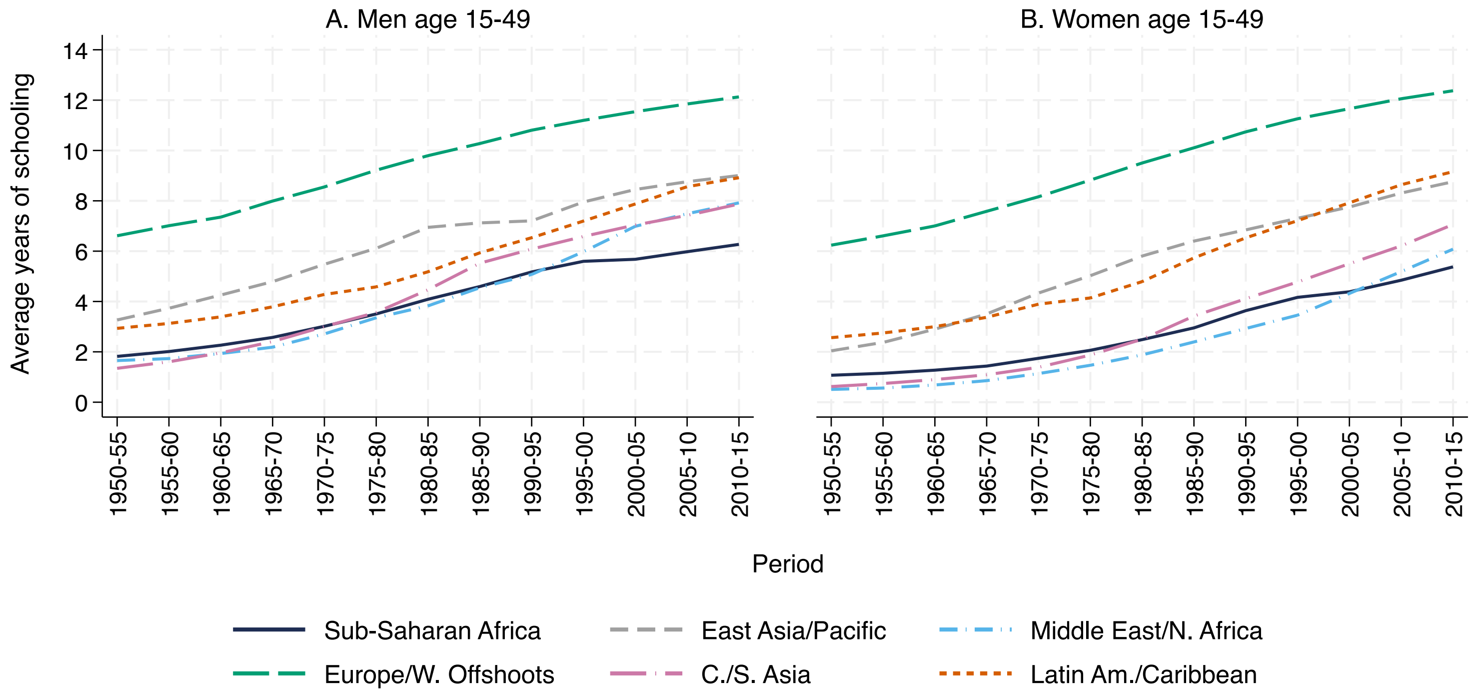
Notes: Sample includes 33 countries and 198 subnational regions. Levels are computed as country- or region-specific averages for the 1965-74 decadal cohort. Rates of change are computed in country- or region-specific regressions of each variable on the woman's year of birth. Sampling weights were used to compute the country- and region-specific averages and rates of change, but the cross-place summary statistics in the table are unweighted.

Figure A1: Total Fertility Rates over Time by World Region, UN Data



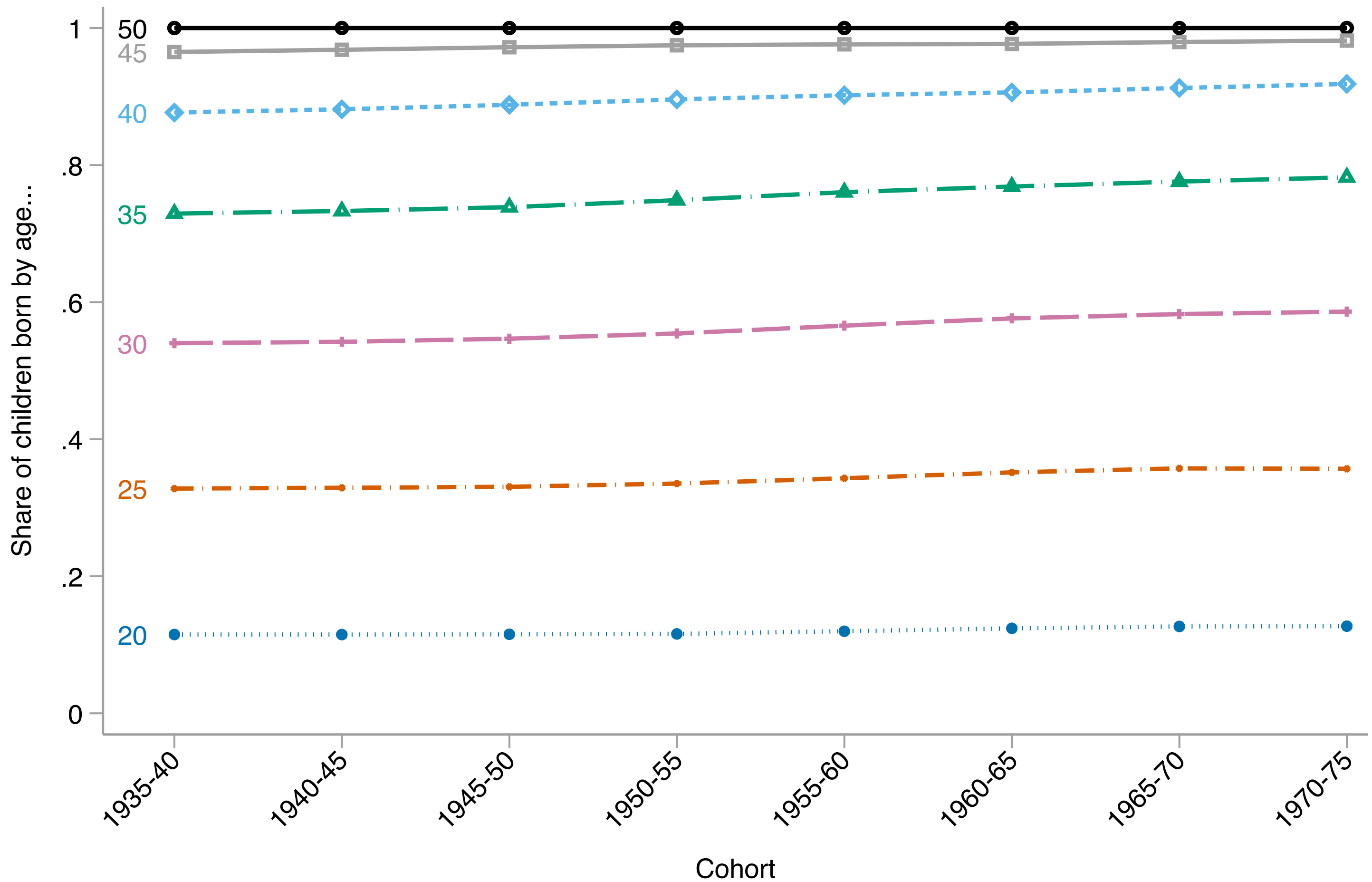
Notes: Population-weighted average total fertility rates across 235 countries. Source: United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Population Prospects 2019*, Volume I: Comprehensive Tables.

Figure A2: Educational Attainment over Time by World Region, Barro-Lee Dataset



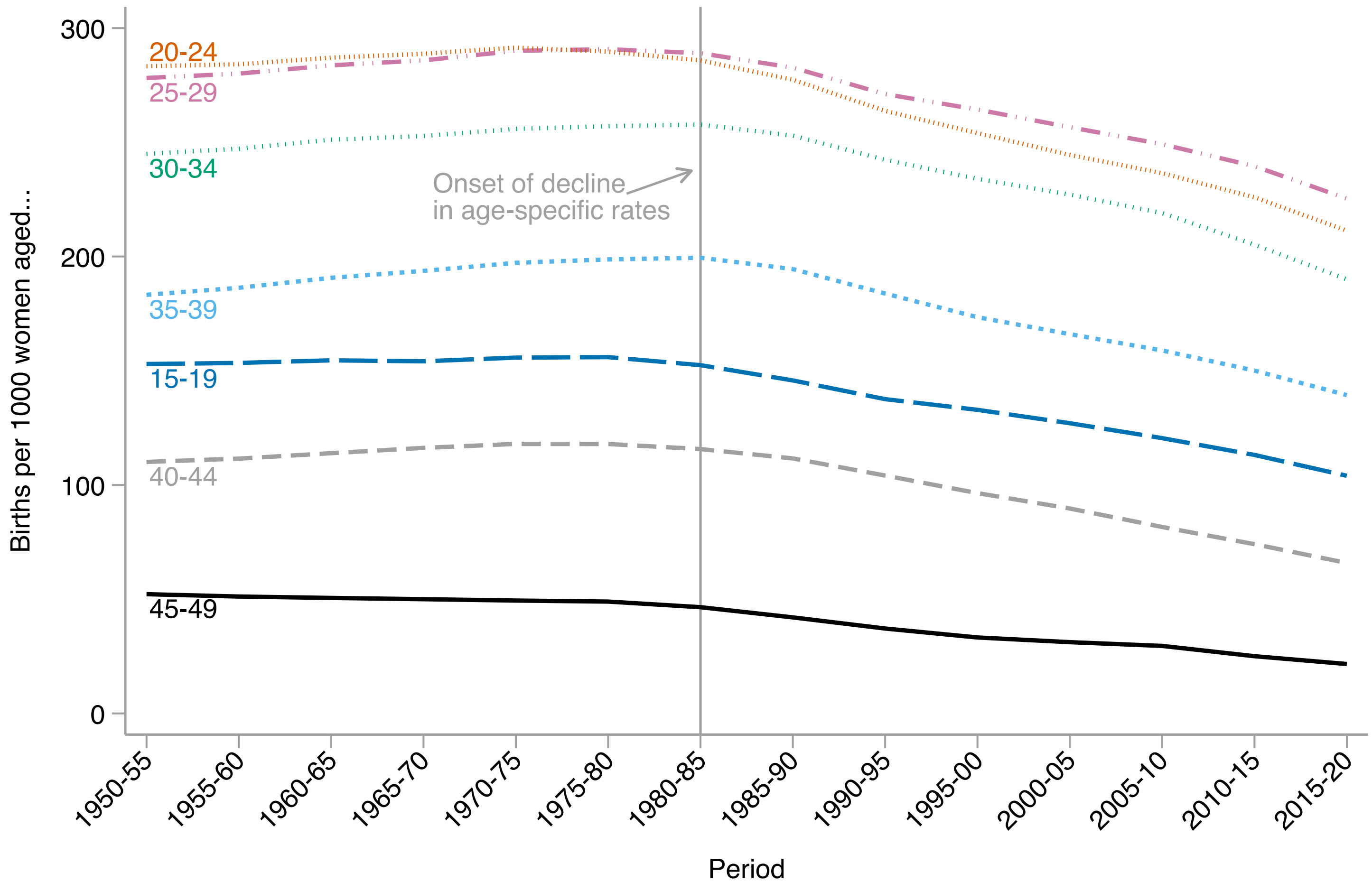
Notes: Population-weighted average years of schooling across 146 countries. Source: Barro, Robert, and Jong-Wha Lee. (2013). "A New Data Set of Educational Attainment in the World, 1950-2010." *Journal of Development Economics* 104: 184-198.

Figure A3: Shares of Cohort Children Ever Born by Specific Ages, UN Africa Data



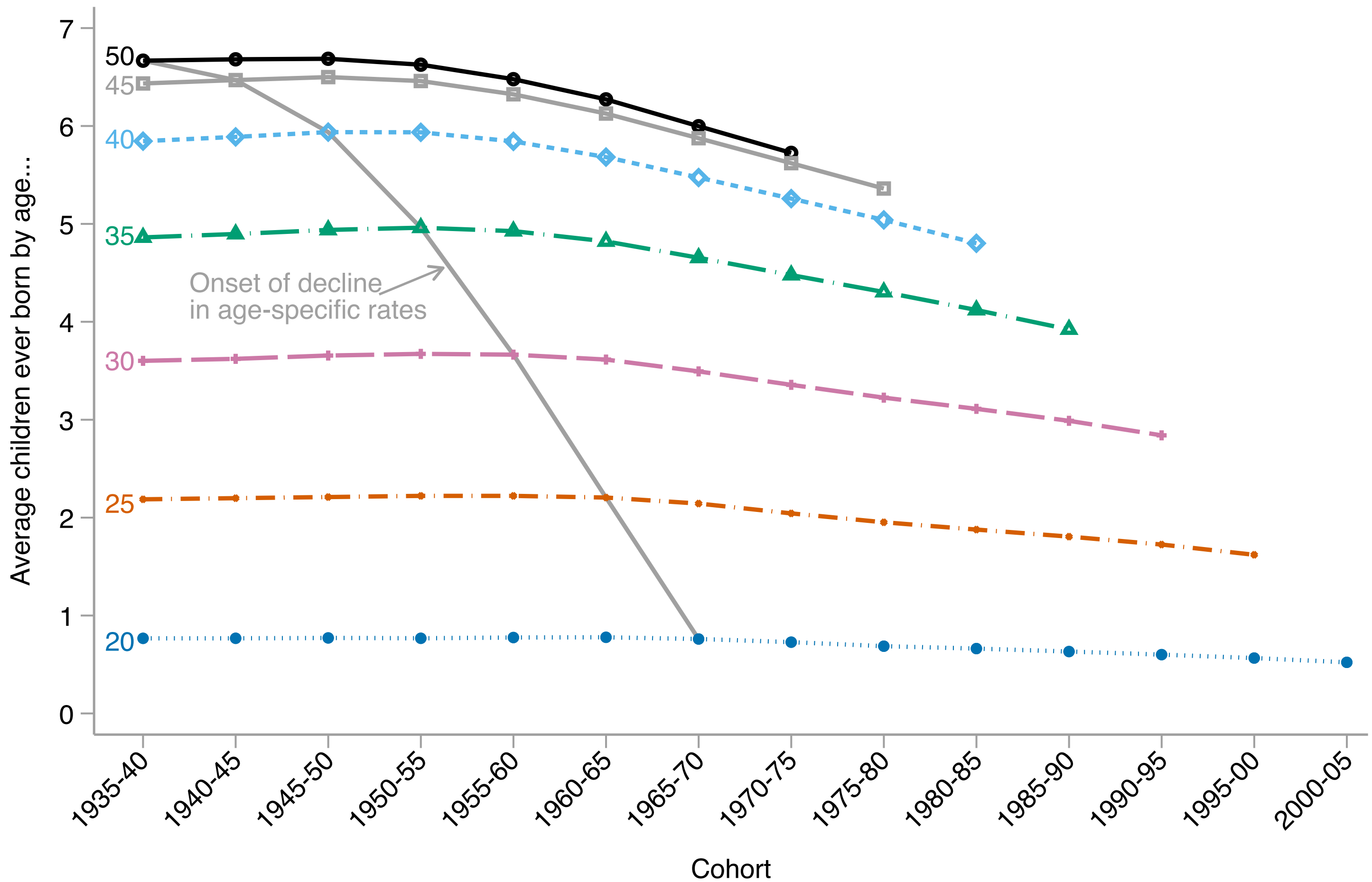
Notes: Cohort refers to the five-year period of birth. Average children ever born computed from age-specific fertility rates for each cohort in 51 sub-Saharan countries. Source: United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Population Prospects 2019*, Volume I: Comprehensive Tables.

Figure A4: Age-Specific Fertility Rates by Period, UN Africa Data



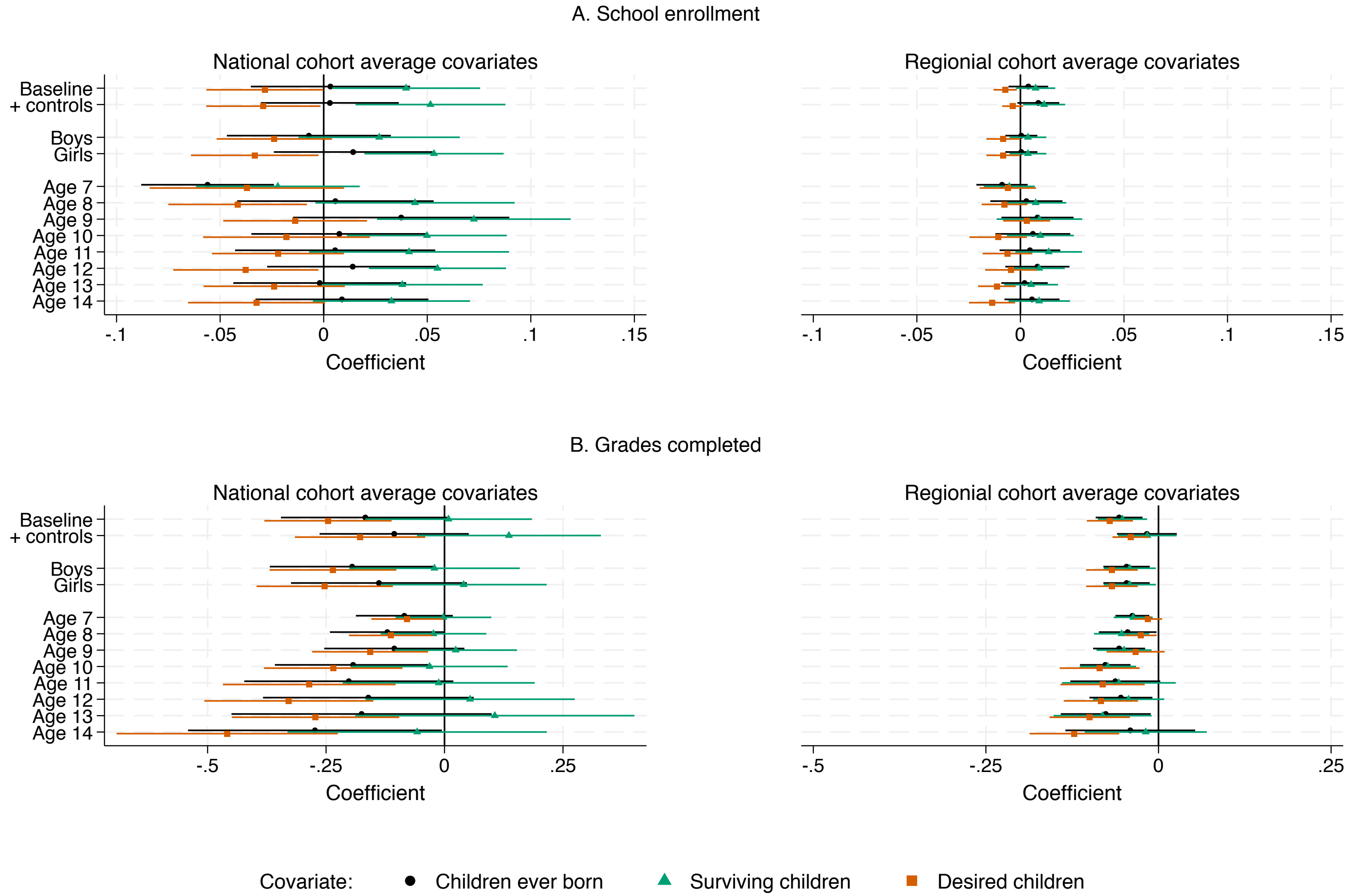
Notes: Average age-specific fertility rates weighted by age-group populations across sub-Saharan 51 countries. Gray "onset" line indicates the last period before most age-specific rates started declining. Source: United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Population Prospects 2019*, Volume I: Comprehensive Tables.

Figure A5: Average Children Ever Born by Cohort, UN Africa Data



Notes: Cohort refers to the five-year period of birth. Average children ever born computed from age-specific fertility rates for each cohort in 51 sub-Saharan countries. Plot reflects the average across countries, weighted by cohort population at age 25-29. Gray "onset" curve indicates the last cohort to not exhibit declines in cumulative fertility at the specified age. Source: United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Population Prospects 2019*, Volume I: Comprehensive Tables.

Figure A6: Sensitivity and Heterogeneity in Fixed-Effect Regressions of Children's Education on Fertility



Notes: Coefficients and 95% confidence intervals (based on standard errors clustered by country) from regressions of average children's education on average fertility. Regressions using national cohort averages include country indicators interacted with child age indicators and birth year indicators interacted with child age indicators. Regressions using regional average covariates include region indicators interacted with child age indicators and three-way interactions of country indicators, maternal birth year indicators, and child age indicators. Controls include averages of women's and husbands' education, and rates of current marriage, never marriage, and missingness of husbands' data.