Fertility Decline and Educational Progress in African Women and Children

Tom Vogl*

January 2025

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 these theories' relevance to the continent's transitions in both realized and desired fertility. Across countries and subnational regions, lower fertility is associated with higher education in both generations. Across cohorts within a country or region, while fertility decline remains associated with the educational progress of women, it has at most a weak relationship with that of children. 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 ideal family size at the end of the reproductive period more consistently predict children's educational progress, suggesting that this interplay may become more relevant to African fertility change as women update ideals and improve their implementation.

*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 (Figure A1). In several African countries, fertility rates "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 (Figure A2). Several 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 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. I also ask whether desired and realized fertility display similar relationships with education. Economic models in the Beckerian tradition often conflate the two, but demographers have emphasized obstacles that limit women from achieving their desired family sizes (Bongaarts and Casterline 2018).

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. (2000), 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

[1]Studies of individual-level variation in these variables have muddled results in Africa, documenting positive, negative, and null

on their influential work by studying within-place changes in both variables: a new check on applications 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] The focus on cross-sectional variation follows a longstanding tradition in studies of women's education and fertility in Africa (Martin 1995; Ainsworth et al. 1996; Shapiro and Tenikue 2017). 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 is 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. 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. I ask whether places with more cross-cohort fertility decline have experienced relatively more cross-cohort educational progress among women and their children.

---

relationships between sibship size and education (Buchmann and Hannum 2001; Eloundou-Enyegue and Williams 2006; Vogl 2016).

[2] Schoumaker and Sánchez-Páez (2024) dispute Kebede et al.'s conclusion on the role of women's education in fertility "stalls," but they too rely on cross-sectional variation.

[3] The findings on realized fertility are corroborated by randomized 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 desired fertility, however.

Considering cross-place, cross-cohort variation in this way allows me to rule out spurious relationships due to cross-sectional heterogeneity or secular trends.

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 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.

Analyses at both levels of aggregation find that declining realized 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, and they are sensitive to the schooling measure. In the cross-section, higher realized 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] They are also consistent with attainment being a closer proxy for children's school engagement—and parents' investments therein—than enrollment.

Overall, one must squint to see evidence that child schooling systematically rises as realized fertility falls. But desired fertility may respond to changing educational conditions more immediately and precisely than realized fertility. Indeed, lower desired fertility more consistently predicts 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 con-

[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).

tribute 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-20th century find a prominent link with the former but a substantially weaker link with the latter. Although these findings are not causal, they suggest that while education policy may influence future fertility, any cross-effects of education policy on current fertility or of family planning policy on current education may be nuanced.

2 The Fertility-Education Triangle

Parents' own education levels interact with their fertility and child schooling decisions. Thus, the three legs of the fertility-education triangle—linking fertility, adult education, and 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 a cohort approach to studying these hypotheses simultaneously.

2.1 The Triangle in Theory

Figure 1 represents the triangle visually, with fertility, adult education, and child education as vertices, and key mediators inside. To reduce clutter, the figure combines the education of women and their husbands, the relative importance of which vary across domains and mechanisms. Most links point downstream from adult education, but a few point upstream from fertility and child education. The downstream links alone imply an association between fertility and children's education, but the upstream links expand and complicate this association. They imply that any effects of parental education on one child domain may propagate to the other.

Fertility and Child Education The Caldwellian theory features 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. The key upstream links in his theory point from children's schooling to net child costs and family norms. Schooling may increase direct child costs, reduce income from child labor, and raise children's expectations of independence from their parents. It may also spread new cultural values regarding ideal family size and children's independence. Economists' 'quality-quantity' theory (Becker and Lewis 1973; Willis 1973) focuses on the first set of forces in Caldwell's theory—net child costs—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. As a result, both fertility and child education have bidirectional links with net child costs. These theories generally predict that children's education rises wherever fertility falls, but they leave directionality ambiguous.

The application of these theories to the 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. (2000) 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 school enrollment reorganizes children's time undoubtedly transforms the family economy, but when schools are free and under-resourced, it may not be best interpreted as a costly investment in children's human capital. For younger children, the cost of enrollment even has an unclear sign, as young children contribute little to family production and require care when they are not in school. Attainment, which captures cumulative school progression, may better proxy the key investments in the Beckerian framework.

Adult Education and Fertility One cannot think about parents' decisions regarding the number and education of their children without 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, in which more educated mothers have higher time costs or returns to child investment (Schultz 1997). 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 the characteristics of the men they marry.[5]

Adult Education and Child Education The link between the education of parents and children closes the triangle. Large literatures in economics and sociology explore mechanisms that could explain an effect of parental education on child education, which include economic resources, heterogeneity in schooling returns, socialization, and cultural capital (Torche 2021). Women and their husbands have correlated education levels (Pesando 2021), but their relative importance for children's education is unclear.[6] To the extent that parental economic resources support children's schooling, husbands' education is likely to be more important, given the low prevalence of wage work among African women (Dinkelman and Ngai 2022). To the extent that parental time and knowledge support children's schooling, however, women's education may be important. The balance of these forces may differ between enrollment and attainment, with the latter arguably more responsive to non-pecuniary investments by parents. 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.

2.2 Empirics of the Triangle

Assessing the triangle's relevance to Africa's fertility transition requires two decisions: (i) whether to use individual or aggregate data and (ii) whether to focus on periods or cohorts. On (i), because fertility decline is an population-level phenomenon, aggregate variation is more informative than individual. On (ii), because the triangle involves family choices across multiple child-rearing domains, one would ideally measure these choices for the same families, and only a cohort orientation allows one to do so. At a point in time, the total fertility rate and the school enrollment rate reflect the choices and outcomes of different families, since some mothers of school-age children will be older than reproductive age. However, in a cohort of women, average fertility and average child schooling necessarily reflect the choices and outcomes of the same families. As such, the study takes an aggregate cohort approach.

The cohort approach deals with timing in an appealing way, although data constraints limit investigation of

[5] Marriage *timing* is another potential channel. More educated women marry and become mothers later (Bongaarts et al. 2017); randomized trials in Ghana and Kenya find that education subsidies reduce teen marriage alongside fertility (Duflo et al. 2015, 2021). However, Grant (2015) finds that cohorts benefitting from free primary school in Malawi had *lower* ages at marriage and first birth.

[6] The share of African couples with the same education level has fallen with educational progress (Lopus and Frye 2020), but marriage remains highly assortative (Pesando 2021).

complex lag structures. 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 are vexing if one scrutinizes the course of conceptions and births, but they become less so if one studies completed fertility, as I do below. Even so, Caldwell might motivate one to study how community enrollment rates measured at various ages over a woman's life course influence her completed fertility. Unfortunately, the Demographic and Health Surveys only allow snapshots of schooling in survey years, rather than full histories of schooling over the life course. Consequently, the analysis will relate a cohort's completed fertility to snapshots of enrollment and attainment in the cohort's children. Notably, attainment is a stock measure, thus capturing the cumulation of past school exposure.

I operationalize cohorts by grouping women by place and birth year. The ideal classification of place would not depend on women's choices, but the data only consistently provide information on place of residence, raising risk of bias from selective migration. Aggregation at the country level minimizes this risk since external migration is rarer than internal, but it leads to fewer geographic units, less sensitivity to heterogeneity, and concerns about confounding national trends and policies. Aggregation at the subnational level addresses these issues but introduces selective internal migration.[7] Because both aggregations are informative, I report both: one by country, the other by subnational region.

Aggregation precludes separate identification of individual and social effects, as Kravdal (2002) explores for fertility and Frye and Lopus (2018) explore for marriage timing, both in the African context. The distinction is relevant to both Caldwell and Becker. Caldwell (1980) hypothesizes that schools promote child dependency, capitalist culture, and Western values, which may occur at the family or community level. Becker et al. (1990) conjecture that the return to investing in children's schooling increases with the prevalence of schooling. As such, both perspectives suggest that the causal mechanisms linking fertility and education may differ at the individual, community, and society levels. However, disentangling these mechanisms in a way that takes causal inference seriously is extremely challenging in observational data. The goal here is not to estimate causal effects of education at various levels but instead to establish facts on how cohort transitions in fertility and education coincide. The aggregate associations will reflect a mix of individual and social mechanisms.

Fertility decline depends on the desired number of children and the capacity to implement those desires,

[7] Some DHS ask whether respondents ever migrated; I report analyses of never-movers in the Appendix, with similar results.

making both desired and realized fertility relevant. Across countries, desired fertility strongly predicts realized fertility (Pritchett 1994), and declines in the former strongly predict declines in the latter (Günther and Harttgen 2016). However, unintended childbearing remains common (Bongaarts and Casterline 2018), and education may have different relationships with desired and realized fertility. Unwanted births are more prevalent in Africa than in other low- and middle-income regions, and they are not keeping pace with declines elsewhere (Günther and Harttgen 2016; Casterline and El-Zeini 2022).

Existing research on African countries has investigated the distinction between desired and realized fertility with respect to women's but not children's education. Analyzing national period aggregates, Bongaarts (2020) documents that increases in women's average education predict declines in both wanted and unwanted total fertility rates in Africa. Analyzing national cohort aggregates, Behrman (2015) estimates that exposure to free primary education in childhood raises women's desired fertility. How these findings translate to children's schooling is unclear. If children's schooling reshapes women's fertility ideals but does not change their capacity to implement those ideals, it may be more related to desired fertility than realized. If family size raises the cost of children's schooling, predictions depend on how whether parents adhere to long-term childrearing plans or adapt to contemporaneous constraints.

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. 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 (Table A1). All calculations apply sampling weights.

The measurement of education differs between adults and children. For women and husbands, I use grades completed. For children, I use enrollment and grades completed among 7-14 year-olds: old enough to exceed every country's school-starting age, young enough to be included in every survey's education module.[8] At

[8]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% 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).

these ages, most children have not yet completed their schooling, so the number of grades completed measures school progression rather than lifetime attainment. The preferred regression models include child age fixed effects, in which case this variable can be interpreted as a child's grade-for-age. 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 reported ideal family size.[9] Answers may reflect *ex post* rationalization, but they offer a window into women's current thinking about children.

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. Cumulative fertility at age 40 is a close proxy for completed fertility; the oldest sample women, age 49, bore 91% of their children before turning 40. Second, women aged 45-49 have fewer 7-14 year-old children than women aged 40-44, and those children have higher birth order and later maternal age at birth (Table A2). Including 40-44 year-olds makes the child sample more representative. Sample children were born when their mothers were in their 20s through 40s; sample women were born between the late 1940s and early 1980s.

To form regional cohorts, I create temporally consistent boundaries for 198 regions.[10] 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.

3.2 Summary Statistics

Table 1 reports summary statistics, with column (1) listing means and standard deviations for the 222,884 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 6.0. Marriage rates are high, with 79% currently married and 97% ever

[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] 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 absorb all variation from these countries.

married. Schooling is low, with women averaging 3.4 grades completed, their husbands 4.4.[11]

Column (2) turns to the children of these women. Data are available for 302,283 children, who coreside with 153,666 mothers. By construction, this sample overrepresents families with children: mothers have 6.9 children ever born and 5.9 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). 74% of children are enrolled in school, and the average child has completed 2.4 grades.

Sample-wide averages mask age variation in children's educational outcomes. Figure 2 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 enrollment rate starts from 60% at age 7, grows to 81% at age 11, and then trails off to 74% at age 14. Average attainment starts from 0.48 grades at age 7 and steadily grows to 4.37 grades at age 14.

The slope of the age-attainment relationship suggests that children progress through the education system more slowly than by design. The start and end points of the "all children" curve imply that grades rise 0.56 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 0.80 grades at age 7 to 5.40 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

I seek 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 do not account for differences in cohort coverage across countries, nor differences in child age structure across cells.

The regression models address these limitations while allowing me to parse within-place variation from

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

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 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 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.[12]

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

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

year fixed effect, while δ_c^a is a country fixed effect. For child schooling outcomes, both vary with child age.

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

$$y_{ircb}^a = \bar{X}_{rcb}'\beta + \tau_{cb}^a + \delta_{rc}^a + \varepsilon_{ircb}^a$$

where again the a superscript applies only to child schooling outcomes. As before, the pooled cross-sectional version of the model excludes τ_b^a and δ_c^a, while the fixed-effect version 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_{rc}^a. Second, the birth year fixed effect τ_{cb}^a now varies by country, so that the regression restricts to within-country comparisons of regional change. As before, both fixed effects vary with child age when the dependent variable is a child schooling outcome.

For each model, I 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 of these, such that β measures the extent to which places that experienced greater changes in average X also experienced greater changes in average y.

The analysis proceeds in three steps, each corresponding to a different leg of the fertility-education triangle. The first defines y as child schooling and X as fertility; the second defines y as fertility and X as women's education; 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. The links between child schooling and fertility are bidirectional, so the choice of y and X is arbitrary. Indeed, in their early work on Caldwell's (1980) hypothesis, Lloyd et al. (2000) treat child schooling as the independent variable; research on family size and children's schooling more typically treats it as the dependent variable (Buchmann and Hannum 2001). Treating it as the dependent variable allows me to flexibly control for the child's age, so I follow this approach for practical rather than conceptual reasons.

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

Figure 3 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 levels. For reference, Table A3, Panel A, details the quantiles of each variable across countries and regions.

Both the national maps and the regional maps plainly indicate 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 suggest the same.

The geography of changes differs from the geography of levels. Figure 4 maps cross-cohort rates of change in the same five variables, with the rate of change computed as the slope coefficients from place-specific regressions of the variable on the woman's year of birth. Places are classified into quartiles of the rate of change, and darker colors imply faster change. For reference, Table A3, Panel B, details the quantiles the rates of change across countries and regions. In all cases, the median rate of change is negative for fertility variables and positive for education variables. In most African countries and regions, fertility has trended downward, while education has trended upward in both generations.

Figure 4 illuminates which places experienced more fertility decline and which experienced more educational progress. Patterns are similar 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 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 4 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 2. The regression frameworks of Section 4 address 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. Ever-born, surviving, and ideal children serve as measures of realized and desired fertility. Because both sets of variables in part reflect parental choices, these regressions 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.

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 3. For both measures of realized fertility, an additional child per woman is associated with 8-13 percentage point lower enrollment (Panel A) and 0.5-0.6 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, especially 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.[13] 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 $\frac{1}{17}$-$\frac{1}{20}$ 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 2.2 percentage point increase in school enrollment, although this association is significant only at the 14% level, and a 0.21 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. The latter three results are all significant at the 1% level.

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. The relative strength of the attainment results is consistent with enrollment being a noisier proxy for parental investment. The relative strength of the desired fertility results may relate to gaps between desired and realized fertility, or to the updating of ideal family size following child investment, as in Axinn and Barber's (2001) sequential model.

The Appendix checks these findings in two alternate samples. Table A4 restricts the sample to women and children who have lived in the same place all their lives, as a partial check on bias from migration. Results are extremely similar to those for the full sample. Table A5 expands the sample to include children whose mothers are in the relevant birth cohort but are not included in the fertility averages. These children mainly come from earlier surveys, before their mothers reached age 40. The child attainment results have similar statistical significance but shrink in magnitude because the newly added children tend to be younger, with lower mean and variance of grades completed. The child enrollment results are uniformly weak, this time

[13] The national attainment association approaches statistical significance for children ever born ($p = 0.057$) but is close to zero and non-significant for surviving children ($p = 0.895$).

for desired fertility too. That is to say, the ideal family size women state in their 40s does not predict their children's earlier school enrollment. Ideal family size may update to reflect current school investments but not past ones.

The Appendix also reports analyses of non-linearity, heterogeneity by child age and sex, and robustness to adjustment for average parental characteristics, none challenging the conclusions from Table 2. Figure A3 presents partial regression plots, which display relationships between fertility and education after partialing out the intercepts or fixed effects from the pooled cross-sectional or fixed-effect models. The plots appear linear, ruling out the possibility that the null fixed-effect results in Table 2 reflect nonlinearities or outliers. Figure A4 re-estimates the fixed-effect models separately for boys and girls, by single year of age, and with and without average parental covariates. The 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.

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. 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 estimates the relationship between the women's education and fertility. Columns (1)-(4) use covariates averaged at the national cohort level, while columns (5)-(8) 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 0.25 fewer children ever born per woman, 0.11 fewer surviving children per woman, and 0.24 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 -0.2 (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 women's 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 0.28 fewer children ever born per woman, 0.14 fewer surviving children per woman, and 0.31 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 0.22-0.24 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. 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 cases none at all. 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 variables as Table 3, but with the same children's outcomes 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 6.2 percentage point higher child school enrollment rate and a 0.30-0.32 grade higher child average attainment (columns [1] and [5]). Fixed effects shrink this association by two-thirds or more. In the fixed-effect regressions, a one grade increase in women's attainment predicts a 0.1-1.2 percentage point increase in child enrollment and a 0.10-0.12 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' schooling predicts a 0.06-0.08 grade increase in child average attainment in regional variation. In national variation, only husbands' schooling is relevant to child attainment.

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 more consistently predict rising child enrollment and attainment.

6 Discussion

Several demographic and economic theories predict that fertility decline coincides with 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 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 ideal family size, reported toward the end of the reproductive period, are more strongly linked with progress in children's schooling than are declines in realized fertility. If gaps between realized and desired fertility narrow in the future, or if desired fertility adapts to educational conditions earlier in the reproductive period, then realized fertility may become more systematically linked with expansions in children's schooling.

Although the study's null results seem to challenge prevailing theories of fertility decline, one can account for them with an appropriate blend of the sociological and economic forces in these theories. That increases in children's schooling coincide with declines in desired rather than realized fertility suggests that Beckerian and Caldwellian considerations shape parents' hopes for their children, even if they break down when fertility deviates from the desired level or when the desired level changes over the life course. This perspective implies that if African policymakers wish to harness the human capital benefits of fertility decline, then they may need to match reductions in the demand for children with efforts to help women and their partners achieve their desired fertility. If they wish to exploit the fertility-reducing effects of schooling expansions, then they may need to couple schooling expansions with efforts to help families update their fertility ideals. Research suggests that family planning programs can help achieve these goals in the African context (Bongaarts 2020).

By simultaneously analyzing all three legs of the fertility-education triangle, the study also highlights the divergent roles of women's and men's schooling in shaping family outcomes. Rising women's education more strongly predicts falling fertility, while rising husbands' education more strongly predicts rising children's schooling. These findings suggest that parents' education influences the number and schooling of their children through separate channels. For example, women's education may shape fertility by increasing women's autonomy and capacity to use family planning methods, while husbands' education may boost children's schooling by increasing income and wealth. Weak implementation or life course updating of fertility desires may prevent Beckerian and Caldwellian forces from translating the influence of parents' education in one domain to the other. The distinct roles of women's and men's education also mechanically contribute to the decoupling of realized fertility and children's schooling. This is especially so for changes in children's enrollment, which are associated with rising husbands' but not wives' education.

The particular weakness of the enrollment results has three potential explanations that go beyond regression mechanics. 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, to the extent that expansions in the supply of schooling reduce parents' childcare burdens or endow children with human capital without costs to parents, they could have effects at odds with the conventional interpretation of the Beckerian framework. Here again, these mechanisms may apply especially to enrollment. Third, 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 does not speak to the causal pathways underlying the associations (or the lack thereof). Instead, the study contributes a coherent set of cohort facts on changing fertility and education among women, their husbands, and their children. 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.

Ainsworth, Martha, Kathleen Beegle, and Andrew Nyamete. (1996). "The Impact of Women's Schooling on Fertility and Contraceptive Use: A Study of Fourteen Sub-Saharan African Countries." *World Bank Economic Review* 10(1): 85-122.

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.

Becker, Gary S., Kevin M. Murphy, and Robert Tamura. (1990). "Human capital, Fertility, and Economic Growth." *Journal of Political Economy* 98(5): S12-S37.

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).

Bongaarts, John, and John B. Casterline. (2018). "From Fertility Preferences to Reproductive Outcomes in the Developing World." *Population and Development Review* 44(4): 793-809.

Bongaarts, John, Barbara S. Mensch, and Ann K. Blanc. (2017). "Trends in the Age at Reproductive Transitions in the Developing World: The Role of Education." *Population Studies* 71:139-154.

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 Laila O. El-Zeini. (2022). "Multiple Perspectives on Recent Trends in Unwanted Fertility in Low- and Middle-Income Countries." *Demography* 59(1): 371-388.

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.

Dinkelman, Taryn, and L. Rachel Ngai. (2022). "Time Use and Gender in Africa in Times of Structural Transformation." *Journal of Economic Perspectives* 36(1): 57–80.

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.

Frye, Margeret, and Sara Lopus. (2018). "From Privilege to Prevalence: Contextual Effects of Women's Schooling on African Marital Timing." *Demography* 55(6): 2371-2394.

Grant, Monica J. (2015). "The Demographic Promise of Expanded Female Education: Trends in the Age at First Birth in Malawi." *Population and Development Review* 41(3): 409-438.

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.

Günther, Isabel, and Kenneth Harttgen. (2016). "Desired Fertility and Number of Children Born across Time and Space." *Demography* 53: 55-83.

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.

Kravdal, Øystein. (2002). "Education and Fertility in Sub-Saharan Africa: Individual and Community Effects." *Demography* 39(2): 233-250.

Martín, Teresa Castro. (1995). "Women's Education and Fertility: Results from 26 Demographic and Health Surveys." *Studies in Family Planning* 26(4): 187-202.

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.

Lloyd, Cynthia B., Carol E. Kaufman, and Paul Hewett. (2000). "The Spread of Primary Schooling in Sub-Saharan Africa: Implications for Fertility Change." *Population and Development Review* 26(3): 483-515.

Lloyd, Cynthia B., and Barbara S. Mensch. (2008). "Marriage and Childbirth as Factors in Dropping out from School: An Analysis of DHS Data from Sub-Saharan Africa." *Population Studies* 62(1): 1-13.

Lopus, Sara, and Margaret Frye. (2020). "Intramarital Status Differences across Africa's Educational Expansion." *Journal of Marriage and Family* 82(2): 733-750.

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.

Pritchett, Lant H. (1994). "Desired Fertility and the Impact of Population Policies." *Population and Development Review* 20(1): 1-55.

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

Schoumaker, Bruno D., and David A. Sánchez-Páez. (2024). "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* 50(1): 59-85.

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.

Shapiro, David, and Michel Tenikue. (2017). "Women's Education, Infant and Child Mortality, and Fertility Decline in Urban and Rural Sub-Saharan Africa." *Demographic Research* 37: 669-708.

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	5.74 (2.78)	6.88 (2.36)
Surviving children at age 40	4.72 (2.33)	5.85 (2.01)
Ideal number of children*	5.98 (3.02)	6.37 (3.09)
Grades completed	3.41 (4.36)	2.94 (4.03)
Currently married	0.79 (0.41)	0.86 (0.34)
Never married	0.03 (0.16)	0.01 (0.10)
Husband's grades completed*	4.40 (5.04)	4.03 (4.78)
B. Child variables		
School enrollment		0.74 (0.44)
Grades completed		2.41 (2.33)
Number of women/mothers	222,884	153,666
Number of children		302,210
Number of surveys	121	121
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 = 302,210)	-0.129**	0.005	-0.108**	0.005
	[0.025]	[0.016]	[0.015]	[0.005]
Surviving children at 40 (N = 302,210)	-0.112**	0.041**	-0.086**	0.009
	[0.036]	[0.014]	[0.021]	[0.005]
Ideal number of children (N = 261,871)	-0.083**	-0.022	-0.078**	-0.007**
	[0.012]	[0.015]	[0.007]	[0.002]
B. Child grades completed				
Children ever born at 40 (N = 302,210)	-0.639**	-0.163	-0.590**	-0.059**
	[0.079]	[0.082]	[0.050]	[0.015]
Surviving children at 40 (N = 302,210)	-0.610**	0.011	-0.538**	-0.051**
	[0.121]	[0.080]	[0.080]	[0.016]
Ideal number of children (N = 261,871)	-0.250**	-0.206**	-0.303**	-0.067**
	[0.083]	[0.069]	[0.046]	[0.015]
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* = 222,884)								
Woman highest grade	-0.253**	-0.261**	-0.181**	-0.182**	-0.278**	-0.277**	-0.235**	-0.220**
	[0.043]	[0.085]	[0.043]	[0.043]	[0.027]	[0.051]	[0.047]	[0.055]
Husband highest grade		0.100		0.035		0.068		-0.005
		[0.068]		[0.035]		[0.047]		[0.015]
B. Surviving children at 40 (*N* = 222,884)								
Woman highest grade	-0.113**	-0.138*	-0.198**	-0.213**	-0.136**	-0.159**	-0.175**	-0.174**
	[0.033]	[0.063]	[0.049]	[0.037]	[0.022]	[0.038]	[0.037]	[0.043]
Husband highest grade		0.092		0.062		0.067*		0.015
		[0.051]		[0.037]		[0.034]		[0.015]
C. Ideal number of children (*N* = 195,052)								
Woman highest grade	-0.243**	-0.126	-0.199**	-0.104*	-0.305**	-0.220*	-0.177**	-0.140**
	[0.081]	[0.130]	[0.047]	[0.046]	[0.047]	[0.089]	[0.023]	[0.027]
Husband highest grade		0.102		-0.115**		0.031		-0.043*
		[0.113]		[0.039]		[0.090]		[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* = 302,210)								
Woman highest grade	0.062**	0.005	0.001	-0.018	0.062**	0.013	0.012**	0.003
	[0.008]	[0.012]	[0.007]	[0.010]	[0.006]	[0.009]	[0.004]	[0.005]
Husband highest grade		0.036**		0.026**		0.036**		0.012**
		[0.012]		[0.008]		[0.010]		[0.002]
B. Child grades completed (*N* = 302,210)								
Woman highest grade	0.296**	0.238*	0.103*	-0.000	0.320**	0.221**	0.122**	0.077**
	[0.030]	[0.087]	[0.050]	[0.052]	[0.022]	[0.061]	[0.014]	[0.012]
Husband highest grade		0.073		0.171**		0.099*		0.062**
		[0.065]		[0.043]		[0.048]		[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: The Fertility-Education Triangle

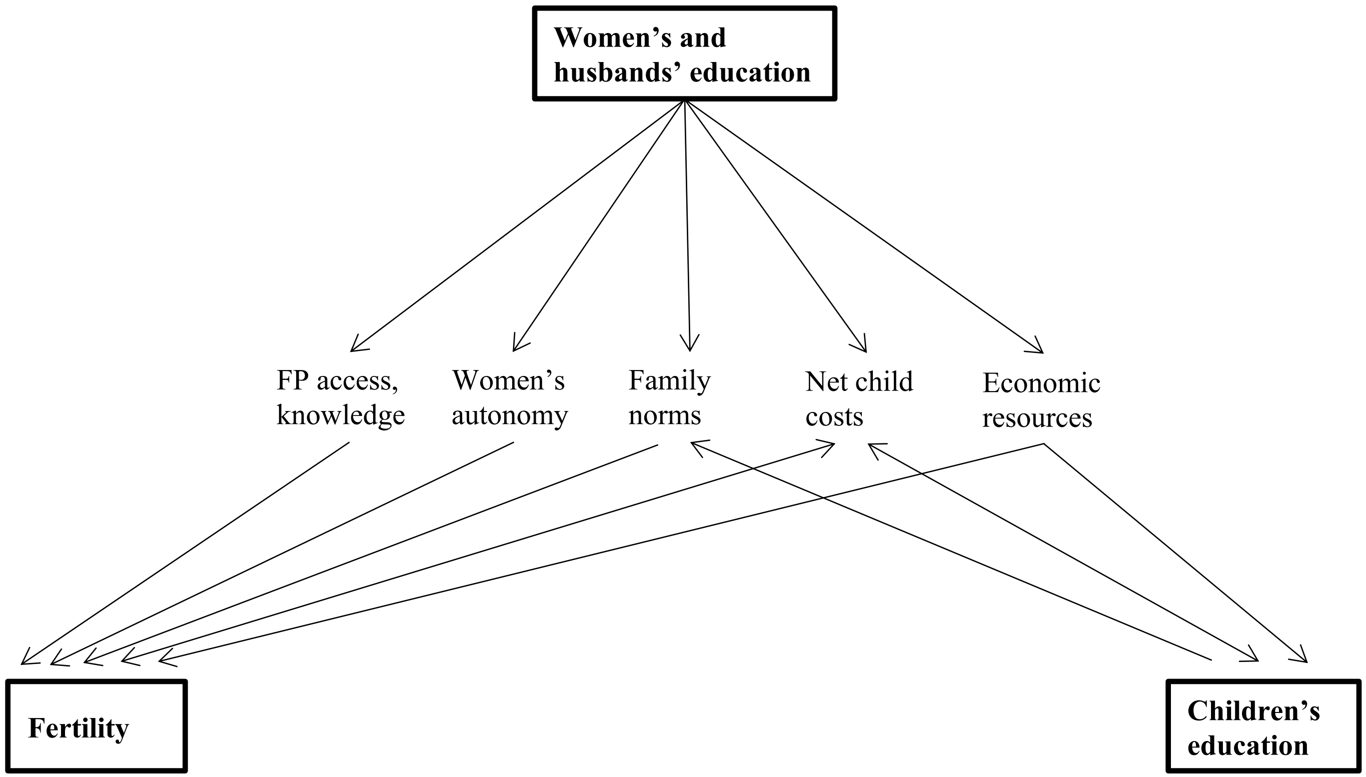
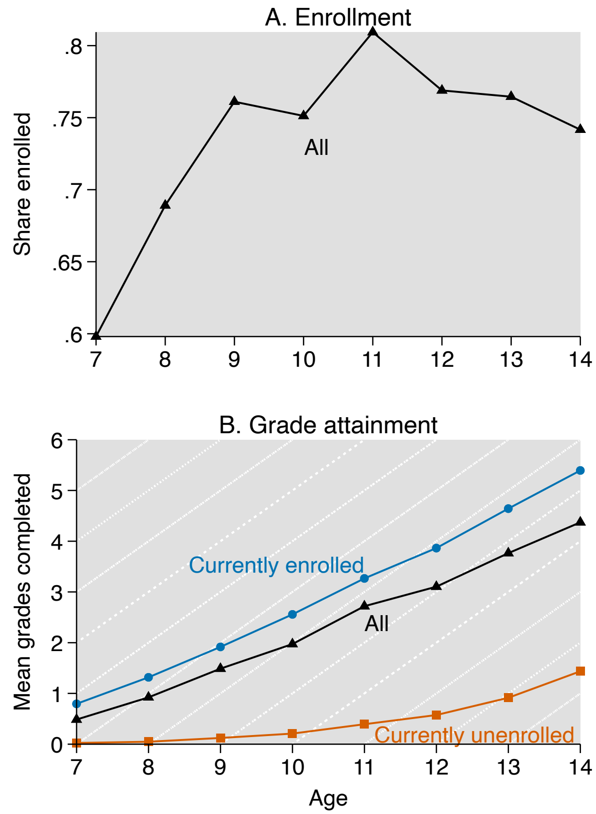
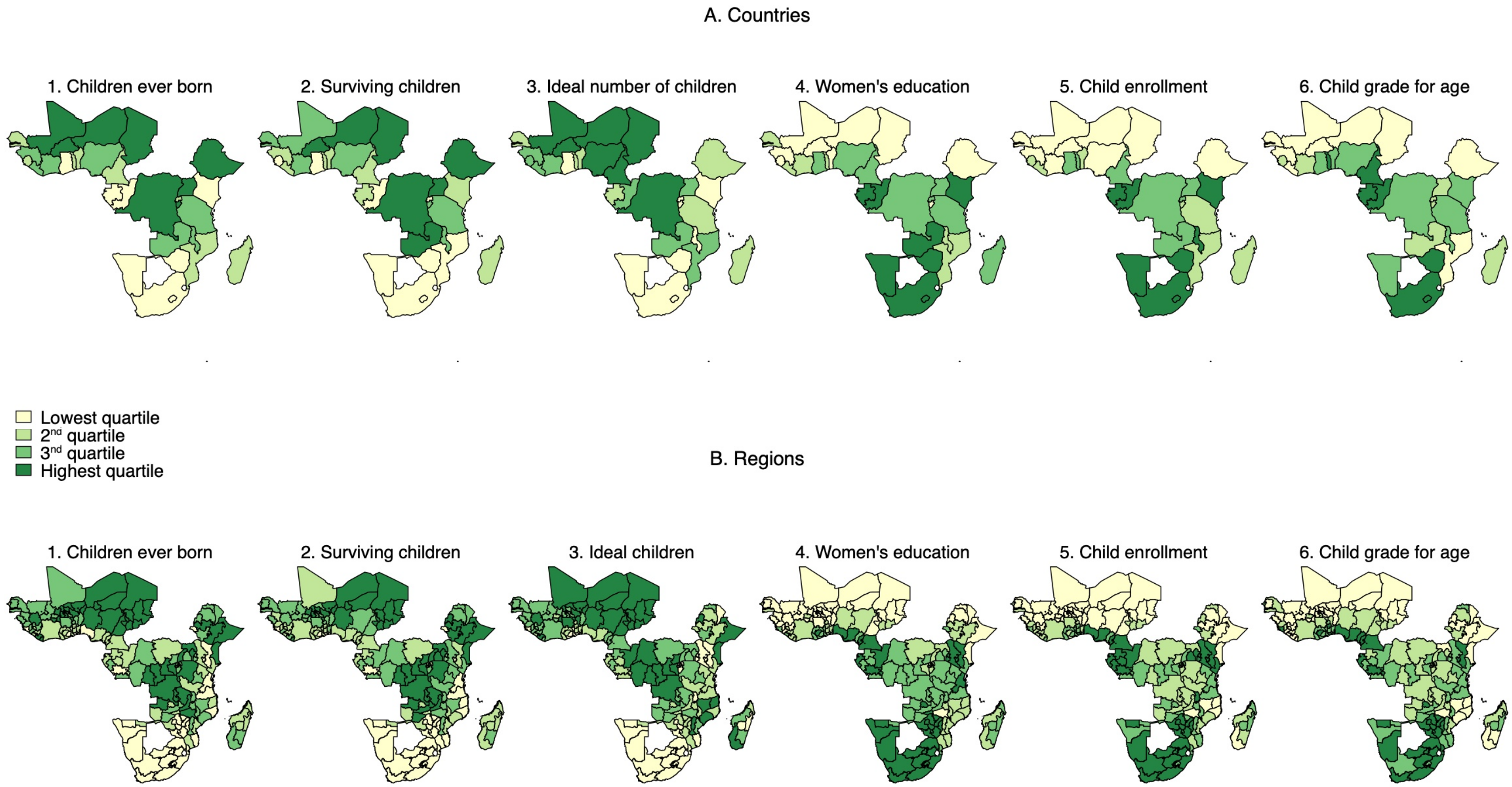


Figure 2: Enrollment and Attainment by Age



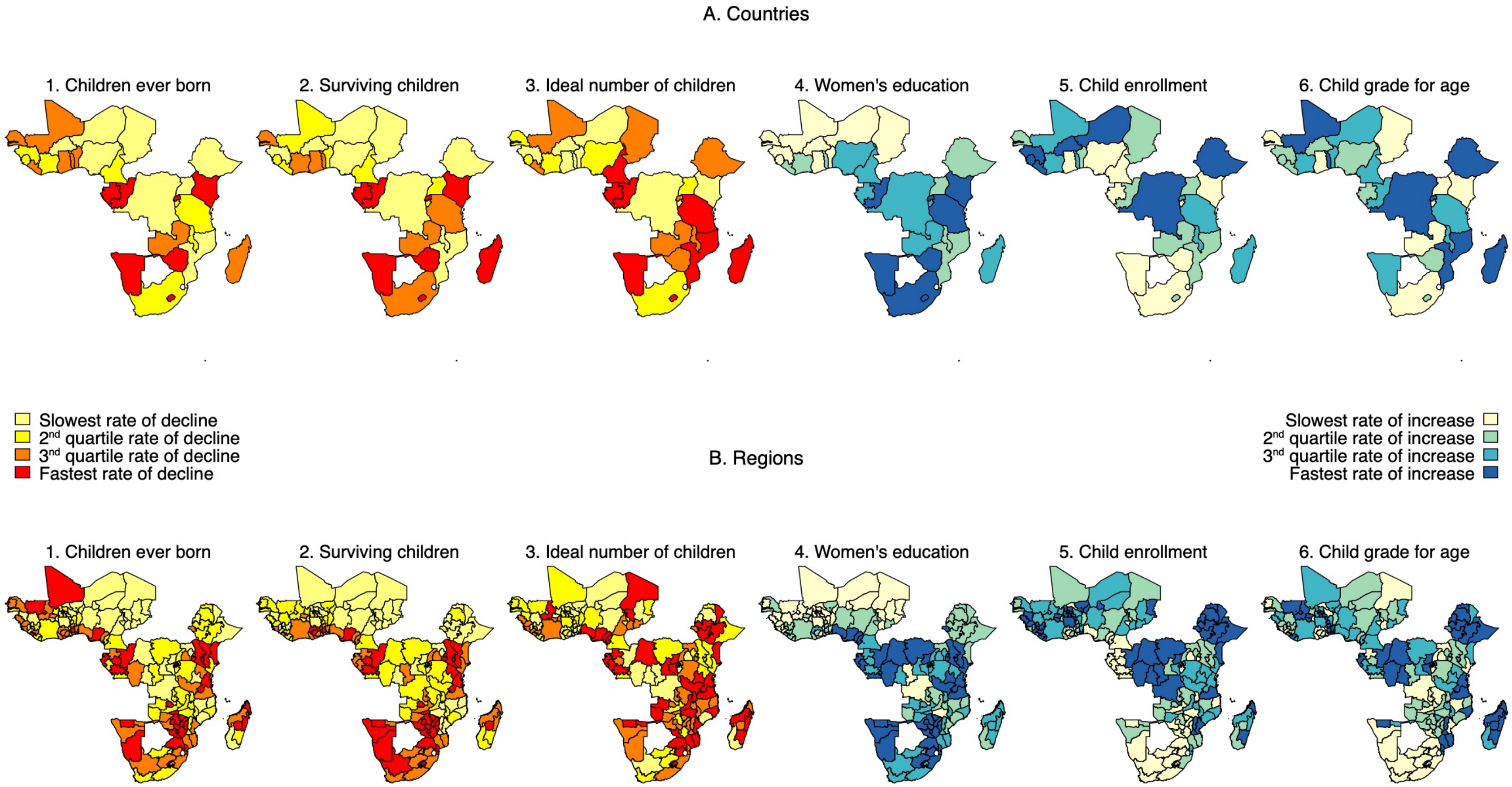
Notes: In Panel B, 45-degree lines are indicated in white.

Figure 3: 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 4: 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.

Table A1: Demographic and Health Surveys and Sample Sizes

Country	Survey years	Women 45-49	Children 7-14
Benin	1996, 2001, 2006, 2011-2012, 2017-2018	10,442	14,177
Burkina Faso	1992-1993, 2003, 2010	6180	9195
Burundi	2010-2011, 2016-2017	4173	7636
Cameroon	1991, 1998, 2004, 2011, 2018-2019	7365	8306
Chad	2004, 2014-2015	3931	6765
Comoros	1996, 2012	1176	1702
Congo, Rep.	2005, 2011-2012	2906	2912
Congo, Dem. Rep.	2007, 2013-2014	4488	6680
Cote d'Ivoire	1994, 2011-2012	2695	3005
Ethiopia	1992, 1997, 2003, 2008	9514	14,372
Gabon	2000-2001, 2012	2472	2497
Ghana	1993-1994, 1998-1999, 2003, 2008, 2014	5552	6793
Guinea	1999, 2005, 2012	4430	5395
Kenya	1993, 1998, 2003, 2014	8886	12,532
Lesotho	2004-2005, 2009-2010, 2014	3686	3523
Liberia	2006-2007, 2013, 2019-2020	4563	4686
Madagascar	1992, 1997, 2003-2004, 2008-2009	6683	8676
Malawi	1992, 2000, 2004-2005, 2010, 2015-2016	11,440	15,856
Mali	1995-1996, 2001, 2006, 2012-2013	7923	11,903
Mozambique	1997, 2003-2004, 2011	5642	6632
Namibia	1992, 2000, 2006-2007, 2013	5311	4384
Niger	1992, 1998, 2006, 2012	5350	8716
Nigeria	1990, 2003, 2008, 2013, 2018	23,703	30,329
Rwanda	2000, 2005, 2010-2011, 2014-2015, 2019-2020	10,946	16,569
Senegal	1992-1993, 2005, 2010-2011, 2012-2014, 2015-2016, 2017, 2018, 2019	15,958	23,301
Sierra Leone	2008, 2013, 2019	6541	6113
South Africa	1998, 2016	4090	2986
Tanzania	1991-1992, 1996, 2004-2005, 2009-2010, 2015-2016	8549	11,568
Gambia	2013, 2019-2020	3127	4266
Togo	1998, 2013-2014	3125	4497
Uganda	1995, 2000-2001, 2006, 2011, 2016	7178	10,448
Zambia	1992, 1996-1997, 2001-2002, 2007, 2013-2014, 2018-2019	8773	12,558
Zimbabwe	1994, 1999, 2005-2006, 2010-2011, 2015	6086	13,232

Notes: To be included, surveys must have relevant variables and allow mother-child linkage; countries must have >1 survey meeting these criteria.

Table A2: 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	256,066	0.67	1.26	1.11	0.05	0.08	15.41	1.12	0.05	0.06
25-29	236,958	0.88	2.60	2.28	0.39	0.73	18.43	1.39	0.39	0.57
30-24	190,154	0.94	3.89	3.36	0.67	1.59	21.76	2.07	0.67	1.29
35-39	161,085	0.96	5.03	4.25	0.75	1.86	26.22	3.26	0.75	1.57
40-44	122,164	0.97	5.83	4.82	0.73	1.73	30.87	4.69	0.73	1.48
45-49	100,822	0.97	6.38	5.10	0.64	1.38	35.68	6.13	0.64	1.19

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

Table A3: 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	5.35	4.97	5.40	5.91	5.40	4.57	5.52	6.39
Surviving children at age 40	4.54	4.25	4.61	4.87	4.58	4.04	4.63	5.26
Ideal number of children	5.81	5.11	5.84	6.56	6.00	4.85	5.98	6.86
Woman grades completed	4.06	1.69	3.57	5.56	4.04	1.35	3.74	6.23
Child school enrollment	0.80	0.73	0.82	0.83	0.80	0.73	0.84	0.95
Child grades completed	2.71	2.22	2.65	3.39	2.70	2.05	2.67	3.42
B. Rates of change, all women and their children								
Children ever born at age 40	-0.049	-0.030	-0.050	-0.074	-0.042	-0.014	-0.048	-0.075
Surviving children at age 40	-0.020	-0.002	-0.018	-0.036	-0.015	0.013	-0.018	-0.045
Ideal number of children	-0.039	-0.021	-0.039	-0.061	-0.038	-0.012	-0.037	-0.062
Woman grades completed	0.099	0.061	0.097	0.137	0.096	0.027	0.091	0.153
Child school enrollment	0.008	0.004	0.007	0.012	0.008	0.003	0.007	0.013
Child grades completed	0.040	0.021	0.038	0.048	0.038	0.015	0.038	0.058

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.

Table A4: Fertility and Child Education, Excluding Women and Children who Ever Moved

	National cohort averages		Regional cohort averages	
	(1)	(2)	(3)	(4)
A. Child enrollment				
Children ever born at 40 (N = 88,110)	-0.159**	-0.009	-0.122**	0.004
	[0.028]	[0.013]	[0.018]	[0.007]
Surviving children at 40 (N = 88,110)	-0.109*	0.027	-0.067**	0.009
	[0.045]	[0.019]	[0.022]	[0.007]
Ideal number of children (N = 76,518)	-0.105**	-0.028	-0.087***	-0.013**
	[0.016]	[0.016]	[0.011]	[0.004]
B. Child grades completed				
Children ever born at 40 (N = 88,110)	-0.697**	-0.098	-0.569**	-0.062**
	[0.094]	[0.078]	[0.067]	[0.012]
Surviving children at 40 (N = 88,110)	-0.525*	0.028	-0.373**	-0.059*
	[0.222]	[0.110]	[0.116]	[0.027]
Ideal number of children (N = 76,518)	-0.309**	-0.213**	-0.305**	-0.083**
	[0.110]	[0.051]	[0.050]	[0.026]
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

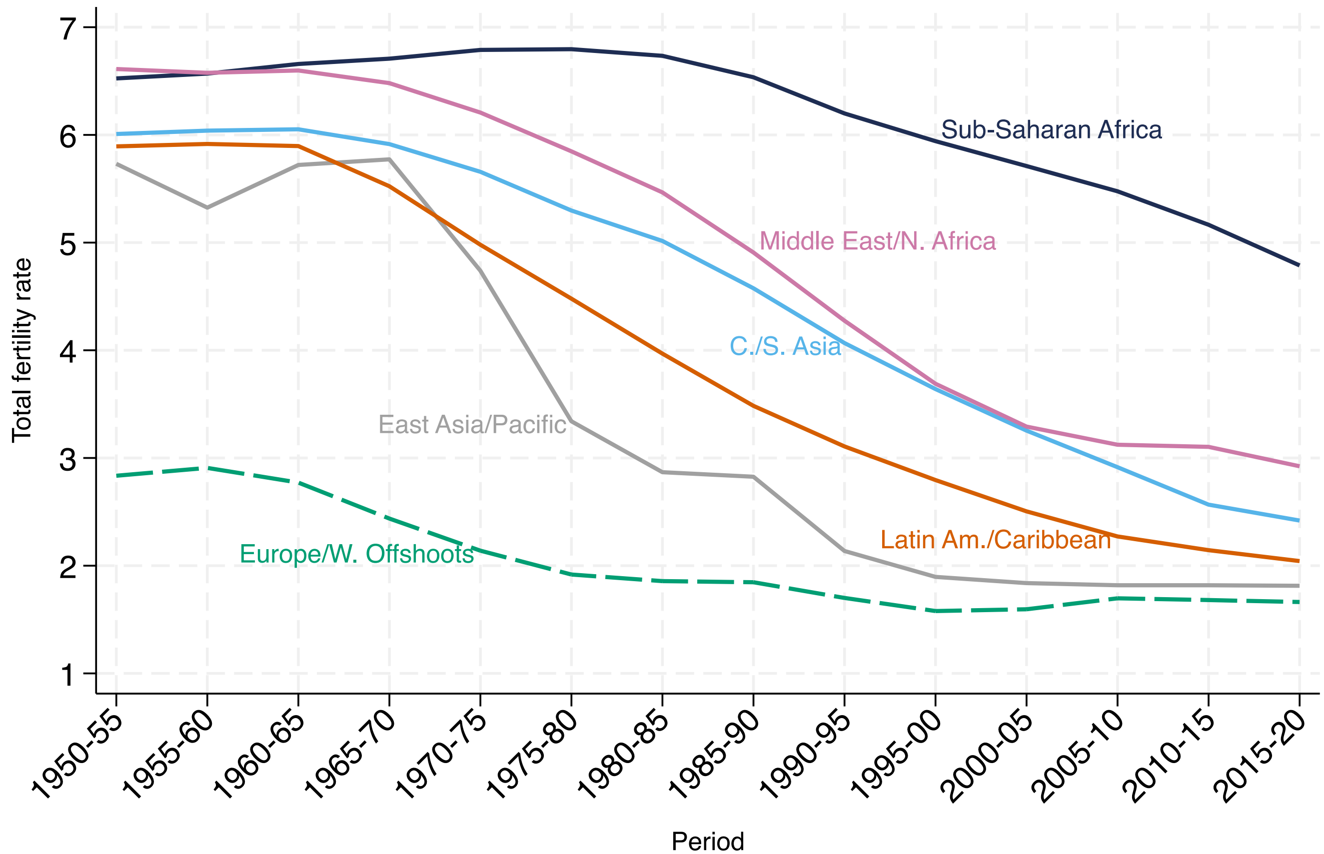
Notes: Re-estimation of Table 2 using only women who report living in the same place their whole lives, in the surveys that ask about lifelong place of residence. Each coefficient is from a separate regression of the specified fertility outcome on the specified child education covariate and the specified 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 A5: Fertility and Child Education, Including Children of Non-Sample Mothers

	National cohort averages		Regional cohort averages	
	(1)	(2)	(3)	(4)
A. Child enrollment				
Children ever born at 40 (*N* = 718,091)	-0.123**	-0.003	-0.100**	0.0030
	[0.025]	[0.008]	[0.015]	[0.0022]
Surviving children at 40 (*N* = 718,091)	-0.122**	0.009	-0.089**	0.0038
	[0.040]	[0.010]	[0.020]	[0.0024]
Ideal number of children (*N* = 513,948)	-0.089**	-0.004	-0.082**	-0.0020
	[0.013]	[0.007]	[0.008]	[0.0018]
B. Child grades completed				
Children ever born at 40 (*N* = 718,091)	-0.448**	-0.076**	-0.430**	-0.016*
	[0.085]	[0.026]	[0.049]	[0.007]
Surviving children at 40 (*N* = 718,091)	-0.457**	-0.040	-0.410**	-0.021*
	[0.131]	[0.031]	[0.075]	[0.010]
Ideal number of children (*N* = 513,948)	-0.213*	-0.076*	-0.265**	-0.025**
	[0.083]	[0.031]	[0.044]	[0.008]
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

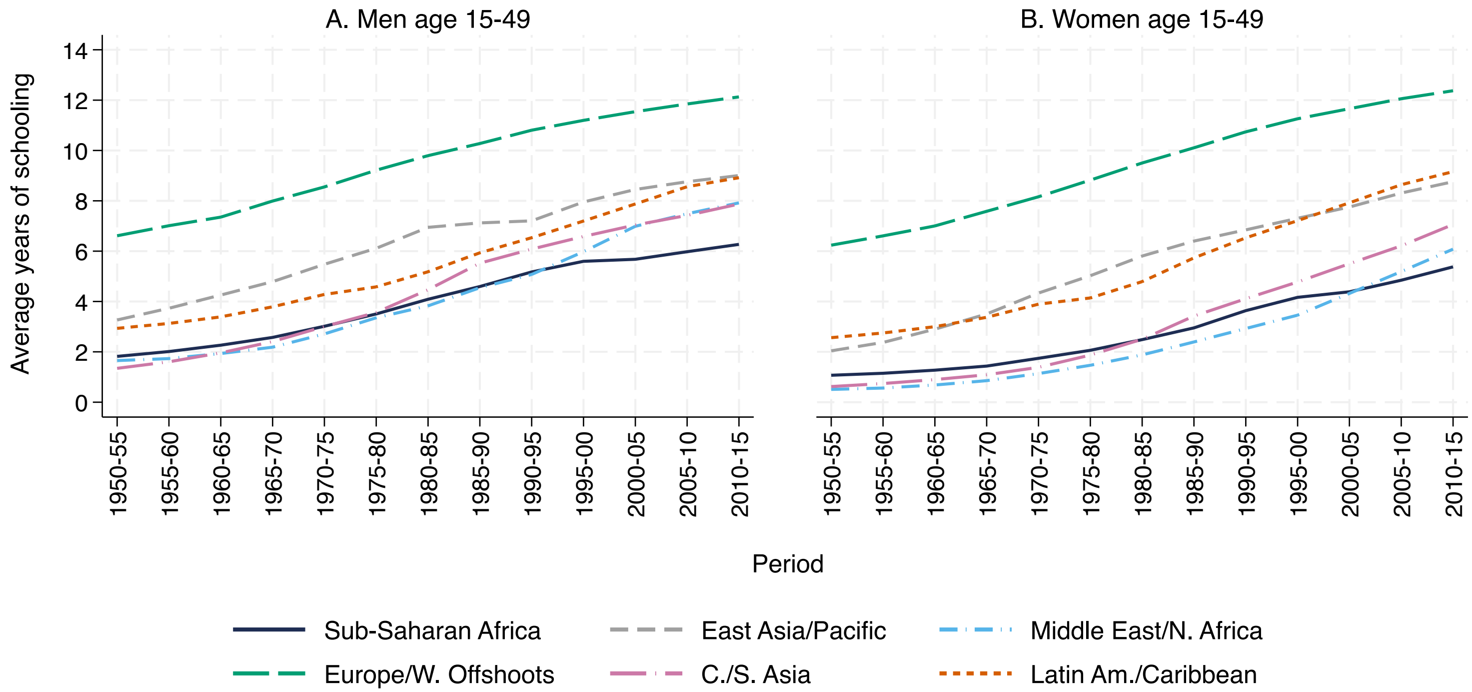
Notes: Re-estimation of Table 2 including children with mothers not in the fertility sample, either because they were not interviewed or because they were less than 40 at the time of the interview. Each coefficient is from a separate regression of the specified fertility outcome on the specified child 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

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



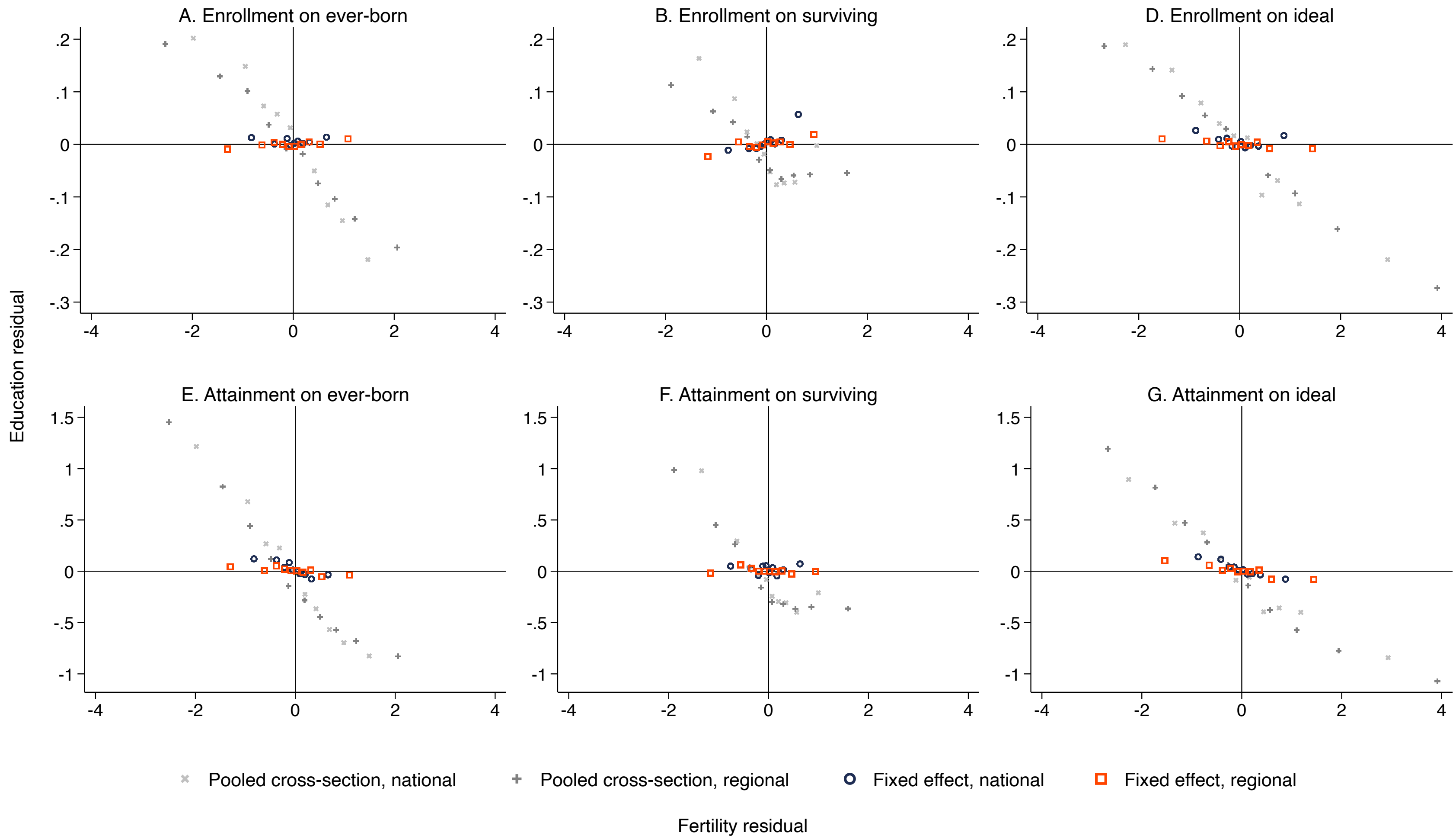
Notes: Population-weighted average total fertility rates across 235 countries. Source: United Nations, Department of Economic and Social Affairs, Population Division. (2019). *World Population Prospects 2019*, Volume I: Comprehensive Tables.

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



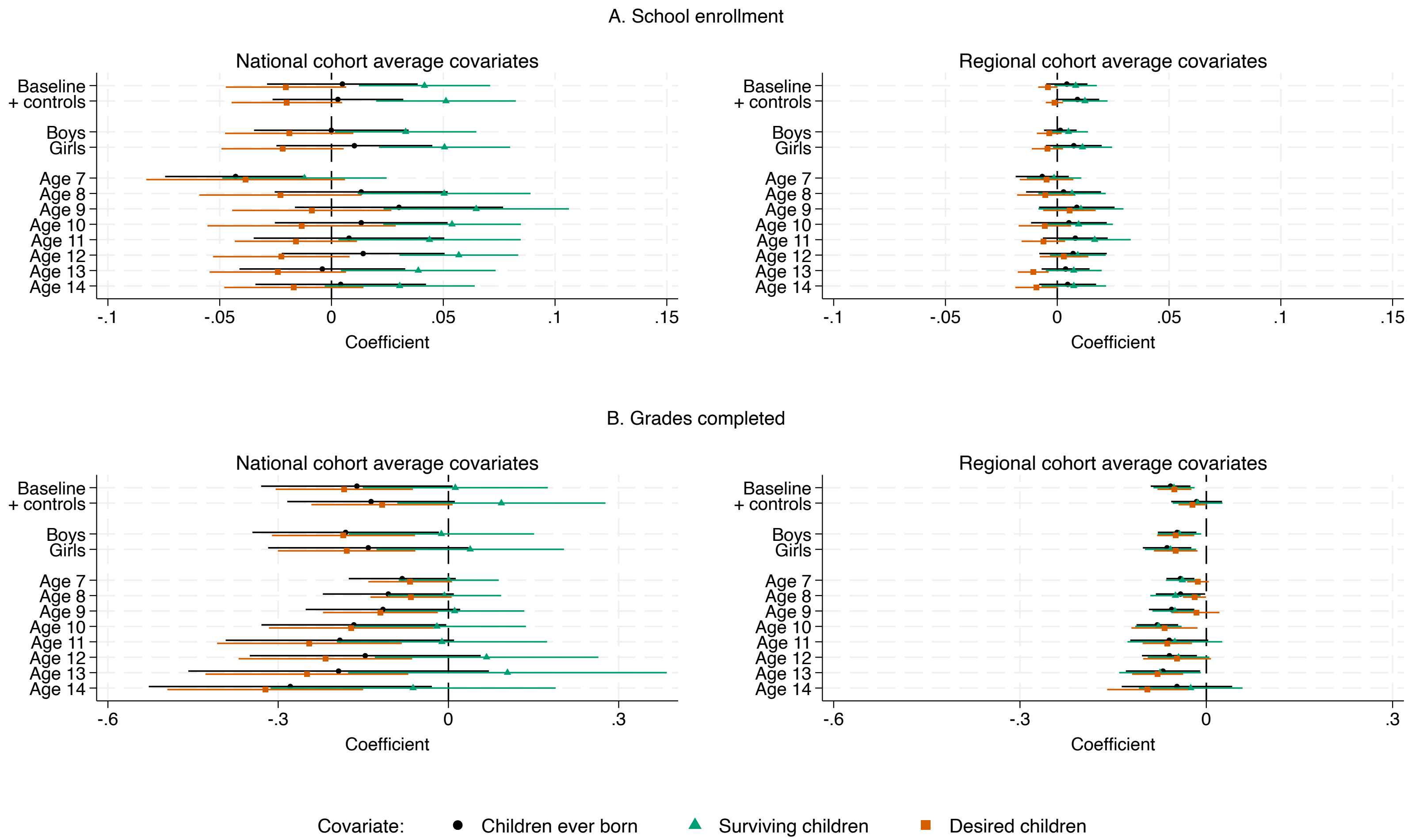
Notes: Population-weighted average years of schooling across 146 countries. Source: Barro, Robert, and Jong-Wha Lee. (2013). "A New Data Set of Educational Attainment in the World, 1950-2010." *Journal of Development Economics* 104: 184-198.

Figure A3: 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.

Figure A4: 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.