REGIONAL EDUCATIONAL OPPORTUNITIES AND FERTILITY RESPONSES IN DEVELOPING COUNTRIES

by

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This research examines the relationship between regional educational opportunities and the fertility decisions of women. Since the announcement of the Millennium Development Goals by the United Nations in 2000, global schooling levels have risen at an increased rate. This thesis looks at the fertility responses of women who are not themselves beneficiaries of increased educational opportunities in their regions, but whose future children will be. The theoretical framework for this leads to an ambiguous conclusion, calling attention for the need of an empirical examination of this issue. Utilizing survey data from 30 countries, an inverse relationship is found between regional educational opportunities and fertility.

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Abbreviations

DHS	Demographic and Health Surveys
IIASA	International Institute for Applied Systems Analysis
MDG	Millennium Development Goal
ODA	Official development assistance
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary least squares
PPP	Purchasing power parity
PWT	Penn World Tables
UN	United Nations
UNDP	United Nations Development Programme
UPE	Universal primary education
USAID	United States Agency for International Development
VID	Vienna Institute of Demography

INTRODUCTION AND BACKGROUND

Parents face a tradeoff between the number of children they have and the resources they can devote to each of those children. Fertility rates, as measured by the number of children per woman, remain particularly high in the developing world. This thesis tests the relationship between regional education conditions in 30 developing countries and the fertility decisions of women in those regions. Most economic research examining education and fertility has focused on the impact that increasing an individual's education level has on their own fertility decisions. This research chooses to examine education and fertility through the lens of the parent's quantity-quality tradeoff, a so far largely overlooked aspect of both household and development economics.

Fertility rates have been of interest to economists since at least the time of Thomas Malthus (1826). Malthus created a model in which a limited amount of resources in the world is divided among an increasingly large population. Malthus envisioned a disastrous situation in which too large a population would lead to universal poverty as the amount of global resources could not support so many individuals. While Malthus' model has been discredited for overlooking technological advances that would lead to an increase in resources, an interest in the economic consequences of population growth has not disappeared. Modern development economists continue the examination of fertility rates.

In the year 2000 the United Nations (UN) released its Millennium Development Goals (MDGs). These are eight specific, measurable goals for international development aimed at fighting global poverty. This research is in part motivated by the recognition that this year, 2015, was set as the deadline to achieve MDG targets. Among the MDGs is achieving universal primary education (UPE). Left out of the MDGs is any fertility related goal. Assuming that countries did respond to the MDGs, this creates an opportunity to observe how women adjust their fertility decisions to improvements in education when they are not direct beneficiaries.

Millennium Development Goals

The UN General Assembly unanimously adopted the Millennium Declaration in September 2000. UN member nations committed to eight specific time-bound goals, each of which contained quantitative targets by which success would be judged. The MDGs contained no true enforcement or incentive mechanisms and may appear to be purely aspirational at first glance, however they have had an influence in both shaping development policy and achieving outcomes. For example, in 2005 donor countries agreed to provide $50 billion a year to go towards the MDG of fighting extreme poverty and in 2008 committed $16 billion more for MDG initiatives (UNDP 2010). Beyond normal aid flows, wealthier countries have supported the MDGs through debt relief. Developing a global partnership for development is one of the MDGs. A target within this MDG is addressing the debt problems of developing countries. Progress has been achieved in this regard. Debt burdens are significantly lower for developing countries now than at the onset of the MDGs, allowing them to dedicate more resources toward achieving other development goals and enhancing productive capacity rather than exhausting those resources on servicing debt.[1]

The eight MDGs reflect issues seen as critical for the development trajectory of countries. A number of the goals are tied to health issues (for example reducing childhood mortality and

[1] According to the UN's *Millennium Development Goals Report 2014*, the debt burden of developing countries, as measured by the proportion of external debt service to export revenue, was 3.1 percent in 2012. In 2000, this measure was at 12 percent. The success of this target is slightly muted as levels appear to have leveled off.

improving maternal health) and a full list of the MDGs, targets, and indicators is available in the appendix in Table A-3.

2015 was set as the deadline for countries to achieve all eight MDGs. According to the UN's *Millennium Development Goals Report 2014*, the success of the MDGs is mixed. Some targets have been successfully reached (including cutting extreme poverty in half and increasing access to safe drinking water), but most targets remain unmet, though the degree by which varies.

Goal 2 of the MDGs is "Achieve universal primary education". This goal reflects the belief that education is one pillar of development. The UPE goal is unmet globally, but notable progress has been made nonetheless, as discussed later in this paper. The policies to achieve UPE vary, but examples include reductions or removals of user fees, increasing the supply of schools, making primary schooling compulsory, and providing subsidies to impoverished households (UN Millennium Project 2005). Perhaps the simplest of these is the removal of fees combined with compulsory education. In a number of countries this has led to rapid spikes in primary school enrollment (Kattan 2006).[2]

Economic Theory

Becker (1960) constructed a model of household demand for children by applying models of consumer behavior to fertility decisions. In this model, children are goods consumed by parents. The model of household fertility makes several assumptions. First, parents have perfect control over fertility in both the number of children they have and their birth spacing. As a practical matter, this is achieved through modern birth control methods. Second, parents view

[2] An example of a visibly effective national UPE initiative (in this case Tanzania) can be seen in the appendix in Figure A-1.

children as a good which generates utility. Parents derive some pleasure from having children and in this way children are a consumption good. They may also generate income for parents and in this way are a production good. Parents may see investing in their children's education as generating a payoff later. This would encourage parents to value educated and uneducated children differently depending on returns to education. Several other factors would influence their preferences to include personal and community tastes, discount factors, knowledge of and access to birth control, and potential labor needs.

A quantity-quality tradeoff model building off this was then constructed by Becker and Lewis (1974). Parents face a tradeoff between the quantity of children they can have and the quality of those children. As they increase the quality of children, the price also increases for each child, assuming quality levels are constant across children. They face the following budget constraint:

$$(1)\ I = (p * C) + p_0(q * N)$$

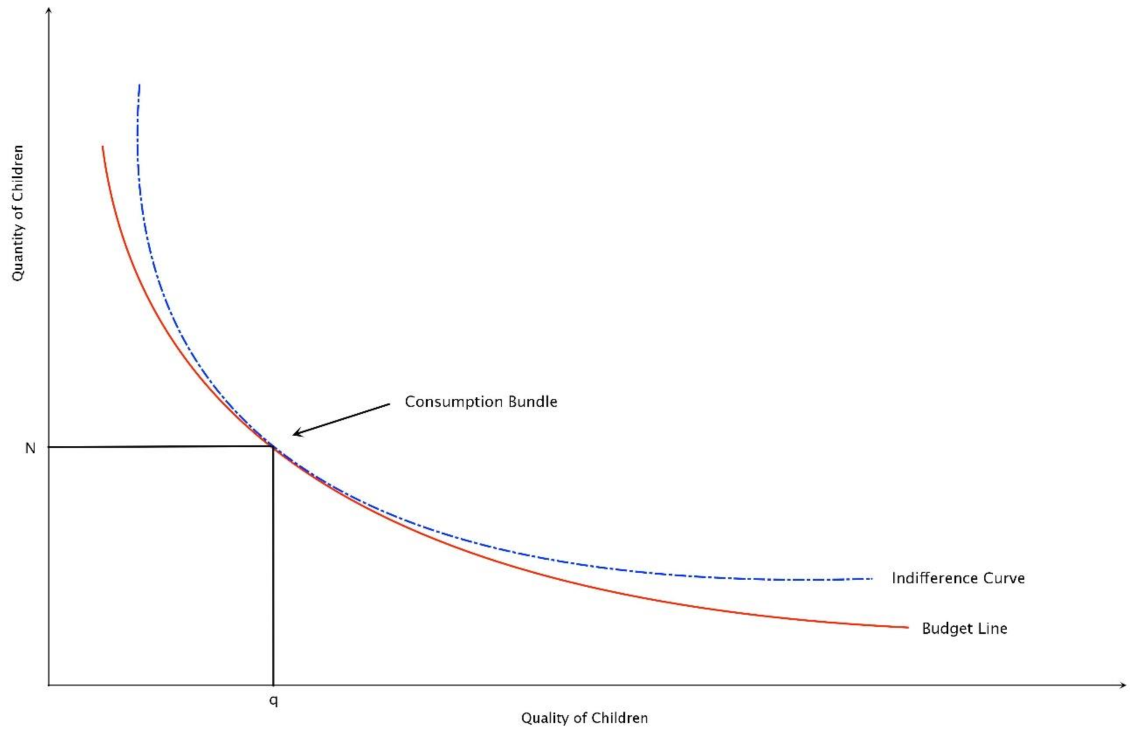
In this I is parental income. C is a composite good and p is the price of that composite good. q is the quality of children, N is the quantity of children, and p_0 is the price of $q*N$.

Solving this equation for number of children we get the following:

$$(2)\ N = \frac{I - (p * C)}{p_0 * q}$$

This can be represented graphically as such:

Figure 1: Quantity-Quality Tradeoff in Children

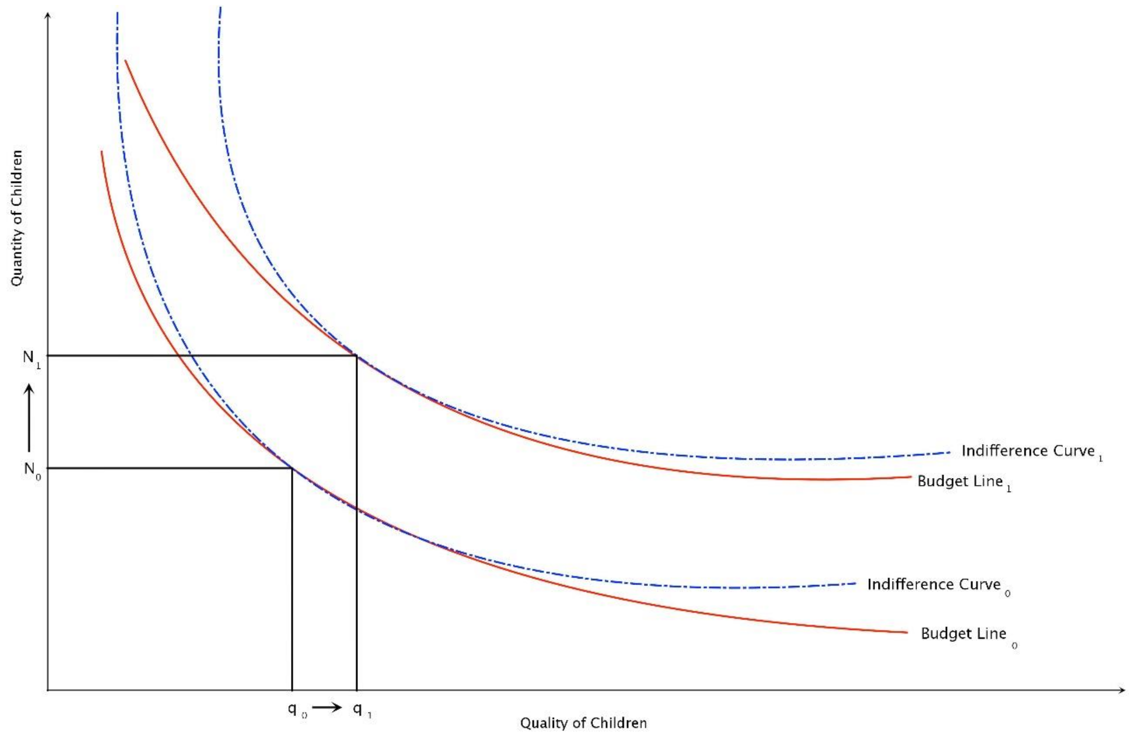


UPE reforms lower the cost of educating children (increasing quality) p_0. This moves the budget line up graphically. This model leads us to an ambiguous result with regards to child quantity *N* as quality *q* increases as a result of UPE. Theoretically, parents may choose either to increase or decrease their fertility levels with this shift in the budget line. This is because of the unknown slope of the indifference curve and the curved slope of the budget line, given below:

$$(3)\ \frac{dN}{dq} = -\left[\frac{I-(p*C)}{p_0}\right]\frac{1}{{p_0}^2}$$

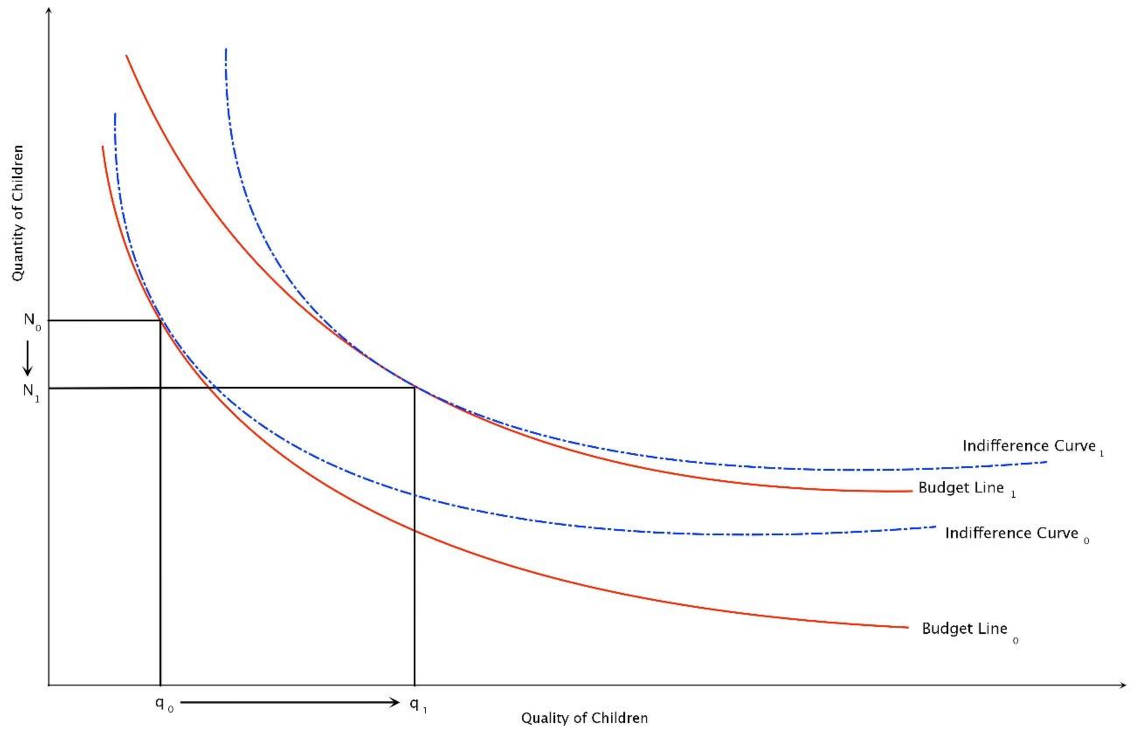
The differing outcomes can be demonstrated graphically:

Figure 2: Quantity Increase with Quality Increase Resulting from UPE



In this case we observe that quality of children and quantity of children have both increased in response to the rotation of the budget line.

Figure 3: Quantity Decrease with Quality Increase Resulting from UPE



In this case we observe that quality of children has increased while quantity of children has decreased. The rotation of the budget line is the same as in Figure 2, however a different set of indifference curves is represented. These theoretical results are ambiguous, indicating the need to examine the relationship empirically.

Universal primary education and similar reforms which have several potential effects within this model. UPE lowers the cost of education, which is considered to be a part of the cost of quality. Quality children are now less expensive and more of can potentially be had with the same income. Parents' real incomes have increased. Because of this parents may choose to invest in a greater quantity of children or fewer children of greater quality.

Graphically this change in real income would be represented by an outward pivot of the budget constraint line along the X axis. Parents would move to a higher indifference curve, which may or may not change the quantity of children depending on income and substitution effects. What we are ultimately concerned with in this study is measuring the change in quantity with a change in price ($\frac{dN}{dp_0}$).

A strong social safety net may lead to less demand for children. Parents may view children as a future source of support in old age (Leibenstein 1975). In countries with a strong old age insurance system the burden of supporting the elderly shifts from their children to the state, explaining one possible source of variation in fertility rates between the developed and developing worlds. The growth of formal support structures in these countries may influence fertility rates in a noticeable manner and will be a consideration in model specification.

Beyond the intensive margin impacts (quantity of children), changes in education may also have an impact at the extensive margin (whether or not to have any children). Based on theory, it can be expected that lowering the cost of education could increase the portion of women who choose to have children as women see that the cost of children decreases.

Empirical Findings

The inverse correlation between development (typically represented by a country's GDP per capita) and fertility (represented by the number of children per woman) is clearly borne out by data. A debate concerns which direction the causality lies. Does high fertility cause poverty? Does poverty cause high fertility? Is there another variable connecting the two? These questions have been asked by researchers on both a micro and macro level.

Brander and Dowrick (1994) find that birthrate declines precede economic growth increases. Their work indicates that high birth rates are the cause of lagging economic growth rather than a symptom of it. This research shows that as birth rates decline, the rate of income growth increases in the medium-term; the causal relationship goes from fertility to income.

Other works are more ambiguous in their findings regarding causality. Herzer, Strulik, and Vollmer (2012) find that growth of income leads to a decline in fertility rates. However, they are clear that causality can go both ways, as a "virtuous cycle of demo-economic development" occurs.

Recent work by Aaronson, Lange, and Mazumder (2014) found that increases in schooling opportunities in the United States a century ago led to decreases in intensive margin fertility measures and increases at the extensive margin for the cohort of potential mothers that were not beneficiaries of expanded education. These two effects were essentially offsetting. For women who were beneficiaries of expanded education, there were declines at both margins.[3] Since developing countries in this current era face some of the demographic transitions that were occurring in the United States during the earlier period, a similar result may be expected to emerge.

Implications

In relatively poor nations, falling fertility rates can lessen the strain on already limited public resources. A large population is also of concern because of its environmental impact. More births means more people generating waste, using water, and taking up space. As countries come to value the condition of their environment and the global environment more, population growth will demand increased attention.

If UPE leads to a decrease in fertility among non-beneficiary mothers, then UPE can be considered as a policy to reduce fertility in a relatively rapid manner. The traditional view that increasing education leads to a decrease in fertility would lead us to believe that UPE's fertility

[3] The decline at the extensive measure for these younger women did not necessarily reflect a choice to stay childless permanently, but more likely a decision to delay motherhood.

benefits are relatively long run- taking at least a decade to begin to take hold. Viewing UPE as changing parents' fertility decisions based on the quality-quantity tradeoff would imply that the expansion of educational opportunities will pay much more immediate benefits than typically recognized.

Explicit government attempts to curtail population growth have often taken the form of restrictions on the ability of citizens to make personal decisions. China's one child policy is the most visible and well-known of these kinds of policies. This study could show an alternative method of achieving the same goals without using strong government coercion to limit citizens' choices while also encouraging the growth of human capital in the long run.

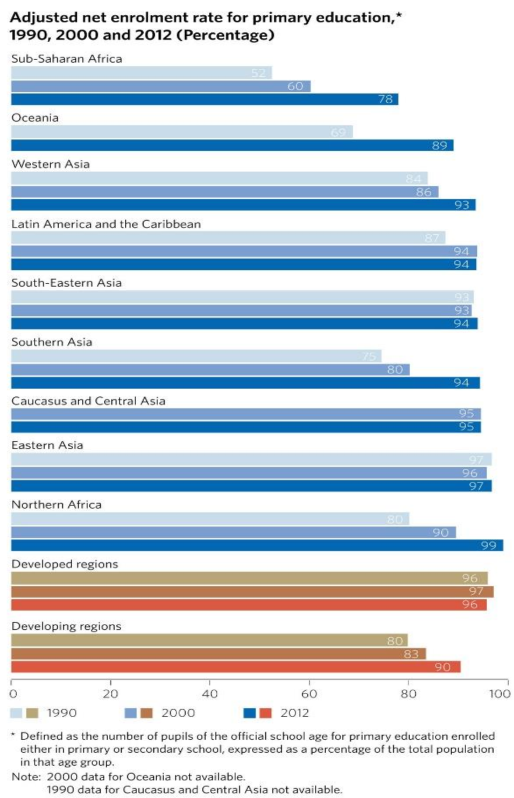
MDGs and Educational Changes

Data indicates that countries have responded to the UPE MDG and enrollment rates in primary education have increased globally. However, despite improvements, "progress in reducing the number children out of school has slackened considerably" since 2007 (UN 2014). It appears unlikely that the UPE MDG will actually be achieved by the 2015 deadline. Despite this shortcoming, the real progress that has been made in education still provides the opportunity for analysis. Figure 4 shows both quantitative changes since the release of the MDGs and the UN's own qualitative measure of success as informed by the quantitative measures. We can see from this that for developing countries, net enrollment rates were at nearly 90 percent for primary school age children in 2012. This is up from 83 percent at the time of the MDG announcement. The poorest performing region in this regard is Sub-Saharan Africa, where the enrollment rate was 78 percent in 2012. Though this is far below the desired level, the region improved in this measure by 18 percentage points since the MDGs, compared to an increase of only 8 percentage points (52 percent to 60 percent) between 1990 and 2000. The UPE MDG has had an impact on schooling levels.

Using data obtained from the World Bank's DataBank we can observe changes in average education levels before and after the announcement of the MDGs. These changes are shown in Figure 5 for the 30 countries that are used in the fertility response analysis to be conducted later in this paper. The graphs here show changes in schooling for two age cohorts, 15-19 year olds and 20-24 year olds. The 15-19 year old cohort can be considered treated by the MDGs. The oldest members of that cohort (19 year olds) would have been primary school age in 2000 and could be beneficiaries of educational improvements resulting from the MDGs. The older cohort may be partially treated, but we would not expect them to see the benefits of UPE to the degree of the younger cohort. We see that both cohorts did broadly see rises in schooling levels between 2000 and 2010. For nearly two thirds of these countries the gains in the MDG period (2000-2010) exceeded those in the pre-MDG period (1990-2000). Those countries that had low baseline levels of education saw greater gains. This indicates a closing of the schooling gap between countries with very low education levels and those with higher levels. When we compare the cohorts against each other we see that the closing of this gap is stronger in the younger cohort as we would expect if they are the main beneficiaries of UPE initiatives.

Looking at national level data, most countries within the 30 country sample that is used later for analysis of fertility response saw gains in overall schooling levels between 2000 and 2010 for the younger UPE beneficiary cohort (Figure 5) (Barro and Lee 2010). For comparison, the same measure is examined in the 10 years prior (1990-2000). More countries increased schooling levels during the MDG period (post-2000) for both age groups than in the prior period. Those countries that had the lowest starting levels of education in 2000 generally saw the biggest gains and did not see losses. This progress demonstrated at the national level indicates the viability of this research and the need for local level analysis.

Figure 4: UN Enrollment Data



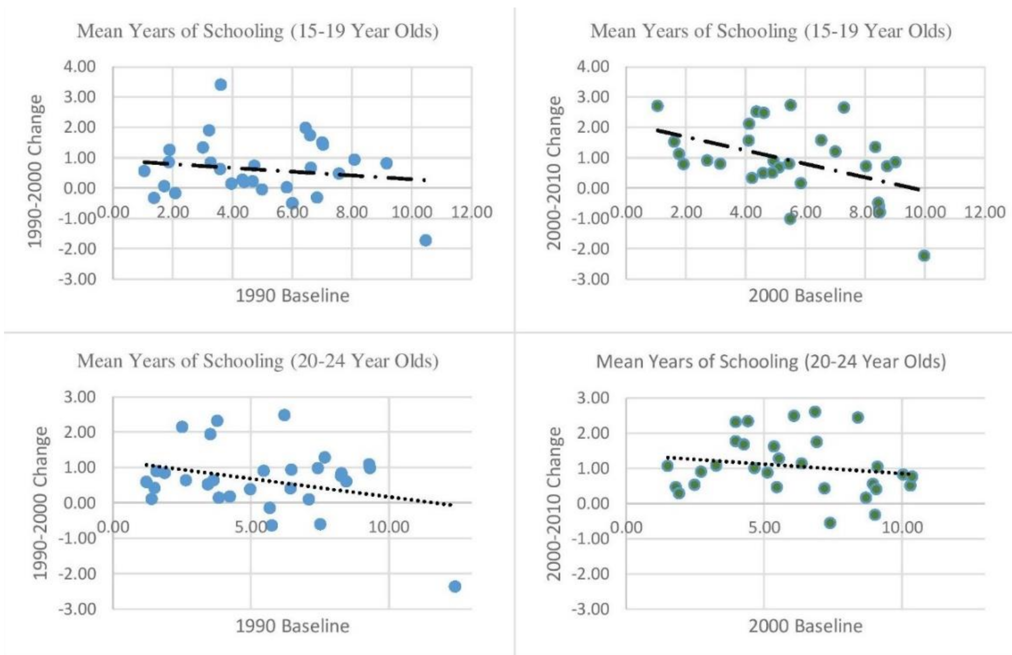
Goals and Targets	Africa: Northern	Africa: Sub-Saharan	Asia: Eastern	Asia: South-Eastern	Asia: Southern	Asia: Western	Oceania	Latin America and the Caribbean	Caucasus and Central Asia
GOAL 2 | Achieve universal primary education									
Universal primary schooling	high enrolment	moderate enrolment	high enrolment	high enrolment	high enrolment	high enrolment	moderate enrolment	high enrolment	high enrolment

The progress chart operates on two levels. The words in each box indicate the present degree of compliance with the target. The colours show progress towards the target according to the legend below:

- Target already met or expected to be met by 2015.
- Progress insufficient to reach the target if prevailing trends persist.
- No progress or deterioration.
- Missing or insufficient data.

Sources: United Nations *Millennium Development Goals Report 2014 / Millennium Development Goals: 2014 Progress Chart*

Figure 5: Changes in Mean Years of Schooling by Age Group and Time Period[4]



Having demonstrated that countries have increased their schooling levels and that there has been some response to the MDG, we examine the factors behind educational improvement at a subnational level. As detailed later, the 30 country sample used for fertility response analysis is subdivided into a total of 218 districts. In each of these districts a measure of expected education was constructed using data from the Demographic and Health Surveys (DHS) by taking the weighted mean years of schooling from all 15 year olds in a given district in surveys before and after the announcement of the MDGs. 15 year olds were chosen for this measure because they would have been old enough to be beneficiaries of UPE reforms in the second survey period, but generally too young to have begun making fertility decisions.[5] Improvement

[4] For source data, see Table A-2 in the Appendix

[5] Since the smallest gap between DHS surveys is 8 years, any 15 year old in the post-period could be expected to have been full treated if countries responded quickly to the MDGs. A 15 year old in 2008 (the earliest follow-year) would have been 7 years old and in primary school at the time the MDGs were released.

in education within a district was then measured by taking the difference between the later expected schooling and the pre-MDG expected schooling.

By regressing the change in schooling between survey periods within a district on the initial schooling level in that district and controlling for other factors we can test whether or not the relatively simplistic results observed in Figure 5 hold up to stricter scrutiny at a subnational level. Table 1 demonstrates that this is the case. We find that for each additional year of baseline schooling, districts see a decrease in the difference in schooling levels (*Schooling Change*) of slightly less than 1 year of schooling. This coefficient is highly statistically significant. The negative effect shows that higher baseline levels of schooling within a district were associated with smaller gains, all else equal. This result indicates the closing of the schooling gap at the district level. This could be attributed to several factors. Areas with high initial levels of schooling may have already been approaching UPE and this natural limit meant no possibility of real growth. Also, these districts could see increasing marginal costs for each additional amount of schooling. At the lower end, districts may have been totally lacking education and could benefit from increasing marginal returns. Other factors, to include GDP, relative regional wealth[6], and foreign aid (ODA), were also significant, but positive.

[6] Relative wealth is measured using the DHS wealth index. This measure indicates a household's living standard based on factors including ownership of certain items, water access, and the construction materials of housing. All of these factors are addressed by DHS survey questions. The weighting of different factors varies by country, meaning that a wealth index score reflects the living standard of a household compared to households in the same country.

Table 1: Educational Improvement Factors

	(1) Schooling Change	(2) Schooling Change	(3) Schooling Change
Initial Expected Schooling	-0.729***	-0.530***	-0.875***
	(0.0693)	(0.0587)	(0.0574)
Years Between Surveys	-0.744***	0.0307	-1.221***
	(0.202)	(0.0297)	(0.285)
Log(Per Capita GDP)		0.700***	0.853***
		(0.149)	(0.207)
High ODA Recipient		0.553***	0.991***
		(0.125)	(0.150)
Wealth Index			0.973***
			(0.183)
Urban			0.376
			(0.335)
Country Fixed Effects	Yes	No	Yes
Observations	218	218	218
Adjusted R^2	0.702	0.504	0.810

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Standard errors clustered by region

METHODOLOGY OVERVIEW

Statistical Techniques

The primary quantitative technique that is used to examine the relationship between UPE and fertility in this research is regression analysis. This technique seeks to explain movements in one variable (dependent variable) as a function of the movements of other variables (independent variables). This is quantified in a single equation. A simple linear regression with a single independent variable could be represented as follows:

$$Y_{itl} = \beta_0 + \beta_1 X_{itl} + u_i$$

In this equation Y_{itl} is the i^{th} observation of the dependent variable at time t in location l and X_{itl} is the i^{th} observation of the independent variable at time t in location l. β_0 is a constant, or intercept, within the model. β_1 is the parameter which tells how Y_{itl} is influenced by X_{itl}. u_i is a disturbance term that recognizes that Y_{itl} is not perfectly explained by X_{itl}.

Econometric Strategy

The data used for this study is repeated cross-sectional information on women's fertility, as measured by total children ever born and births in the previous five years. Details on the dataset and its sources are explained later. To measure the average effect of expected schooling in a district on fertility rates data cells were constructed based on cohorts of women in region r of country c at time t. Because there are 218 regions in dataset, this meant the creation of 436 cells. Once this was constructed, cells were weighted according to size and the following equation was estimated using ordinary least squares (OLS):

$$(1)\ log(Fertility_{rct}) = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rct} + a_r + a_t + a_{t-s} + \varepsilon_{it}$$

In this equation and those that follow, the outcome variable *Fertility* can represent two measures. The first is the total number of children ever born to a woman. This provides us with a measure of long-term fertility. The second measure is the total number of times a woman has given birth in the last five years. This provides us with a relatively short-term measure of fertility. We include this because we would expect it to be more responsive to recent changes in the independent variables. In all regressions we take the log of these fertility measures so that coefficients can be interpreted as having a percent change effect on fertility rather than changing fertility in levels. The variable $log(Fertility_{rct})$ represents the log of the particular fertility measure for women in a given cohort. The variable $ExpSchooling_{rct}$ represents the expected schooling level for children in a given cohort. The construction of the measure is described above. X_{rct} represents time varying national and demographic controls. The set of national level controls includes the log of per capita GDP, the portion of the population that is working, and the portion of GDP that government spending accounts for. All of these measures are for country c at time t. The demographic controls include the average age, average years of schooling, portion of urban residents, and portion of married respondents for women in region r at time t. By controlling for schooling here, it is possible to separate the effects of a woman's own education on her fertility choices from the effects of the expected education that her child will be receiving. a_r represents region fixed effects. a_t represents year fixed effects. a_{t-s} represents fixed effects for the time between time t and the initial survey year s. This has been included since the gap between DHS survey years in the sample varies. For cells in the initial survey year *t – s* will equal 0, for all other cells the value is between 8 and 16.

The coefficient of interest is β_1, which estimates the impact of an additional year of expected schooling in a region on the fertility rate in that region in percentage change terms. A positive β_1 would indicate that increasing schooling by an additional year is associated with an increase in the total fertility rate in that region. A negative β_1 coefficient would indicate an inverse relationship between regional expected schooling levels and fertility rates.

The above regression only takes into account differences between women in different regions. However, it can be expected that regional differences are not all that we should consider in constructing cells. Different age groups would likely respond differently to expected schooling levels in their regions. For this reason age cohorts were used to create cells in a manner consistent with that used to obtain average effects above. Women were placed in age cohorts based in five year intervals starting with 20-24 year olds and going up to 45-49 year olds. Thus, cells contained all women in age group *g* in region *r* in country *c* at time *t*. This created 2180 cells of various sizes. Cells were weighted according to size and the following equation were then estimated using OLS:

$$(2)\ log(Fertility)_{rctg} = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rctg} + a_r + a_t + a_{t-s} + a_g + \sum_g \beta^g (a_g * ExpSchooling_{rct}) + \varepsilon_{it}$$

The outcome variables and national level controls are the same as above. a_g represents age group fixed effects. Because this is included, age is dropped from the demographic controls.

Age group fixed effects are also interacted with expected schooling levels. This model will indicate whether different age groups actually do respond differently to the expected schooling level in their district. For each age group, other than a reference group, we are given a coefficient β^g. That coefficient is then added to the coefficient β_1 to give us the overall effect of expected schooling on a particular age group. For the reference group, β_1 is this estimated effect (we could also think of this as β^g equaling zero for the reference group. For the estimates in this study, the reference group is the youngest cohort.

Just as age groups would be expected to respond to schooling differently, effects could be expected to vary with education cohorts. Women were divided in three terciles based on their years of schooling. This created a low education cohort, a medium education cohort, and a high education cohort. Cells based on these three groups were then created for each region *r* in each country *c* in time *t*. There were 1308 cells created by this. Cells were weighted according to size and the following equations were then estimated using OLS for each educational tercile *e*:

$$(3)\ log(Fertility)_{rcte} = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rcte} + a_r + a_t + a_{t-s} + \varepsilon_{it}$$

In addition to this, a similar model was constructed to analyze all three terciles together:

$$(4)\ log(Fertility)_{rcte} = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rcte} + a_r + a_t + a_{t-s} + a_e + \sum_e \beta^e (a_e * ExpSchooling_{rct}) + \varepsilon_{it}$$

The outcome variables and national level controls remain the same as above. a_e represents educational cohort fixed effects. Because this is included, schooling is dropped from the demographic controls. Age is included with demographic controls. Education cohorts are also interacted with expected schooling levels. Like the age cohorts model, we will add the β^e coefficients to β_1 and this will be interpreted as the effect of expected schooling on that cohort *e*. The reference group in this model is the low education cohort. This model will indicate whether different educational groups respond differently to the expected schooling level in their district.

Finally, to best separate out the impacts of own schooling and regional expected schooling on fertility, cells of women are constructed based on age group and education cohort. Thus a cell now contains women of the same age group, educational level, region, and time period. We estimate the following model:

$$(5)\ log(Fertility)_{rctge} = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rctge} + a_r + a_t + a_{t-s} + a_g + a_e + \varepsilon_{it}$$

This model includes both age group and education cohort fixed effects. The model remains similar to the above ones, though it should be our most powerful model for estimating the impact of expected schooling net of variation in age and education profile. Recognizing that older women in our sample may be outside of their peak fertility years, we consider only the youngest two age cohorts (20-24 year olds and 25-29 year olds) for our measure of short-term fertility in this model.

The regressions thus far have addressed changes at the intensive margins of fertility. The extensive margin is also of interest (Aaronson et al 2014). The cells constructed above based on educational cohort, age group, region, and time period are used in this analysis. The following equation is estimated:

$$(6)\ EverGivenBirth_{rctge} = \beta_0 + \beta_1 ExpSchooling_{rct} + \beta_2 X_{rctge} + a_r + a_t + a_{t-s} + a_r + a_g + \varepsilon_{it}$$

This regression is run separately for women between ages 20 and 29 and those between ages 30 and 49. It is assumed that the younger women are in their peak years for fertility decisions. Older women would have already made fertility decisions at the extensive margin that would not be responding to UPE. The outcome variable $EverGivenBirth_{rctge}$ is a dummy that takes on a value of 1 if a woman has ever given birth and 0 otherwise. When aggregated, it represents the portion of women within a cohort that have ever given birth. The β_1 coefficient can be interpreted as signifying the percent increase in the likelihood of ever having given birth following a one year increase in the expected schooling level in a region. The β_1 coefficient will be positive if more women have any children in response to higher expected schooling in their region. If the coefficient is negative it will indicate that more women choose not to have any children in response to increased schooling in their region. A negative coefficient should be interpreted as indicating possibly delaying fertility decisions and not simply choosing to never have children.

Data

DHS are surveys conducted approximately once every five years in various developing countries. The DHS program is sponsored by the United States Agency for International Development (USAID) and implemented by agencies within the countries where surveys are being conducted. The sample size is typically between 5,000 and 30,000 households. Interview subjects are surveyed on a variety issues, including fertility, education, health indicators, women's empowerment, and more. A standard set of questions is asked in every participating country. A smaller set of country-specific questions are also asked in each country.

This survey is particularly useful for conducting this research because of its large sample size, coverage of relevant issues, and the large amount of historical data. The survey includes data on both the fertility figures and education figures that are necessary to examine the relationship between fertility rates and educational access.

Much of this research examines variables at a regional level. The DHS is statistically representative at the district (or equivalent) level and variables in the fertility response analysis are aggregated at this level. In many cases, the way in which the DHS structured districts changed between surveys. When this occurs, only districts that exist in both datasets are included.

When surveys are conducted across two years, as was the case for several surveys, the survey was treated as having been conducted in a single year. The choice of year for this was whichever of the two possible years the majority of respondents had been surveyed in. This was done to simplify the aggregation of data.

A shortcoming of the DHS surveys is that they lack specific information about local education infrastructure. While the surveys reveal a great deal about individual education levels, they are not strong indicators of whether or not individuals have access to educational facilities.

To address some of the drawback of DHS data, country level data from the Penn World Table (PWT) and the Organization for Economic Cooperation and Development (OECD) was utilized. PWT includes measures of national income accounts in real purchasing power parity

(PPP) terms over several decades for all countries in this sample. Using PWT, national level comparisons can be made across both time and space in common terms. Further, PWT contains information on employment levels within countries, a potentially useful control. The OECD compiles measures of official development assistance (ODA), a measure of foreign aid. Aid may be given to support educational programs in these developing countries and ODA measures were included in the earlier analysis of regional education level changes.

National educational improvements were measured using the Barro-Lee educational dataset. This was used to measure gains at a national level between 1990 and 2010. This provides a quick measure of educational changes and the efficacy of any educational reforms. The second aspect of this research, how women respond to education changes, hinges in part on the expectation that there is some variation in education levels and that improvements have occurred. Barro-Lee data was unavailable for certain countries. In these instances data from the International Institute for Applied Systems Analysis/ Vienna Institute of Demography (IIASA/VID) Projections was used. Actual measures of schooling in 1990 and 2000 and projections of 2010 were used from this.

Country Selection and Dataset Construction

Countries were considered for the sample if a standard DHS survey was taken between 1996 and 2000 as well as after 2008, as provides a sufficient time period for countries to respond to the MDGs and implement reforms. Countries that met this DHS criteria were included in the sample if relevant country-level data was available from PWT 8.0 and the OECD statistical database. Based on this criteria, the sample consists of 30 developing countries. The list of countries in the sample is contained in Table A-1 in the appendix.

FERTILITY RESPONSE RESULTS

Average Effects

We can view the average effect of expected schooling on fertility in Table 2. The columns in this table represent regressions run with increasingly stringent sets of controls as you move from left to right across the table. Columns 1 through 4 show results when the log of total children ever born to a woman is used as the outcome variable. Columns 5 through 8 replace the log of total children ever born with the log of children born in the last five years as the outcome variable.

Column 1 is run with only expected schooling as an explanatory variable. Year, measurement gap, and country fixed effects are included in this model. We see that expected schooling is highly statistically significant and negative.

In column 2 region fixed effects replace country fixed effects in the model. No new controls are added. Expected schooling is still highly significant and negative, but the coefficient is smaller than before.

Column 3 adds in national level controls while maintaining region fixed effects as in column 2. We see that the coefficient on expected schooling becomes slightly more negative and stays highly significant.

Demographic controls are added into the equation in column 4. Now that these controls are included, expected schooling is not statistically significant. This large change in the coefficient suggests collinearity between changes in expected schooling and overall changes characteristics of women.

Columns 5 through 8 demonstrate similar results when the outcome variable is changed to the log of children born in the last five years. Whether fertility is measured by total children ever born or births in the last five years, we see no statistically significant result for expected schooling levels when controlling for demographic characteristics (columns 4 and 8).

Age Cohort Effects

Though we have observed that the average effect of expected schooling on fertility is insignificant, we can expect that different age cohorts will respond differently and such analysis may be more informative. Age cohort effects are displayed in Table 3. To preserve space, this table only includes models run with the most stringent set of controls as established in Table 2 (region fixed effects, national controls, demographic controls). Thus, columns 1 and 2 correspond most closely to column 4 in Table 2. The difference between columns 1 and 2 is the inclusion of interaction terms. The reference group for this table is the 20-25 year old age group of women.

Column 1 considers the fertility rate as measured by total births and contains only group dummies for age cohorts. We see a statistically significant result here for expected schooling. In this model, an additional year of expected schooling in a region leads to a 2.6 percent decrease in total fertility. When the model is expanded to include interactions between age groups and expected schooling we find that the expected schooling variable is no longer significant (column 2). However, each interaction term is significant and negative.

It may be that the expected schooling coefficient in column 2 is insignificant because of collinearity between education and expected schooling for the reference group. Because this is the youngest group included in these estimations and the structure of this data, some of the women in this age group may have been beneficiaries of education and so their own schooling reflects the expected schooling to some degree.

Columns 3 and 4 show the results for this same model, but using births in the last five years as the outcome variable. When only age group dummies are included, the expected schooling effect on short-term fertility is stronger than on total fertility (column 3).

Education Cohort Effects

Knowing that a woman's own education has a very large impact on fertility decisions, we can view educational cohort effects in Table 4. Educational cohorts' total fertility responses are estimated separately from each other in columns 1, 2, and 3. Column 4 contains the results when regressions are run using all three educational cohorts and includes interaction terms for education cohorts and expected schooling. In column 4 the reference group is the low education cohort of women. As before, only results using the stringent set of controls are included.

We see that response to expected schooling varies between these cohorts. The low education group sees a 1.9 percent decrease in fertility for each additional year of expected schooling. The medium education cohort does not have a statistically significant response. The response for the high education cohort is a 3 percent decrease. The demographic controls for each group are highly significant.

When all three cohorts are measured together the value of the expected schooling variable is no longer significant. The reference group for this regression is the low education cohort. Though expected schooling was statistically significant for the low education cohort when run in isolation, this coefficient is insignificant when all three groups are run together with the low education cohort as the reference group. This change comes from the coefficient becoming closer to zero while the standard errors remain essentially the same. In this same regression we that the effects of expected schooling are stronger for both the medium and high education groups, though the interaction term is only significant for the medium education cohort.

Age Education Cohort Effects

Considering that controlling for both educational and age cohort effects appears important, we combine the two to create cohorts based on age and education. The results of this are given in Table 5 and provide us with the strongest results. Here we can observe the effect of expected schooling net of any intraregional differences in education and age. We can interpret the coefficient on expected schooling as providing us with the average effect of expected schooling levels in a region for women a particular age and education cohort.

For this table, we again move from least controlled to most controlled model as we move from left to right across the table. We initially run the model with no country or region fixed effects (columns 1 and 6), then run two models using either of these (columns 2, 3, 7, and 8), then run a model with region fixed effects and national level controls (columns 4 and 9), and finally run our most controlled model by including demographic controls (columns 5 and 10).

There is a 2.9 percent decrease in total fertility for each additional year of regional expected schooling (column 5). This effect is highly statistically significant. This tells us that net of any variation in education and age profile within a particular region, we can expect a 2.9 percent decrease in the total fertility rate of a region when expected schooling increases by one year in that region.

We see a similar result in column 8 which measures births in the previous five years for women aged 20-29. An additional year of expected schooling here leads to a decrease of 2.6 percent in the short-term fertility measure and is statistically significant.

These results allow us to conclude that regional expected schooling does in fact have a negative relationship with fertility. Women choose quality children over quantity of children as educational opportunities increase for their children.

Extensive Margin Effects

Table 6 contains results for the analysis of extensive margin effects. The cells here are constructed the same as in Table 5. We are utilizing this structure because, as demonstrated above, it appears to be the best way of determining the effect of expected schooling on our variables of interest. We are most interested in the results for our younger cohort because they are most likely to be in their peak fertility years. The younger group cohort (columns 1 through 4) are in the age range when they are most likely to be potentially engaging in childbearing for the first time. For both of our age cohorts in this table we run regressions ranging from least controlled to most stringently controlled.

We find that for our younger cohort (20-29 year olds) there is a very small inverse relationship between expected schooling levels and having any children (column 4). A slightly less than 1 percent decrease in the portion of young women to have ever given birth occurs when expected schooling in a region increases by one year. Viewing column 8 we see that this effect totally disappears in the older cohort (30-49 year olds). The suggestion here is that some younger women may choose to delay giving birth when expected schooling levels are high, but this effect is largely dominated by other effects and the practical significance is relatively low.

Table 2: Average Effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(Total Kids)				log(Five Year Births)			
Expected Schooling	-0.128***	-0.0786***	-0.0806***	-0.00148	-0.140***	-0.0767***	-0.0768***	-0.0182
	(0.0136)	(0.0132)	(0.0151)	(0.00980)	(0.0180)	(0.0131)	(0.0158)	(0.0114)
Log(Per Capita GDP)			0.00773	-0.135**			-0.0138	-0.207***
			(0.103)	(0.0580)			(0.111)	(0.0760)
Employment Level			0.0614	-0.414			-0.413	-0.737*
			(0.465)	(0.302)			(0.562)	(0.446)
Government Spending Portion			0.485	0.489**			0.750*	0.687**
			(0.362)	(0.211)			(0.386)	(0.293)
Age				0.0512***				-0.0359**
				(0.00933)				(0.0139)
Urban				-0.122**				-0.105
				(0.0552)				(0.0713)
Years of Education				-0.0511***				-0.0661***
				(0.0140)				(0.0161)
Ever Married				0.948***				0.828**
				(0.243)				(0.325)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Measure Gap FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country FE	Yes	No	No	No	Yes	No	No	No
Observations	450515	450515	450515	450515	450515	450515	450515	450515
Cells	218	218	218	218	218	218	218	218
Adjusted R^2	0.811	0.941	0.942	0.979	0.884	0.968	0.969	0.980

Standard errors in parentheses, Standard errors clustered at regional level
Cells constructed using region and time period
Cells frequency weighted
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Age Cohort Effects

	(1)	(2)	(3)	(4)
	log(Total Kids)		log(Five Year Births)	
Expected Schooling	-0.0250***	0.00792	-0.0567***	0.0639***
	(0.00856)	(0.0110)	(0.0203)	(0.0195)
Urban	-0.199***	-0.140***	-0.780***	-0.425***
	(0.0469)	(0.0455)	(0.123)	(0.102)
Years of Education	-0.0290***	-0.0397***	0.0734***	-0.00658
	(0.00666)	(0.00662)	(0.0270)	(0.0238)
Ever Married	1.167***	1.301***	1.024***	1.547***
	(0.0997)	(0.106)	(0.242)	(0.237)
25-29	0.500***	0.588***	0.0459	0.0865***
	(0.0135)	(0.0181)	(0.0357)	(0.0293)
30-34	0.812***	0.990***	-0.148***	0.104**
	(0.0182)	(0.0266)	(0.0502)	(0.0400)
35-39	1.014***	1.215***	-0.478***	0.0359
	(0.0215)	(0.0329)	(0.0633)	(0.0564)
40-44	1.134***	1.368***	-1.106***	-0.266***
	(0.0236)	(0.0377)	(0.0752)	(0.0805)
45-49	1.203***	1.408***	-2.256***	-0.938***
	(0.0255)	(0.0395)	(0.0966)	(0.108)
25-29 * Exp Schooling		-0.0204***		-0.0293***
		(0.00393)		(0.00720)
30-34 * Exp Schooling		-0.0380***		-0.0780***
		(0.00684)		(0.0123)
35-39 * Exp Schooling		-0.0434***		-0.133***
		(0.00870)		(0.0172)
40-44 * Exp Schooling		-0.0497***		-0.194***
		(0.0100)		(0.0220)
45-49 * Exp Schooling		-0.0459***		-0.283***
		(0.0101)		(0.0255)
National Level Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Measurement Gap FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	450515	450515	448711	448711
Cells	1308	1308	1308	1308
Adjusted R^2	0.975	0.978	0.887	0.919

Standard errors in parentheses, Standard errors clustered at regional level
Cells constructed using region, time period, and age group
Cells frequency weighted
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Education Cohort Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	log(Total Kids)				log(Five Year Births)			
	Low Education	Medium Education	High Education		Low Education	Medium Education	High Education	
Expected Schooling	-0.0201**	-0.0142*	-0.0304***	-0.0146	-0.0341**	-0.0221*	-0.0243*	-0.0287**
	(0.00927)	(0.00834)	(0.00844)	(0.00888)	(0.0152)	(0.0122)	(0.0130)	(0.0128)
Age	0.0312***	0.0621***	0.0492***	0.0382***	-0.0986***	-0.0536***	-0.0625***	-0.0826***
	(0.00728)	(0.00621)	(0.00629)	(0.00316)	(0.0122)	(0.00963)	(0.00921)	(0.00625)
Urban	-0.117***	-0.220***	-0.210***	-0.217***	-0.203***	-0.258***	-0.197***	-0.268***
	(0.0375)	(0.0660)	(0.0358)	(0.0320)	(0.0666)	(0.0782)	(0.0661)	(0.0478)
Ever Married	0.993***	0.899***	1.008***	1.309***	1.721***	1.137***	1.369***	2.189***
	(0.265)	(0.237)	(0.106)	(0.0704)	(0.370)	(0.311)	(0.183)	(0.134)
Medium Education				-0.0394*				-0.163***
				(0.0219)				(0.0365)
High Education				-0.342***				-0.430***
				(0.0408)				(0.0643)
Medium Education * Expected Schooling				-0.0110***				0.00579
				(0.00352)				(0.00558)
High Education * Expected Schooling				-0.00277				0.0387***
				(0.00576)				(0.00938)
National Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Measurement Gap FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	163221	143787	143498	450506	163204	143787	143496	450487
Cells	218	218	218	654	218	218	218	654
Adjusted R^2	0.913	0.960	0.984	0.973	0.962	0.970	0.979	0.944

Standard errors in parentheses
Standard errors clustered at regional level
Cells constructed using region, time period, and education cohort
Cells frequency weighted
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Education/Age Cohort Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			log(Total Kids)					log(Five Year Births)		
Expected Schooling	-0.0876^{***}	-0.159^{***}	-0.109^{***}	-0.115^{***}	-0.0291^{***}	-0.0826^{***}	-0.161^{***}	-0.0934^{***}	-0.105^{***}	-0.0262^{**}
	(0.00991)	(0.0178)	(0.0166)	(0.0187)	(0.0093)	(0.0124)	(0.0226)	(0.0170)	(0.0191)	(0.0124)
Urban					-0.215^{***}					-0.109^{**}
					(0.0362)					(0.0466)
Ever Married					1.460^{***}					1.730^{***}
					(0.0651)					(0.0671)
National Level Controls	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Education Cohort FE	No	No	No	No	Yes	No	No	No	No	Yes
Age Group FE	No	No	No	No	Yes	No	No	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Measurement Gap FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Country FE	No	Yes	No	No	No	No	Yes	No	No	No
Observations	450411	450411	450411	450411	450411	192053	192053	192053	192053	192053
Cells	3924	3924	3924	3924	3924	1308	1308	1308	1308	1308
Adjusted R^2	0.089	0.146	0.172	0.173	0.963	0.210	0.421	0.503	0.504	0.894

Standard errors in parentheses
Standard errors clustered at regional level
Cells constructed using region, time period, age group, and education cohort
Cells frequency weighted
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6: Extensive Margin Effects

	20-29 Year Olds (1)	(2)	(3)	(4)	30-49 Year Olds (5)	(6)	(7)	(8)
	Ever Given Birth				Ever Given Birth			
Expected Schooling	-0.0538***	-0.0329***	-0.0401***	-0.0072*	-0.0108***	-0.0062***	-0.0081***	-0.0017
	(0.00713)	(0.00744)	(0.00791)	(0.0041)	(0.00237)	(0.00197)	(0.00243)	(0.0017)
Urban				-0.0247*				-0.0159***
				(0.0137)				(0.0047)
Ever Married				0.763***				0.735***
				(0.0162)				(0.0317)
National Level Controls	No	No	Yes	Yes	No	No	Yes	Yes
Education Cohort FE	No	No	No	Yes	No	No	No	Yes
Age Group FE	No	No	No	Yes	No	No	No	Yes
Measurement Gap FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country FE	Yes	No	No	No	Yes	No	No	No
Observations	192175	192175	192175	192175	274382	274382	274382	274382
Cells	1308	1308	1308	1308	2616	2616	2616	2616
Adjusted R^2	0.338	0.392	0.394	0.950	0.236	0.310	0.311	0.692

Standard errors in parentheses
Standard errors clustered at regional level
Cells constructed using region, time period, age group, and education cohort
Cells frequency weighted
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

DISCUSSION

The results of this research demonstrate that local schooling levels do have some impact on fertility decisions for women in developing countries. At the intensive margin we see that, controlling for their schooling and age, women have fewer children in both the short- and long-term as schooling levels in their regions increase. This provides an empirical response to theoretical ambiguity generated by the Becker and Lewis model.

As educational opportunities expand through measures like UPE, the cost of quality of children decreases and we observe a decrease in fertility at the intensive margin. Quality rises and quantity decreases. At the individual level, this indicates that this smaller group of children should receive more education and can expect greater returns in terms of future income than they would otherwise have. These enhanced returns to the child's income make increased investment in quality, especially if discounted through UPE, the rational choice for parents who expect their children to serve as old age insurance.

The characteristics of individual women play a larger role in their fertility decisions than schooling levels. This is not a surprise. We should expect that women would be more influenced by their own education and age than by educational opportunities of their children. Still, to find that those opportunities can play some role in decision making is a valuable insight. Improving educational opportunities affects outcomes for both beneficiaries (children) and the broader community (mothers). The average annual change in expected schooling for our 218 districts was a gain of 0.11 years of schooling. This means that over the period of a decade the value of expected schooling in the average district increased by slightly over 1 year. All else equal, we would expect the average district to see a drop in fertility of more than 3 percent in response to this. In the initial survey period, the mean number of children ever born to woman was 2.97. In the follow-up period, this value was 2.51 children per woman, a drop of 15.5 percent. Improvements in educational opportunities and a shift towards quality preference may explain much of this change.

The extensive margin effect findings are not completely consistent with other studies of fertility at the extensive margin. Aaronson et al. (2014) found that for older women, the expansion of educational opportunities led to an increase of fertility at the extensive margin. For younger women, they found a result similar to that in this study. The inconsistency between that research and this research may arise because older women in high fertility developing countries are not responding to schooling so much as to other more immediate factors, such as economic conditions, health infrastructure, and cultural norms that diverge from those affecting women in the United States and other developed countries. Still, these results indicate that with a one year increase in regional expected schooling we can expect seven women out of 1000 in peak child bearing years to choose not to have children when they otherwise would. It should also be noted that while extensive fertility rates in the 30 country sample are high compared to developed countries, out of a sample of over 250,000 individuals, 25 percent of women in the younger cohort were childless. This rate of childlessness is higher than might be expected. For the older cohort, the childlessness rate is only 7.3 percent. By not engaging in motherhood at a young age, women can instead potentially enhance their human capital through education or participate in the labor force. These decisions can contribute to female empowerment in areas where opportunities are traditionally limited for women.

One criticism of efforts to increase schooling levels is that while schooling levels are increasing, the benefits are overstated (Pritchett 2013). Simply being enrolled is does not mean that students are learning valuable skills. This research provides one possible counter to that argument. Even if increased schooling in developing countries is not benefitting students to the degree desired, schooling gains provide other benefits. Countries faced with high fertility rates can lessen the burdens of high fertility through expanded education.

Though expected schooling is insignificant in the average effects, we do observe other interesting results. The national employment to population ratio coefficient is highly significant and negative for births in the last five years, but insignificant for total births. This suggests that in the short-term fertility rates are highly responsive to national employment conditions. We might expect this as women find that increased labor opportunities increase the opportunity cost of child rearing and choose to delay having children in order to engage in work. That the total births response to this is insignificant may show that temporal labor conditions do not carry over permanently to fertility decisions and is in keeping with the idea that current labor conditions merely affect the timing of fertility decisions. Whether these results carry over to a more robust test of these effects is worth evaluation. The relationship between unemployment levels, fertility, and health outcomes has been examined in developed countries. This research has indicated that credit constraints are a factor that lead to fertility decreasing as unemployment rises, but for women with increased access to credit fertility rises with unemployment rates (Dehejia and Lleras-Muney 2004). The relationship observed with our DHS data is in keeping with this result. This probably reflects, in part, the poor state of credit markets in the developing world.

This study does encounter limitations with regards to causal interpretations of the results. Though we can say that there is an inverse correlation between regional schooling opportunities and fertility in developing countries, there are several omitted variables that could influence this. It could be that improvements in health infrastructure accompany increases in schooling and that these lead to the reduction in fertility that we observe. If educational gains are accompanied by healthcare gains that lead to decreases in childhood mortality, it could be that some of the effect we are observing is actually parents responding to better healthcare outcomes for the children. Employing a quantity-quality model, a decrease in childhood mortality decreases the expected cost of surviving children (Barro and Becker 1989). If this effect is strong and the change in mortality is relatively large, it could overstate the estimated effect of regional expected schooling. Similarly, decreases could be driven by increased access to contraception. Expanded schooling may be accompanied both by increased physical access to contraception and by increased effectiveness if proper techniques are being taught. Such effects are difficult to determine with the datasets that were used to conduct this study, especially in consideration of its scope. Further study of this issue could focus on specific countries for which these variables could be effectively monitored and controlled for.

Another complication to this may come from the measure of expected schooling. The measure that was constructed here is relatively simplistic. By taking the mean schooling level of 15 year olds we may overlook rapid gains in schooling that are occurring contemporaneously at the primary level. As these 15 year olds are not beneficiaries, this measure would not reflect such a change, though potential mothers could still observe and respond to it. The likelihood of this being a significant issue in this study, particularly considering that the sample consists of 218 districts in 30 countries, is small. Strong pushes for education could have occurred in a few countries or districts, but would be insignificant in the larger context.

Despite these limitations, the results uncovered here appear reasonable and could be expected to hold up if more controls are introduced. As demonstrated, the variables with the strongest impact on fertility were individual characteristics. The introduction of further regional controls may only have a small impact on the estimated effect of expected schooling. The idiosyncrasies of policies in particular countries or regions should have minimal effect on the results with the inclusion of fixed effects in the model. However, further examination of specific cases is worthwhile to establish what practices are most effective with regards to both increasing education and inducing a fertility response. While this work establishes that a connection between the two exists, further research can strengthen our understanding of this connection.

APPENDIX

Table A-1: Sample Countries

Country	Initial Year	Follow Up Year	Years Between Surveys
Armenia	2000	2010	10
Bangladesh	1999	2011	12
Benin	1996	2012	16
Bolivia	1998	2008	10
Burkina Faso	1999	2010	11
Cambodia	2000	2010	10
Cameroon	1998	2011	13
Colombia	2000	2010	10
Comoros	1996	2012	16
Cote d'Ivoire	1999	2012	13
Dominican Rep.	1999	2013	14
Egypt	2000	2008	8
Ethiopia	2000	2011	11
Gabon	2000	2012	12
Ghana	1998	2008	10
Guinea	1999	2012	13
Indonesia	1997	2012	15
Jordan	1997	2012	15
Kenya	1998	2008	10
Madagascar	1997	2009	12
Malawi	2000	2010	10
Mali	1996	2012	16
Mozambique	1997	2011	14
Nepal	1996	2011	15
Niger	1998	2012	14
Philippines	1998	2013	15
Rwanda	2000	2010	10
Tanzania	1999	2010	11
Uganda	2000	2011	11
Zimbabwe	1999	2010	11

Table A-2: Mean Years of Schooling

	15-19 Year Olds						20-24 Year Olds					
Country	**1990**	**2000**	**2010**	**90-00 Δ**	**00-10 Δ**	**Δ2-Δ1**	**1990**	**2000**	**2010**	**90-00 Δ**	**00-10 Δ**	**Δ2-Δ1**
Armenia	10.47	8.75	9.47	-1.72	0.72	2.44	12.42	10.05	10.87	-2.37	0.82	3.19
Bangladesh	3.61	7.01	8.21	3.40	1.20	-2.20	3.78	6.09	8.58	2.31	2.49	0.18
Benin	3.02	4.36	6.87	1.34	2.51	1.17	3.45	3.97	5.74	0.52	1.77	1.25
Bolivia	9.17	9.98	7.75	0.81	-2.23	-3.04	9.33	10.31	10.82	0.98	0.51	-0.47
Burkina Faso *	1.88	2.72	3.63	0.85	0.90	0.06	1.88	2.72	3.63	0.84	0.90	0.06
Cambodia	3.97	4.11	5.67	0.14	1.56	1.42	3.84	3.98	6.30	0.14	2.32	2.18
Cameroon	5.83	5.85	6.01	0.02	0.16	0.14	6.48	7.41	6.85	0.93	-0.56	-1.49
Colombia	6.63	7.30	9.95	0.67	2.65	1.98	7.43	8.41	10.86	0.98	2.45	1.47
Comoros *	4.73	5.46	6.26	0.73	0.80	0.06	5.47	6.36	7.50	0.90	1.13	0.24
Cote d'Ivoire	4.39	4.59	5.08	0.20	0.49	0.29	3.53	5.47	5.93	1.94	0.46	-1.48
Dominican R.	7.04	8.47	7.87	1.43	-0.60	-2.03	7.68	8.96	9.52	1.28	0.56	-0.72
Egypt	6.46	8.44	7.95	1.98	-0.49	-2.47	6.22	8.70	8.86	2.48	0.16	-2.32
Ethiopia *	2.10	1.93	2.72	-0.17	0.79	0.96	1.59	2.48	3.01	0.89	0.53	-0.36
Gabon	6.61	8.35	9.70	1.74	1.35	-0.39	8.29	9.12	10.16	0.83	1.04	0.21
Ghana	6.84	6.53	8.11	-0.31	1.58	1.89	7.53	6.92	8.67	-0.61	1.75	2.36
Guinea *	1.90	3.15	3.96	1.25	0.80	-0.44	2.64	3.28	4.35	0.63	1.08	0.44
Indonesia	6.02	5.51	8.24	-0.51	2.73	3.24	6.45	6.86	9.47	0.41	2.61	2.20
Jordan	8.09	9.02	9.87	0.93	0.85	-0.08	9.29	10.37	11.13	1.08	0.76	-0.32
Kenya	6.01	5.50	4.48	-0.51	-1.02	-0.51	7.11	7.20	7.63	0.09	0.43	0.34
Madagascar *	5.00	4.95	5.84	-0.05	0.89	0.95	5.77	5.13	6.01	-0.65	0.88	1.53
Malawi	3.59	4.22	4.55	0.63	0.33	-0.30	4.25	4.42	6.76	0.17	2.34	2.17
Mali	1.05	1.61	3.14	0.56	1.53	0.97	1.40	1.51	2.57	0.11	1.06	0.95
Mozambique	1.38	1.05	3.76	-0.33	2.71	3.04	1.21	1.80	2.26	0.59	0.46	-0.13
Nepal	3.28	4.12	6.24	0.84	2.12	1.28	3.65	4.28	5.96	0.63	1.68	1.05
Niger	1.72	1.78	2.90	0.06	1.12	1.06	1.51	1.93	2.22	0.42	0.29	-0.13
Philippines	7.57	8.04	8.76	0.47	0.72	0.25	8.47	9.07	9.47	0.60	0.40	-0.20
Rwanda	3.22	5.12	5.80	1.90	0.68	-1.22	2.51	4.65	5.66	2.14	1.01	-1.13
Tanzania	4.34	4.61	7.08	0.27	2.47	2.20	5.69	5.54	6.82	-0.15	1.28	1.43
Uganda	4.68	4.90	5.40	0.22	0.50	0.28	4.98	5.36	6.98	0.38	1.62	1.24
Zimbabwe	7.01	8.50	7.70	1.49	-0.80	-2.29	8.27	9.03	8.71	0.76	-0.32	-1.08

Source: Barro-Lee (IIASA/VID if * next to country name)

Table A-3: Millennium Development Goals, Targets, and Indicators

Millennium Development Goals (MDGs)	
Goals and Targets (from the Millennium Declaration)	**Indicators for monitoring progress**
Goal 1: Eradicate extreme poverty and hunger	
Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	1.1 Proportion of population below $1.25 (PPP) per day[7] 1.2 Poverty gap ratio 1.3 Share of poorest quintile in national consumption
Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	1.4 Growth rate of GDP per person employed 1.5 Employment-to-population ratio 1.6 Proportion of employed people living below $1.25 (PPP) per day 1.7 Proportion of own-account and contributing family workers in total employment
Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	1.8 Prevalence of underweight children under-five years of age 1.9 Proportion of population below minimum level of dietary energy consumption
Goal 2: Achieve universal primary education	
Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	2.1 Net enrolment ratio in primary education 2.2 Proportion of pupils starting grade 1 who reach last grade of primary 2.3 Literacy rate of 15-24 year-olds, women and men
Goal 3: Promote gender equality and empower women	
Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	3.1 Ratios of girls to boys in primary, secondary and tertiary education 3.2 Share of women in wage employment in the non-agricultural sector 3.3 Proportion of seats held by women in national parliament
Goal 4: Reduce child mortality	
Target 4.A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	4.1 Under-five mortality rate 4.2 Infant mortality rate 4.3 Proportion of 1 year-old children immunised against measles
Goal 5: Improve maternal health	
Target 5.A: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio	5.1 Maternal mortality ratio 5.2 Proportion of births attended by skilled health personnel
Target 5.B: Achieve, by 2015, universal access to reproductive health	5.3 Contraceptive prevalence rate 5.4 Adolescent birth rate 5.5 Antenatal care coverage (at least one visit and at least four visits) 5.6 Unmet need for family planning
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 6.A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	6.1 HIV prevalence among population aged 15-24 years 6.2 Condom use at last high-risk sex 6.3 Proportion of population aged 15-24 years with comprehensive correct knowledge of HIV/AIDS 6.4 Ratio of school attendance of orphans to school attendance of non-orphans aged 10-14 years

[7] For monitoring country poverty trends, indicators based on national poverty lines should be used, where available.

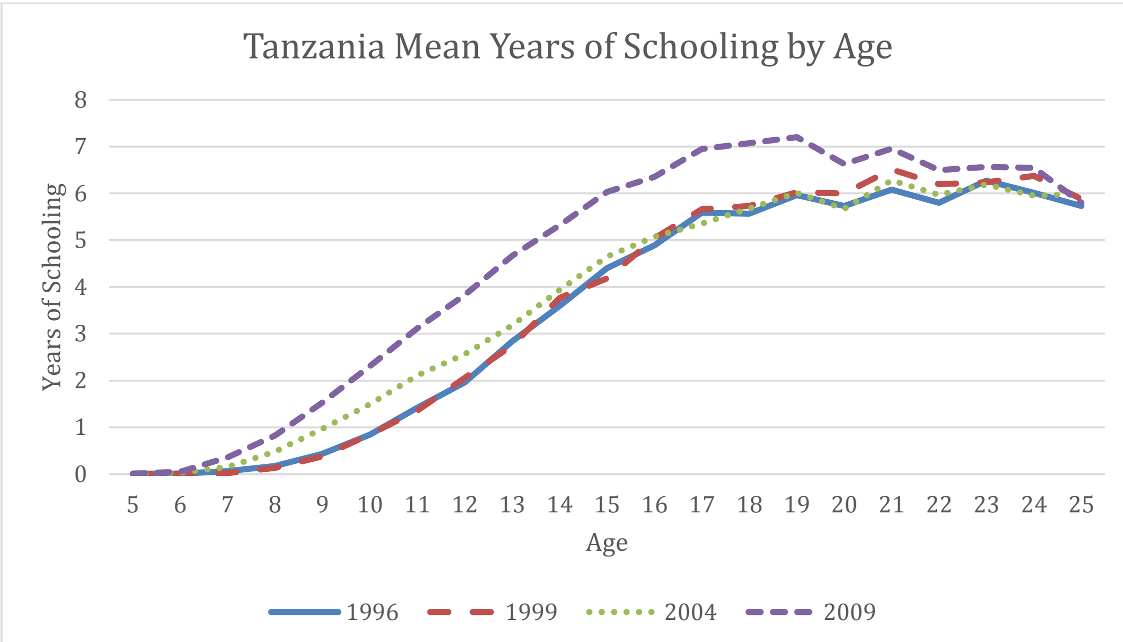
Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it	6.5 Proportion of population with advanced HIV infection with access to antiretroviral drugs
Target 6.C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	6.6 Incidence and death rates associated with malaria 6.7 Proportion of children under 5 sleeping under insecticide-treated bednets 6.8 Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs 6.9 Incidence, prevalence and death rates associated with tuberculosis 6.10 Proportion of tuberculosis cases detected and cured under directly observed treatment short course
Goal 7: Ensure environmental sustainability	
Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	7.1 Proportion of land area covered by forest 7.2 CO2 emissions, total, per capita and per $1 GDP (PPP) 7.3 Consumption of ozone-depleting substances 7.4 Proportion of fish stocks within safe biological limits 7.5 Proportion of total water resources used 7.6 Proportion of terrestrial and marine areas protected 7.7 Proportion of species threatened with extinction
Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	7.8 Proportion of population using an improved drinking water source 7.9 Proportion of population using an improved sanitation facility
Target 7.D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	7.10 Proportion of urban population living in slums[8]
Goal 8: Develop a global partnership for development	
Target 8.A: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Includes a commitment to good governance, development and poverty reduction – both nationally and internationally Target 8.B: Address the special needs of the least developed countries Includes: tariff and quota free access for the least developed countries' exports; enhanced programme of debt relief for heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction Target 8.C: Address the special needs of landlocked developing countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly) Target 8.D: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term	*Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked developing countries and small island developing States.* Official development assistance (ODA) 8.1 Net ODA, total and to the least developed countries, as percentage of OECD/DAC donors' gross national income 8.2 Proportion of total bilateral, sector-allocable ODA of OECD/DAC donors to basic social services (basic education, primary health care, nutrition, safe water and sanitation) 8.3 Proportion of bilateral official development assistance of OECD/DAC donors that is untied 8.4 ODA received in landlocked developing countries as a proportion of their gross national incomes 8.5 ODA received in small island developing States as a proportion of their gross national incomes Market access 8.6 Proportion of total developed country imports (by value and excluding arms) from developing countries and least developed countries, admitted free of duty 8.7 Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries 8.8 Agricultural support estimate for OECD countries as a percentage of their gross domestic product 8.9 Proportion of ODA provided to help build trade capacity Debt sustainability

[8] The actual proportion of people living in slums is measured by a proxy, represented by the urban population living in households with at least one of the four characteristics: (a) lack of access to improved water supply; (b) lack of access to improved sanitation; (c) overcrowding (3 or more persons per room); and (d) dwellings made of non-durable material.

	8.10 Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative) 8.11 Debt relief committed under HIPC and MDRI Initiatives 8.12 Debt service as a percentage of exports of goods and services
Target 8.E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries	8.13 Proportion of population with access to affordable essential drugs on a sustainable basis
Target 8.F: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications	8.14 Fixed-telephone subscriptions per 100 inhabitants 8.15 Mobile-cellular subscriptions per 100 inhabitants 8.16 Internet users per 100 inhabitants

Source: United Nations

Figure A-1: Schooling Levels in Tanzania Before and After UPE Initiatives



Source: DHS

Tanzania implemented a formal UPE program in 2001. This mostly entailed the elimination of school user fees. As we can see in this chart, spikes in schooling levels occurred for the young children in the first survey period following this reform (2004), but older children had essentially the same schooling levels as those in their same age cohorts five and eight years earlier. In the second survey following reforms (2009), we see again that schooling levels are rising, but the gap now begins to close later, as we would expect given the previous results. However, the gap does not close completely as in the previous survey. It appears that some older children are benefitting from these reforms in addition to the younger children that make up the treatment group.

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