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Evidence from a natural experiment in Ethiopia**
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Higher education and fertility: Evidence from a natural experiment in Ethiopia

Miron Tequame¹ and Nyasha Tirivayi²

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Abstract

This paper studies the effect of women's higher education on fertility outcomes in Ethiopia. We exploit an abrupt increase in the supply of tertiary education induced by a liberalisation policy. Using an age discontinuity in the exposure to higher education reform, we find that education lowers fertility by 8% and increases the likelihood of never giving birth by 25%. We explore the role of potential underlying mechanisms and find that this negative effect on fertility is channelled through positive assortative mating and the postponement of marriage and motherhood.

JEL: O12, I23, I25, I38, J12, J13

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1. Introduction

Educating girls and women has long been promoted as an effective policy for controlling population growth (Osili and Long 2008; UN 1995). This view is supported by extensive literature that demonstrates a negative association between female education and fertility (Schultz 1993; Cochrane 1979). Indeed, a growing body of causal evidence from sub-Saharan Africa finds that education (at both primary and secondary margins) reduces teenage pregnancies: Kenya (Ozier 2011; Duflo, Dupas, and Kremer 2014), Nigeria (Osili and Long 2008), Sierra Leone (Mocan and Cannonier 2012) and Malawi (Baird, McIntosh, and Özler 2011).³ While a good part of these studies focused on school girls and thus teen pregnancy, there is some evidence that education also lowers overall fertility; for example in Kenya (Chicoine 2012; Duflo, Dupas, and Kremer 2014) and in Uganda (Keats 2014).

Economic theory proposes several causal mechanisms for this fertility reduction (McCrary and Royer 2006; Lavy and Zablotsky 2011). First, education may increase income via labour market earnings and/or through positive assortative mating (McCrary and Royer 2006).⁴ The increase in income would raise the opportunity cost of having and rearing children and shift preferences towards fewer children of higher quality (Moav 2005; Fort, Schneeweis, and Winter-Ebmer 2011; Becker and Lewis 1973).⁵ Second, education may improve a woman's knowledge and practice of contraception and health behaviours, consequently leading to lower fertility (Grossman 1972; Rosenzweig and Schultz 1989). In addition, education may also increase the bargaining power and independence of women in fertility decisions (Mason 1986).⁶ As such, access to contraception by itself would not be sufficient to reduce fertility unless women independently made decisions regarding its use (Ashraf, Field, and Lee 2010). Lastly, education may directly lower fertility through the "incarceration effect". This refers to how education increases the time spent in school by women thereby reducing or delaying their opportunities to engage in sexual activity and have children (Black, Devereux, and Salvanes 2008).

However, evidence of the role of causal mechanisms in sub-Saharan Africa is inconclusive. Some positive impacts of education on employment have been observed for women in Uganda (Keats 2014) and for only men in Kenya (Ozier 2011).⁷ Education reduces the marital education

³ Similar results have also been reported in Indonesia (Breierova and Duflo 2004) and among Arab women in Israel (Lavy and Zablotsky 2011). In developed countries, (Kirdar, Dayioglu, and Koc 2012; Geruso, Clark, and Royer 2014; Fort 2009; Monstad, Propper, and Salvanes 2008; McCrary and Royer 2006) find that education postpones motherhood, but has no impact on overall/complete fertility. (Cygan-Rehm and Maeder 2013; Leon 2004; Black, Devereux, and Salvanes 2008) find lower fertility while on the other side (Braakmann 2011) observes an increase in fertility.

⁴ Positive assortative mating is when educated women marry spouses with higher education (Behrman and Rosenzweig 2005). This would further increase in permanent income (McCrary and Royer 2006).

⁵ Conversely, among women at the lower end of the educational distribution the income effect could lower the costs child rearing and raise fertility (Fort, Schneeweis, and Winter-Ebmer 2011).

⁶ See (McCrary and Royer 2006) for further explanation of the income and knowledge mechanisms.

⁷ (Braakmann 2011) finds positive impacts on employment in the UK. (Lavy and Zablotsky 2011) study a context of low labour market participation, and find no effect on the employment of Arab women in Israel.

gap in Kenya (Chicoine 2012), but does not affect assortative mating in Uganda (Keats 2014).⁸ Education improves family planning knowledge and women's autonomy in reproductive decision making in Uganda (Keats 2014) and increases the early use of modern contraceptives in Kenya (Chicoine 2012).⁹ Studies also find that education increases teenage sexual abstinence (Alsan and Cutler 2013 in Uganda) and hence delay marriage as in Kenya and Malawi (Baird, McIntosh, and Özler 2011; Duflo, Dupas, and Kremer 2014).¹⁰ However, there is limited and inconclusive evidence on the "incarceration effect" as studies find that education not only delays first birth among teens in schools but also among women in older ages and thus overall fertility (Duflo, Dupas, and Kremer 2014; Chicoine 2012). Yet, all these findings are complicated by the fact that they assess different types of fertility and related behaviours i.e. complete versus teenage fertility. It is also not clear whether the "incarceration effect" is produced equally under non-mandatory policies and mandatory policies of schooling. Overall, there is still little evidence of the effects of education on assortative mating and the labour market. Further studies are required to shed more light on the mechanisms through which education lowers fertility in sub-Saharan African countries.

In this study, we determine the impact of higher education on female fertility in Ethiopia using nationally representative data.¹¹ Our study examines a policy developed in 1994 within a general framework of restructuring and improving the education sector after more than 15 years of communism (1976-1991). Within this framework, the Ethiopian government liberalised the private provision of higher education resulting in a noticeable increase in providers in 2000. These institutions were particularly attractive for women since they focused on providing business and IT courses. Fifty percent of enrolments in the private institutions were women. Furthermore, private provision was complemented by the rehabilitation and expansion of existing public higher education structures.

Our empirical strategy exploits the abrupt increase in the supply of higher education, in the year 2000. In that particular year, Ethiopia experienced nearly 30% of annual growth in higher education enrolments. We use this plausibly exogenous change in the supply of higher education as a natural experiment to determine the impact of higher education on fertility and the potential mechanisms. We utilise a regression discontinuity design to estimate the impact of higher education on fertility. Hence, we estimate local average treatment effects (LATE) on a restricted

⁸ Similar effects are reported in Indonesia (Breierova and Duflo 2004) and among Arab women in Israel (Lavy and Zablotsky 2011). In developed countries, (Lefgren and McIntyre 2006; Anderberg and Zhu 2014; Geruso, Clark, and Royer 2014) find positive effects of education on assortative mating, unlike (Braakmann 2011).

⁹ (Lavy and Zablotsky 2011) find that education increases women's participation in family decision making, reduces religiosity and increases positive attitudes toward modernism among Arab women in Israel. In related literature, (Agüero and Bharadwaj 2014) find that education increases knowledge of HIV-preventive behaviours and HIV transmission in Zimbabwe. (Mocan and Cannonier 2012) find that education has a positive impact on women's contraceptive use, getting tested for HIV, and increases women's aversion to intimate partner violence in Sierra Leone.

¹⁰ In developed settings, there is mixed evidence on the postponement of marriage and fertility. For example, both (Lefgren and McIntyre 2006) and (Anderberg and Zhu 2014) find no effects. (Currie, Moretti, et al. 2003) find that maternal education increased the likelihood of marriage. Documented positive effects of compulsory schooling reforms in Turkey (Kirdar, Dayioglu, and Koc 2012), Germany (Cygan-Rehm and Maeder 2013), Norway (Monstad, Propper, and Salvanes 2008) and the US (non-significant, (Leon 2004)). No effects of compulsory schooling reforms in the UK and Italy (Fort 2009; Braakmann 2011).

¹¹ Fertility statistics show that the fertility rate in Ethiopia is currently 4.8 (DIS 2011).

bandwidth of cohorts who were very likely to take advantage of the discontinuity. The LATE are based on a particular subpopulation of women who enrolled in higher education due to liberalisation and they were more likely to reside in urban areas where higher education institutions are located. Our results suggest that the reform increases the average years of schooling by 1.19 years and it has more than doubled the likelihood of women attending higher education (131% increase). Overall, the results also suggest that higher education lowers fertility in Ethiopia. Both reduced form and instrumental variable estimates show that higher education decreases; the number of total births per woman by about 8% (around 0.2 of a child) and the desired number of total lifetime children by 9% (around 0.43 of a child). Higher education also increases the likelihood of never giving birth by 25%. Our findings are broadly consistent with the evidence presented in (Duflo, Dupas, and Kremer 2014) and (Chicoine 2012) among teens and adult women in Kenya.

We take advantage of the richness of the DHS data and explore an array of potential mechanisms driving the reduction in fertility. Estimates show that higher education significantly lowers the average age gap with a male partner by about 3.5 years (43%). Higher education also reduces the average education gap by 0.4 years, although this is not statistically significant in the overall sample and only marginally significant in urban areas. While higher education increases quality of marriage among ever married, we also find that it decreases the likelihood of entering the marriage market by 34%. Overall, we do not find strong evidence that higher education changes labour market participation rates, although there is suggestive evidence of some impact in urban areas. This result can be attributed to the low demand for labour in Ethiopia as well as structural labour market constraints which create a context of low female labour force participation rates (Lavy and Zablotsky 2011). We find suggestive evidence of an increase in women's involvement in decisions about their own health care in urban areas. However, we do not observe any effects on contraceptive use, sexual activity, other measures of bargaining power and indicators of child quality such as vaccination and nutritional status.

This paper contributes new insights to the literature. To our knowledge, this is the first study to determine the impact of education on fertility at the post-secondary margin in a low income country. Prior literature has examined the impact of education at primary or secondary school levels. However, little is known about the impact of higher education on fertility, particularly in resource poor countries. We also present new findings on the mechanisms through which higher education affects fertility. We interpret the findings in two ways. First, the reduction in the average age and education gap with male partner suggests that education affected fertility through positive assortative mating. Second, the decrease in the likelihood of entering the marriage market and giving birth before the age of 30 suggests a delay and postponement over most of the years when women are at their fertile peak¹².

The remainder of the paper is organised as follows. Section 2 provides some background on the education policy in Ethiopia, section 3 discusses the empirical strategy, and section 4 describes the data. Section 5 presents the results while section 6 explores the potential mechanisms.

¹² Compared to many neighbouring countries, the premarital or out-of-wedlock childbearing rate is very low i.e. lower than 5% (DHS 2011).

Section 7 concludes the study.

2. The Ethiopian Education and Training Policy

The 1994 Education and Training Policy (EETP) was formulated and implemented by the liberal government (Ethiopian People's Revolutionary Democratic Front –EPRDF), which came to power after overthrowing the military Derg Regime in 1991. The policy's main objective was to increase access to education opportunities by improving equity, quality and relevance at all margins of education including raising the quality of secondary and higher education to fit the changing labour market (Nwuke 2008). The policy aimed to bring about a significant change in primary, secondary and higher education sectors within 20 years. As a result of the policy, government investments led to large increases in enrolments at both primary (gross rates of 65% by 2004) and secondary schools. Yet, by 2000, higher education enrolments in Ethiopia were the lowest in Africa, comprising gross tertiary enrolment ratio of 0.8% against the average 4% in sub-Saharan Africa. Hence, the increase in secondary school enrolments created an unmet demand (Nwuke 2008). Growth in the higher education sector had long been stalled due to the 30-year war Eritrean war of independence of Ethiopia and the immense brain drain of highly educated Ethiopians triggered by the repressive rule of the Derg regime (Nwuke 2008).

The Ethiopian government sought to simultaneously address the shortage in higher education institutions, enhance the competitiveness of the workforce and eliminate the wide gender and spatial gaps in higher education. Consequently, core initiatives of EETP included increasing public higher education institutions and liberalisation/deregulation that allowed private provision of higher education for the first time¹³. Enrolments increased from around three thousand in 1994 to over 173,522 students in the 2003/4 academic years (77% in public and 23% in private and nongovernmental institutions). Enrolments in private tertiary education institutions increased from zero in 1998 to about 39,961 in 2005/006, accounting for one fifth of total enrolment. Women accounted for over 30% of total graduates. Detailed enrolment rates are shown in Table 2 (Nwuke 2008).¹⁴ Private tertiary institutions usually enrol about 500 students per year and offer training in areas such as accounting, business administration or IT, educational programs that are not available in public institutions. Therefore, they attract a high proportion of women (almost 50 %) and enrol about 75% of all business, IT and law students (Saint 2004).

Figure 1 illustrates the rapid increase in higher education after 2000 which was followed by steady growth throughout the first decade of the 21st century. Figure 2 shows that public expenditures on education increased exponentially starting from 1994, both as a percentage of

¹³The details of the policy's strategy, implementation and achievements are published and monitored every five years in the Education Sector Development Program (ESDP) series of the Ethiopian government. ESDP series are official documents published on the website of the Ministry of Education. Source: <http://www.moe.gov.et/English/resources/Pages/DocumentByCategory.aspx>

¹⁴ Contemporaneously, existing public institutions were also expanded increasing total enrolments from about 35000 to over 100000 during the period 1996-2003 (Education Statistics Annual Abstract, Ministry of Education-2001-2006).

GDP and as a share of total public expenditure reaching as high as 25 percent. However, the share of expenditure on primary education declined while the share of spending on higher education has increased (Nwuke 2008). Under the new reform, individuals entered higher education after 8+4 years of schooling and by the age of the age of 19 (Figure 3).¹⁵ This is similar to the policies adopted in neighbouring countries like Kenya.

The abrupt increase in the supply of higher education generated a discontinuity in the probability of women to achieve higher education. While female enrolment in public structures represented only 16% before the reform, private provision bridged the gender gap since women represented almost 50% of enrolments in private institutions (Nwuke 2008). Given that enrolments in higher education begin around the age of 18 (or 19 if they started schooling at age 7) those born in 1981 and 1982 are likely to have benefited most from the discontinuity as compared to those from 1979 and 1980. Figure 4 shows the discontinuity in enrolment among women by year of birth (DHS 2005, 2011). Each point in the figure shows average enrolment in higher education by birth cohorts born before and after 1981. The effects of the policy might also have been experienced by older cohorts who decided to go back to the university after the reform. Similarly, students who would have repeated at least one year in their school curriculum, could also have benefitted from the policy.

3. Empirical Strategy

As economic theory shows, education can affect fertility outcomes. A naive parametric model of estimation (OLS) is expressed as follows:

$$Y_{ik} = \alpha_0 + \alpha_1 Education_{ik} + \theta X_{ik} + \varepsilon_{ik} \quad (1)$$

Where Y_{ik} is the number of children for individual i of birth cohort k . X_{ik} includes controls for religion, number of siblings, height, and region fixed effects. Our parameter of interest would be α_1 . However, estimating the causal effect of education on fertility is challenging due to spurious correlation. Causal estimates may suffer from reverse causality and omitted variable bias, particularly the exclusion of variables like individual ability which affect both education and fertility (Osili and Long 2008). Variables such as career aspirations and patience may also jointly influence entry into higher education and fertility (Grönqvist and Hall 2013). The non-random placement of schools in communities and how fertility interrupts education attainment, point to possible endogeneity in the relationship between education and fertility (Osili and Long 2008, Duflo 2001, Angrist and Evans 1999).

Our empirical strategy exploits the implementation of the Ethiopian higher education reform in estimating the impact of education on fertility and underlying mechanisms. We utilise a

¹⁵ This is an approximate age that does not take into account repetition. A detailed description of the education system is illustrated in Table 1.

regression discontinuity approach where we compare women who were 19 years old and younger with those 20 years or older at the time of the reform (year 2000) when there was an abrupt increase in higher education enrolments.¹⁶ We use data from 2 rounds of the Demographic and Health Surveys (DHS), 2005 and 2011). Our strategy is premised on the idea that the cohorts of women near the cut-off (on either side) are similar, and the only plausible difference in outcomes would be the attributed to the jump in the expansion of higher education from the private sector (Gelman and Imbens 2014; Lee and Lemieux 2010; Imbens and Lemieux 2008). Our analysis first determines if this expansion had any impact on education attainment and then examines whether there were subsequent impacts on fertility outcomes.

3.1. *Higher Education Reform and Educational Attainment*

To determine the impact of higher education expansion on educational outcomes, we estimate first-stage regressions of the form:

$$S_{ik} = \beta_0 + \beta_1 T_{ik} + g(\text{Age } 2000_{ik} - c) + \theta X_{ik} + \varepsilon_{ik} \quad (2)$$

Where T_{ik} is the treatment, $g(\text{Age } 2000_{ik} - c)$ is the forcing variable, age in the year 2000 while c is the cut-off age. T_{ik} denotes whether the individual is affected by the higher education reform in 2000 i.e. its equal to one if they were 19 years old or younger and 0 for otherwise. X_{ik} are pre-determined variables that are not correlated with the cut-off region e.g. religion, number of siblings, height, and region fixed effects. ε_{ik} represents the error term. Our parameter of interest is β_1 , which captures the average causal effect of an increase in the supply of higher education on years of schooling.

3.2. *Higher Education and Fertility*

In order to determine the impact of higher education reform on fertility outcomes, we estimate two types of regressions. First, we estimate the reduced form of equation (2). This strategy assesses the “intent to treat” (ITT) effect for those individuals who belong to the cohort exposed to the policy reform as long as the monotonicity condition holds i.e. increasing the supply of higher education induces individuals to increase their years of education and does not lead anyone to drop out earlier. This is obtained by regressing outcomes of interest (Y_i) on the specification in equation (2):

$$Y_{ik} = B_0 + \partial T_{ik} + g(\text{Age } 2000_{ik} - c) + \tau X_{ik} + \varepsilon_{ik} \quad (3)$$

¹⁶ It is likely that students enrol into school at later ages than 6 or they might repeat school years before reaching higher education. The effect of the reform can be dispersed across birth cohorts around the implementation year.

Where $\hat{\delta}$ is the average causal effect of the reform on fertility and underlying mechanisms. T_{ik} is a dummy variable for whether the individual is affected by the higher education reform in 2000 i.e. its equal to one if they were 19 years old or younger and 0 for otherwise.

Second, we identify the local average treatment effect for the compliers measured at the cut-off threshold i.e. “treatment on the treated” (TOT) effect. Compliers refer to women who, who attend higher education if aged 19 or younger, but would not if they were older. The size of 2SLS estimates depends on the characteristics of compliers. If the compliers are similar to the average population the 2SLS estimates are similar to the average population effect. To obtain this causal estimate, we implement 2SLS regression models by using T_{ik} as an instrument for education (years of schooling). Hence, equation (2) becomes the first-stage, which produces a predicted variable of years of schooling \hat{S}_{ik} .

$$Y_{ik} = \gamma_0 + \gamma_1 \hat{S}_{ik} + g(\text{Age}(2000)_{ik} - c) + \phi X_{ik} + \varepsilon_{ik} \quad (4)$$

Our parameter of interest is γ_1 , as long as the order of the polynomial and the bandwidth are the same in the first and second stages (equations 2 and 4), permitting the calculation of standard errors in 2SLS. In section 5.1 we discuss the choice of our polynomials and bandwidth. In all the regressions described above, standard errors are corrected for auto-correlation of an arbitrary form at the survey enumeration area and household level.

As a robustness check, we test the sensitivity of our RDD to different bandwidths: 4, 6 10 and 20 years window. We carry out the following validity tests for our regression discontinuity design. First, we check for manipulation of the treatment variable. Second, we test for whether there are any discontinuities in the covariates that simultaneously affect entry into higher education and fertility outcomes. Third, we run placebo tests on two groups of unaffected cohorts (born before 1981 or older than 19 years).

4. Data

4.1. Source

The data used in this paper are from two rounds of the Demographic and Health Surveys (DHS) of Ethiopia: 2005 and 2011.¹⁷ The DHS are nationally representative household surveys focusing on women in their reproductive age (15-49 years). The individual women’s dataset provides information on demographic characteristics such as birth date, ethnicity, religion, location, marital status, education attainment and wealth. The dataset also provides personal information

¹⁷ Women in the DHS 2000 are too old to be included for the evaluation of the 2000 policy reform.

on fertility history, fertility preferences, family planning knowledge and contraceptive use, fertility behaviour, partner age and education, and autonomy in household decision making.

We are able to use the fertility history and preferences of the women to construct the total number of actual children born to a woman, our main dependent variable for fertility. The available data also allows us to construct variables on the number of desired children, if a woman has never given birth, if a woman has ever married, the age and education gap with spouse, labour market participation and autonomy in decision making. We use years of schooling as the principal indicator of education.

4.2. *Summary Statistics*

Our analytical sample comprises 4291 women who were aged between 18-21 years in 2000. This is based on our preferred age window of analysis for reasons explained in section 5.1. These women were at least 23 years old at the time of the 2005 survey round allowing a life-cycle analysis on their marriage and age at first birth. Since data contains year of birth, we are able to compute their age at the time of the reform. Women aged 19 and younger were likely to benefit most from the reform in terms of highest diploma achieved, years of schooling and the likelihood of enrolling in higher education.

Summary statistics on the analytical sample are shown in Table 3. Our treated group comprises women born in 1981 and 1982 (aged 18 and 19 in the year 2000) and they are compared to a control group of women born in 1979 and 1980 (age 20 and 21 in 2000). We present a description of the overall sample and a sub-sample of women in urban areas. Higher education is mainly concentrated in urban areas and it is likely that such discontinuity is lower or marginal for women from rural areas.

The data show that education among women in Ethiopia is generally quite low compared to many other sub-Saharan countries. However, the averages show that women born in 1981 and 1982 had nearly an extra year of schooling and that they are also more likely to be enrolled in higher education by four percentage points and by seven percentage points in urban areas. With regards to fertility, they also have a lower number of children ever born. Compared to the control group, treated women are also more likely to have never given birth by 7 percentage points. Figure 5 presents graphical evidence of the differences in higher educational attainment between the treated and control groups.

5. Results

Our results are presented in two sub-sections. In the first section, we present evidence of discontinuity in higher education, discuss the form of our specifications and discuss bandwidth selection. In the second section, we present evidence of the impact of the reform on education. In the second section, we examine the effects of education on total number of children ever born, preferred number of lifetime children and if one never gave birth.

5.1 *Specification Checks*

Non-parametric evidence of the discontinuity of enrolment in higher education is shown in Figure 5. Before proceeding with our first-stage regressions, we carry out a series of specification and validity tests. First, we choose the order of the polynomial for our specification (equations 2, 3 and 4). Gelman and Imbens (2014) show that higher order polynomials may be misleading in that: (i) they give huge weight to points that are far from the cut-off, (ii) they are sensitive to the degree of the polynomial and (iii) their confidence intervals can be too narrow increasing the likelihood of rejecting the null hypothesis. Thus, they suggest an approach based on local linear or a local quadratic regression within a neighbourhood of the cut-off. We therefore compare specifications with first and second-order polynomials of the forcing variable. We use Akaike's information criterion (AIC) to determine whether specifications with the first-order of the polynomial of the forcing variable were a better fit for the data than specifications with a second-order polynomial (quadratic). The AIC shows that the second-order polynomial is a better fit for the data at various bandwidths (4 years, 6 years, 10 years). We therefore opt for a second-order polynomial (quadratic) in both first stage and second stage estimations.

We consider three different age windows: 10 years (+/- 5 years on either side of the cut-off, ages 15-24), 6 years (ages 17-22) and 4 years (ages 18-21). These windows allow us to test the robustness of our RD design to various bandwidths around the cut-off. Generally, larger windows enhance precision while narrower windows reduce bias (Lee and Lemieux 2010). For comparison, we also used automatic bandwidth selectors to get an indication of the optimal bandwidth. The automatic bandwidth selectors are based on the Imbens and Kalyanaraman (2012) procedure and the cross validation procedure proposed by Ludwig and Miller (2007). Table A.1 shows that these procedures selected optimal bandwidths of 4.45 and 4.66 years.

5.2 *Effect of Higher Education on Years of Schooling*

We present evidence that the higher education reform in 2000 had a positive impact on education as measured by years of schooling and the probability of attending higher education. Table 4 shows the results of first stage regressions in the form of equation 2 (section 3.1) and with a second order polynomial control. The first stage estimates are positive and significant across the bandwidths. However, we suspect that there is some form of selection in the 10 year window because it compares women at ages 15-19 in 2000 with those at ages 20-24. The younger women were 20 at the time of DHS 2005 and might not have completed their schooling which ultimately causes a downward bias. The coefficients for the four year and six year bandwidths are closer in magnitude than for the 10 year bandwidth.

In our regressions, we only report the results from the 4 year bandwidth, which is the most parsimonious given our sample size and the comparability of birth cohorts. This bandwidth is also closer to the bandwidths obtained from using the automatic bandwidth selectors (see Table A1). The estimates from this window compare women who were 18-19 years old with those who were 20-21 years old in 2000. These women were between the ages of 23-26 in the DHS 2005

survey and between ages of 29-32 in DHS 2011, allowing an assessment of overall fertility. The results suggest that the reform increased the average years of schooling by about 1.2 years (40% increase), and up to 2.4 years in urban areas (37% increase). On average, women were 5 percentage points more likely to attend higher education, which translates to an increase of 114%. These estimates show that the policy more than doubled the probability of attending higher education among women in urban areas between the years 1998-2002.¹⁸

5.3 Effect of Higher Education on Fertility

We now report the OLS, reduced form (Intention To Treat) and the 2SLS (Treatment On the Treated) estimates. Both the reduced form and 2SLS regressions use the age of the woman in 2000 as the forcing variable. We use two measures of fertility. They are the total number of children ever born to a woman and the stated preference of total lifetime children. Almost all women start giving birth after marriage and the time-lag is relatively short in Ethiopia. We evaluate the policy on total number of births and desired number of children by accounting for the fact that women's fertility history can be right censored.

Naive estimates of OLS are from the specification in equation 1 (section 3). As discussed earlier, OLS estimates are likely to be biased due to unobserved characteristics that influence both education and fertility decisions. Since girls in Ethiopia are less likely to be educated, omitted variable bias is more severe in our analytical sample. The reduced form estimates in Table 5 (columns 2, 5 and 8) are based on a specification that is analogous to the first stage regression (equation 3). In equation 4, the cut-off variable (age 19 or less in 2000) is used as an instrumental variable for years of schooling in 2SLS regressions (columns 3, 6 and 9).

All the estimates from OLS, reduced form and 2SLS estimates show that higher education reduces the actual number of children born and desired for both the whole sample and urban sub-sample. The reduced form estimates show that higher education reduces the total number of children ever born by 0.26 while 2SLS estimates indicate that each additional year of schooling reduces total births by 0.21. These effects translate to about 8-9% reduction in fertility (from dividing coefficient with sample mean). The reduced form estimates also suggest that higher education lowers the average number of desired children by 0.55 while 2SLS estimates indicate a reduction by 0.43 (about 9%). Furthermore, education is associated with a 5 percentage point increase in the likelihood of never giving birth (25% increase).¹⁹ Overall, higher education

¹⁸ From raw data of the Ministry of Education, enrolment increased from 63 438 in period 1998-2000 to 92 322 in period 2000-2002 (Table 2).

¹⁹ From Column 1-3 in Table A.2, we show that the negative effect of education on fertility is not driven by a reduction in intended-births. This has important policy implication for contraceptive use and family planning. However, they are to be taken with caution due to *ex-post rationalisation*, i.e. as children grow older there may be a trend in re-characterising them as intended or unintended depending on the mother's feeling *vis-à-vis* the child.

lowers the average number of children (effective and desired), and it increases the likelihood of never giving birth.

Usually, OLS estimates are characterised by an upward bias due to unobserved characteristics. However, in our estimates they are unexpectedly biased downward. This can be explained by the nature of the policy in our evaluation, which is a supply-side intervention aimed at increasing access to higher education. An inspection of our instrumental variable and the context of analysis suggest that few women are affected by the policy and thus the treatment effect should exceed OLS estimates. The compliers are a peculiar group of women compared to the average. They are thus more capable of weighing the costs and benefits of attaining higher education and entering the marriage market and giving birth. The discrepancy in the coefficients is apparent when we compare all women to the urban sample. In urban areas, where access to higher education is easier, the coefficients are smaller in magnitude. Agüero and Bharadwaj (2014) find a similar pattern of results from an evaluation of school expansion on secondary school enrolments in Zimbabwe in 1980.²⁰ Historical gender gaps in higher education in Ethiopia show that women faced serious barriers and substantial costs in accessing higher education, hence the 2SLS estimates can be expected to be larger than the average marginal effect of education on fertility Agüero and Bharadwaj (2014).

Figures 6a-6d present the graphical plots of the discontinuities in the total number of children ever born, number of desired children, number of intended births (coefficients are reported in Table A2) and the likelihood of never giving birth. Women born in 1981 and afterwards (i.e. who were aged 19 or younger in 2000) have fewer births and a lower total number of desired children and intended births than older women. In addition women born in 1981 and afterwards are more likely to have never given birth compared to older women.

In Figure 7 we display non-parametric evidence of the decrease in the number of total births and preferred number of children across all cohorts. We find that total births are decreasing across cohorts among both women with and without formal education. Strikingly, the decline from mothers with higher education reaches an average below one among those aged 30 and younger. For ease of comparison, we plot the ratio of average births from the two groups of women. This ratio is increasing among younger cohorts. Women without formal education have at least 5 times more children when compared to women with secondary or higher education.

6. Mechanisms

In this section, we explore the potential underlying mechanisms in the negative impact of education on fertility. The section is structured as follows. First, we investigate if higher education is associated with; (i) assortative mating, (ii) changes in behaviour relative to age of first marriage and birth, as well as sexual behaviour and partners. Second, we assess the impact

²⁰ Like the Zimbabwe policy, the Ethiopian higher education expansion in 2000 was also a supply side-intervention that likely affected schooling choices or decisions of women, who would have not attended higher education in the absence of the expansion.

of the reform on labour market participation, bargaining power and contraception use. Finally, we assess if higher education improves child quality.

6.1 Assortative Mating

We begin our exploration of potential mechanisms by examining whether higher education affected the quality of marriage. When analysing the role of education on quality, those entering the marriage market are not totally exogenous. Women's education alters entry into marriage through her decision and also that of her husband depending on local norms. The estimated effects of the policy incorporate the role of assortative mating in the marriage market. Hence, our estimates include both the direct and indirect effects of policy on the age and education gap. They are thus to be taken as an upper-bound of the effect of women's education on the age and education gap. Given that the average age-gap between couples is around 8 years, the timing of the reform allows us to disentangle its impact from men's education.

Coefficients from OLS regressions in Table 6 suggest that education reduces the age and education gap with a male partner. Coefficients in Table 6 indicate that women who are likely to benefit from the policy are also probably more educated on average.²¹ The 2SLS coefficients are negative and bigger in magnitude as compared to the naive OLS regression and the reduced form estimates. Higher education reduces the age gap with the partner by an average of 3.5 years, which amounts to a decrease of about 43%. Similarly, the education gap with the partner decreases by 0.4 years (25%), although this is not statistically significant. There is a reduction in the education gap in urban areas of about 0.7 years ($P < 0.10$). Overall, the evidence suggests that higher education leads to some positive assortative mating, a possible pathway in the relationship between education and fertility.

6.2 Sexual Activity, Age at Marriage and Age at First Birth

We now consider the possibility that simply attending higher education lowers the opportunities for women to enter the marriage market and hence give birth. Higher education requires a direct increase in the time/years women spend in school, thereby decreasing their opportunities for sexual partners, marriage or birth. This is similar to the definition of the "incarceration effect" among teen girls (Black, Devereux, and Salvanes 2008).

In Ethiopia, more than 97% of the ever married women entered the marriage market before the age of 25. This allows us to examine the effect of education on marriage given that they were at least 23 years old at the time of the survey.²² Since premarital pregnancy among women in Ethiopia is very low, marriage is often a pre-condition to bear a child.

²¹ The size of 2SLS estimation depends on the characteristics of compliers; the more compliers are similar to average population or bigger in size, the more the 2SLS estimates are similar to the average population effect

²² Average age at marriage is 16.5 among all the population and women in the sample of analysis are at least 24 years old. The average number of women who are never married amounts to 27% of the sample and increases to 43% in urban areas.

Table 6 shows estimates of the impact of education on the likelihood of never being married. Both reduced form and 2SLS estimates (columns 11 and 12) indicate that higher education increases the probability of never getting married by 5-6 percentage points (about 34-40%). The analogous inference from this result is that higher education leads to a 34-40% decrease in the probability of entering the marriage market.²³

While our results indicate that higher education significantly increased the likelihood of never giving birth or getting married, we find that attending higher education does not lead to any changes in their sexual activity, number of partners and extramarital partners in the previous 12 months. These results are not reported here and are available upon request.

In Figures 8a and 8b we analyse the patterns of age at first sex, marriage and birth among both educated and non-educated women in urban areas. The figures plot coefficients from regressing educational status on specific age of first sex, marriage and birth, after controlling for region, age, wealth and religion fixed effects. This is equivalent to comparing these family outcomes of women from the same region, same age, wealth and religion but who differ by their educational status. We compare women at the upper and lower end of the education distribution i.e. those without formal education versus women with higher education. The trend in Figure 8a focuses on women with higher education and shows a clear postponement of age at first sex, marriage and birth, in line with several studies (Baird, McIntosh, and Ozler 2011; Duflo, Dupas, and Kremer 2014). Women who are likely to enrol in higher education encounter their first partner during their studies in their twenties, but delay marriage and birth until after completing their studies. Age at first marriage and birth coincides for many of these women. Figure 8b focuses on women without formal education and the plot shows that teen marriage and birth is still quite common in Ethiopia. These women are likely to enter the marriage market and bear a child before the age of 16.

The trend for women who never got married or gave birth is plotted in Figure 9 across cohorts. The vertical line separates women above and below the age of 30. There is a notable difference between women without formal education and those with secondary or higher education. Women with higher education are less likely to enter the marriage market or bear a child.²⁴ We observe a large gap between the two groups of women. While almost all women without formal education bear a child or enter the marriage market it is not that evident for women with higher education. More than 40% of these women were not yet married or had never given birth by age 30. Consistent with the findings of Keats (2014), the fertility gap between highly educated women and women without formal education persists as women become older showing that there is no “catch-up”.

²³ A similar pattern was found in the US when women first started completing college in 1950s. (Isen and Stevenson 2008) argue that in families based on efficient production of the couple, returns from schooling and technological progress increased the cost of specialising in domestic work and thus women were less likely to marry. (Isen and Stevenson 2008) also argue that in modern times of the US marriage has become consumption efficient, incentivised by assortative matching, optimisation of costs relative to public goods within families all contributed to increasing the likelihood of educated women to enter the marriage market, showing a U shape across cohorts.

²⁴ Almost all women in the sample give birth or get married before the age of 30.

Overall, the results show that higher education may be lowering fertility through the postponement of marriage and motherhood. This postponement persists up to the age of 30, when the average woman is near the end of their fertile peak. Data on higher education enrolments at the time of the surveys are unavailable and as such we are unable to determine if the persistent delay or postponement of marriage and birth after the age of 25 is due to “incarceration” from college attendance or friction in the marriage market.

6.3 *Labour Market Participation*

We explore the potential role of labour market participation as a mechanism for educational impacts on fertility in Ethiopia. Unfortunately DHS surveys do not provide detailed information on wage and work history. We are only able to use information on the likelihood of the woman being in the labour market based on responses to work status at the time of the survey and in the previous 12 months.

Our inference is based on the reduced form and 2SLS estimates in columns 8 and 9 of Table 6.²⁵ Results suggest that while schooling is increasing among women, there is no strong evidence of a positive return on the labour market. The effect of higher education on participation in the labour market, while positive, is not statistically significant for all women. However, in urban areas, education increases the likelihood of women working by 5-11 percentage points (p-value<0.1).²⁶ That the results are not convincing may not be surprising, especially since Ethiopia is a low income country beset with low demand for labour and structural labour market constraints.

6.4 *Women’s Knowledge and Bargaining Power*

We also explore the potential roles of knowledge and bargaining power as channels through which education affects fertility. We tested for the impact of higher education on a range of outcomes such as contraceptive use, attitudes towards gender based violence, decision making on individual health, cooking and household spending. Results in Table 6 (columns 14 and 15), show that we could not find any significant impact on all of these outcomes, except for whether women make decisions on their own health care (urban sample). Here education increases decision making on own health care by 17 percentage points (about 58%). Results on the other outcomes are available on request.

6.5 *Child Quality*

Finally, we explore the role of higher education on the quality of children as measured through child stunting and the likelihood of not having a vaccination card during the first year of birth. Table A.2 presents estimates based on OLS, reduced form and 2SLS regressions. We do not find

²⁵ OLS estimates show a small increase in working of about 2%.

²⁶ This coefficient is significant at 10 percent and only in urban areas.

any strong evidence of a quantity-quality trade-off among treated women. All coefficients are negative and consistent across different estimations. The estimates suggest that higher education attainment by the mother can potentially reduce stunting and increase vaccinations. However, they are not statistically significant. This may partly be attributed to the fact that both stunting and vaccination coverage are objectives of national campaigns and programs in Ethiopia which are accessed by a large population.

6.6 *Validity Tests*

The validity of the design and results rests on the assumption that there is no manipulation of treatment and that women born before and after the cut-off date have similar predetermined characteristics. First, we carry out a test for whether the density of the forcing variable is smooth (age) following the procedure proposed by McCrary (2008). Second, we test for whether there are any discontinuities in the covariates that simultaneously affect entry into higher education and fertility outcomes. If there are discontinuities in pre-determined characteristics, this would imply some form of self-selection into the assignment at the cut-off point. In our survey data we have very limited options for predetermined characteristics (i.e. baseline traits). The data-sets do not have information on the characteristics of the women's parents. Since DHS is nationally representative, we use the 2000 and 2005 DHS to create a sample of women old enough to be plausible mothers of the women (Keats 2014). These are women aged 45 years and older in the 2000 and 2005 DHS. We assess whether there are any discontinuities in their education, number of children born (completed fertility), fertility preferences and body mass index (measure of wellbeing). Figures 11a - 11d show that there are no discontinuities in these characteristics around the cut-off point.

We also carry out a placebo test by exploring if two groups of cohorts, not affected by the policy, present similar discontinuities on the outcomes of interest. This is done by comparing women who were 20-21 versus 22 and 23. These cohorts are less likely to be affected by the policy for their age. Table 7 shows that all the outcomes of interest are not significant demonstrating that the discontinuity is only valid for those aged 19 years and younger. As noted earlier, a gradual increase in age at marriage and birth has been taking place in Ethiopia, part of which is probably due to secular trend. However, these trends are likely to affect both groups of cohorts and will not systematically bias the parameters of interest.

One may also be concerned about any contemporaneous policies could also have lowered fertility from the year 2000. In order to rule out any likely effects on fertility from concurrent increases in contraception due to family planning policies, we carry out a third placebo test. As reported earlier in our analysis of the channels through which education affects fertility, we do not find any impact of the reform on contraceptive use. We present non-parametric evidence on whether there is a discontinuity in contraception use. As shown in Figure 12 we do not observe any discontinuity in contraceptive use, thereby affirming the validity of our empirical strategy.

One concern is that there are “*delays*” in college enrolment or “*repetitions*” that makes the effect of the reform span across different cohorts. Indeed school dropout and repetition is quite high

among female students in Ethiopia and especially during primary school.²⁷ To some extent this bias is alleviated by the fact that our sample is restricted to a very short window of comparable cohorts where treatment and controls are likely to be exposed to similar dropout and repetition rates. Indeed the policy reform program might have alleviated repetition in the intensive margin. Furthermore, it is likely that self-selection occurs among the women who enrol in higher education. We believe the incidence of repetition is lower in the upper-end tail of education. In a resource scarce setting, parents value and invest money for the education of their children and more importantly in private higher education, where enrolment also implies abilities above average.

7. Conclusion

This paper exploits a plausibly exogenous increase in the supply of higher education to determine the causal impact of education on fertility and the underlying mechanisms in Ethiopia. Our results show that expanding the supply of higher education through liberalisation substantially increased years of schooling and the probability of attending higher education by women. We also find that this increase in education lowers fertility and fertility preferences, and it also increases the probability of never giving birth.

Our assessment indicates that higher education affects fertility through positive assortative mating (i.e. lower age and education gap with the partner), postponed marriage and motherhood. We do not find strong evidence of the role of higher education in the labour market, possibly due to the structural labour market constraints and low labour force participation rates in Ethiopia. In urban areas, we find some evidence of an increase in autonomous decision making regarding one's own health care.

Ethiopia's fertility rate combined with the incidence of child marriage, still poses significant risks to women and children's well-being in one of the world's poorest countries. Our study's findings suggest that increasing access to higher education can be an effective policy option for lowering fertility. These findings are particularly resonant in many developing countries afflicted by the scourge of child marriage and unsustainable population growth. Our study also finds a large and increasing gap in the number children born to mothers without formal education compared to those born to mothers with higher education. The likelihood of never giving birth is far much higher among women with higher education thereby diminishing opportunities for the intergenerational transmission of human capital.

Recent research finds that delayed marriage may have negative consequences in some cultures like India. An older age at marriage leads to women marrying into families poorer than their own and experiencing less autonomy and bargaining power (Sivasankaran 2014). While our analysis rules out negative assortative mating, it is reasonable to expect that educated and unmarried older women in Ethiopia may face private social costs like social exclusion, stigma, social pressure,

²⁷ According to UNESCO 2009 country profile, overall repetition rate in primary school was 6.2% while completion rate is 41.7%.

lack of respect and an unmet need for motherhood. There has been little research on whether there is a social cost for women who attain higher education but remain unmarried in developing countries, as our findings show. Future research should assess the overall private return of higher education for women by determining if there are social costs from delaying marriage and whether they are compensated by earnings from the labour market (Boulier and Rosenzweig 1984). We surmise that the net effect of women's education on well-being is contingent to local social norms, labour and marriage markets. We also recommend future assessments of the long term effect of higher education on fertility.

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Figure 1: Enrolment in Higher Education (Millions)

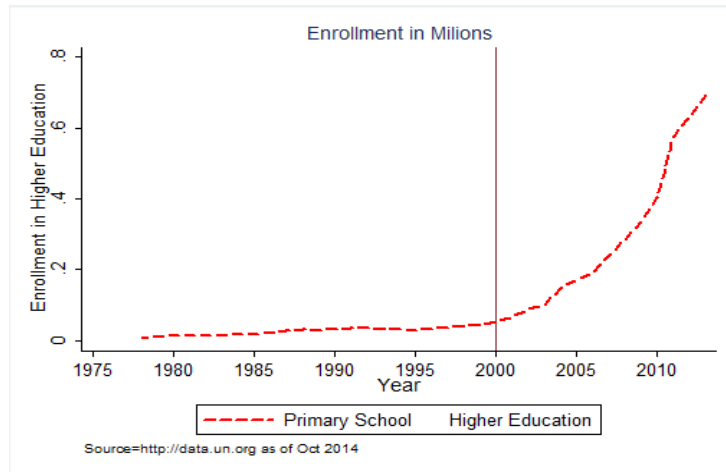


Figure 2: Government Expenditure in Higher Education (%)

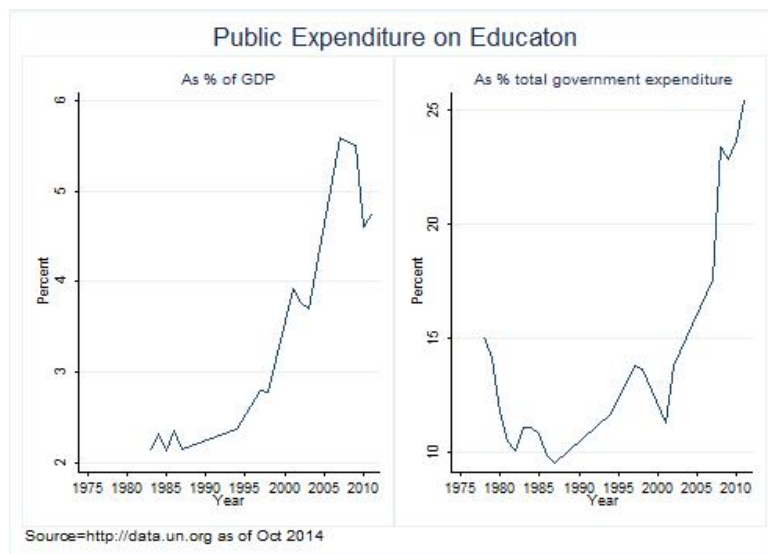
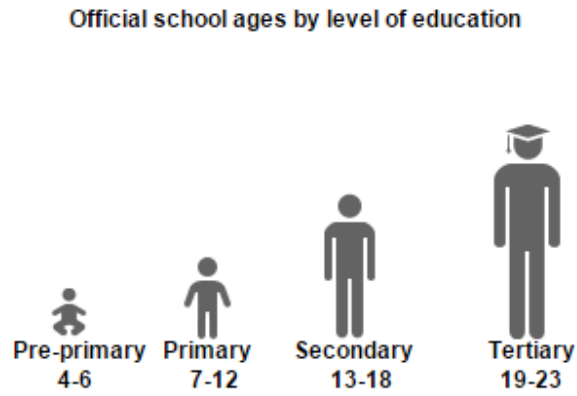
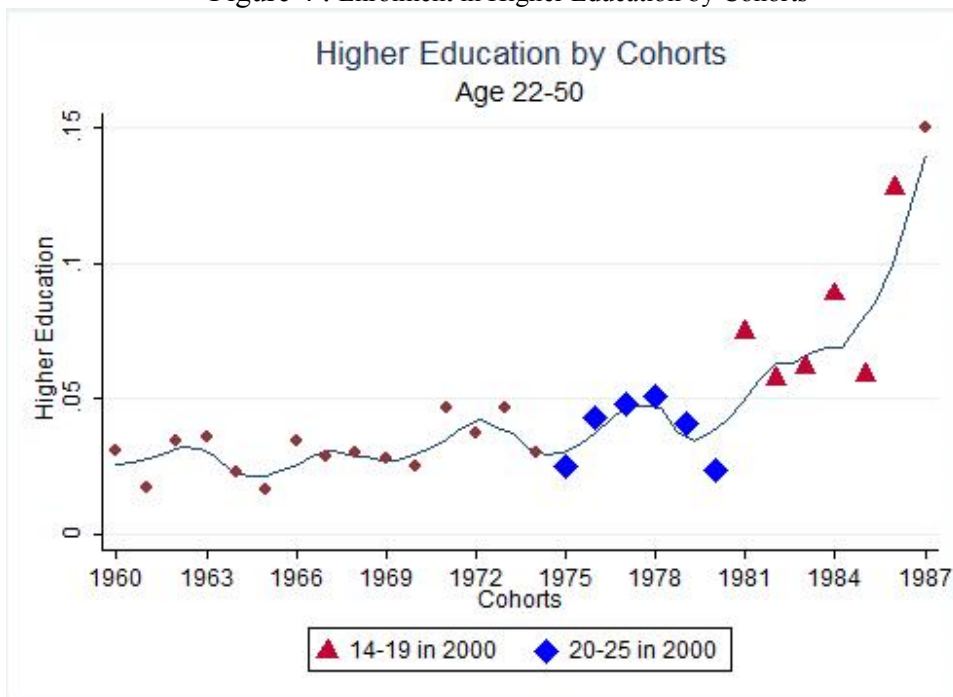


Figure 3: Ethiopian Education System



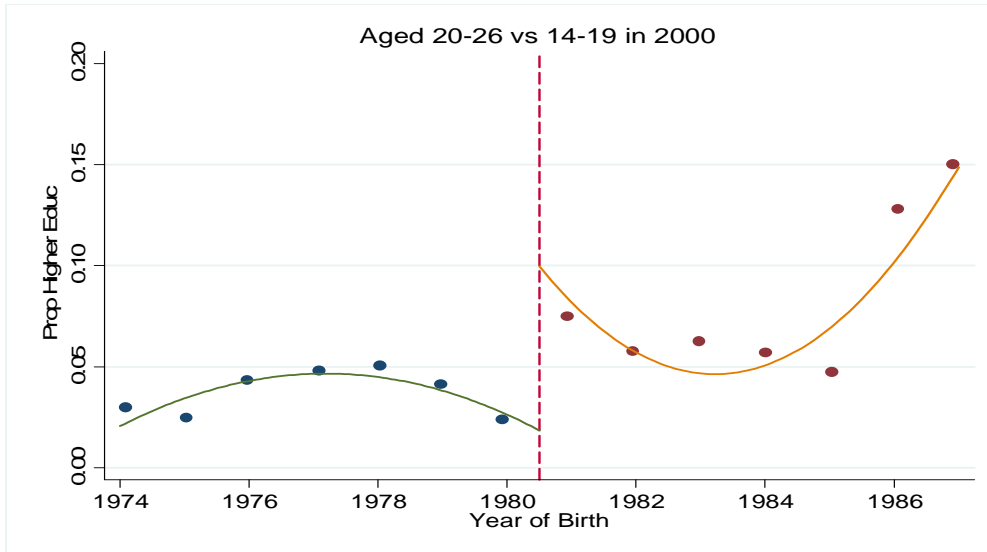
Notes: This figure is based on the UNESCO classification of country profile. The government has changed the structure by increasing years of primary school from six to eight.

Figure 4 : Enrolment in Higher Education by Cohorts



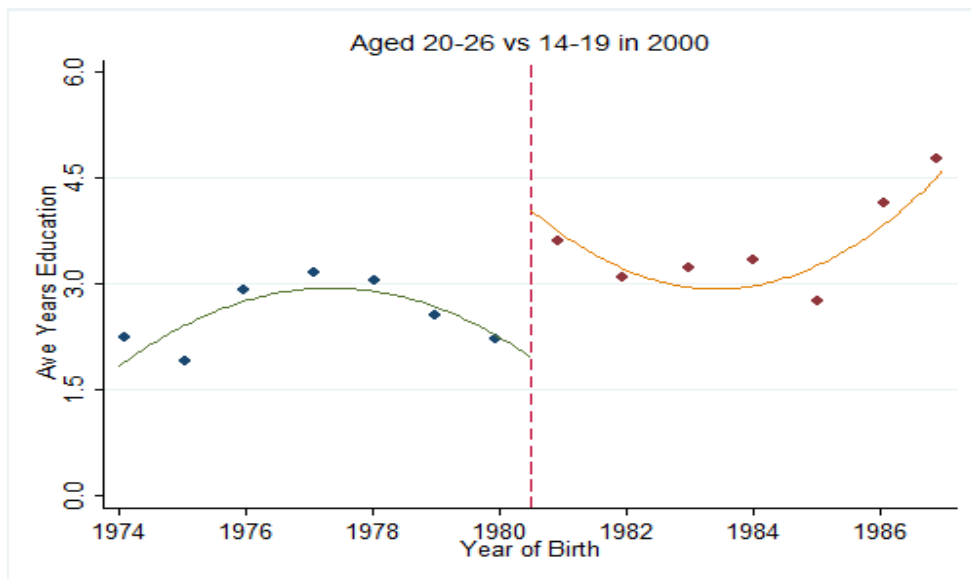
Notes: Data is from DHS 2005 & 2011 of Ethiopia and plots higher education attainment by cohort for women aged 23 and above. The triangle spots are those who benefited from the reform. Sample for analysis is restricted to two cohorts before and after cut-off.

Figure 5a: Enrolment in Higher Education



Notes: Average higher education attainment grouped by birth cohort for women aged between 14-26. The solid line represents the fitted values from a local second order polynomial regression allowing for an intercept shift at those 19 years old and below in 2000.

Figure 5b: Average Years of Education



Notes: Average years of education grouped by birth cohort for women aged between 14-26. The solid line represents the fitted values from a local second order polynomial regression allowing for an intercept shift at those 19 years old and below in 2000.

Figure 6a-6d: Impact of Higher Education of Fertility Outcomes

Figure 6a: Total Number of Births

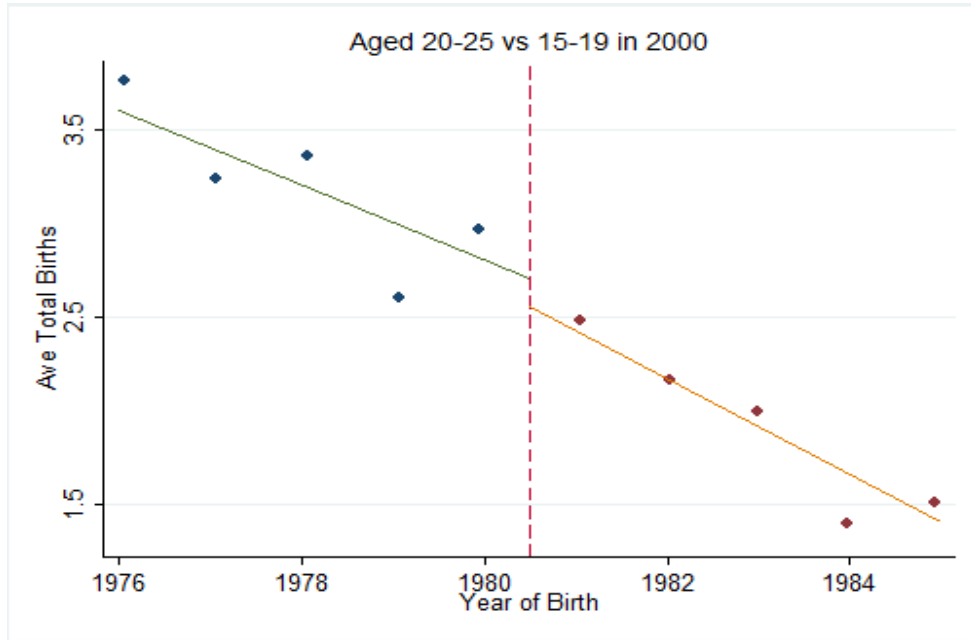


Figure 6b: Desired Number of Children

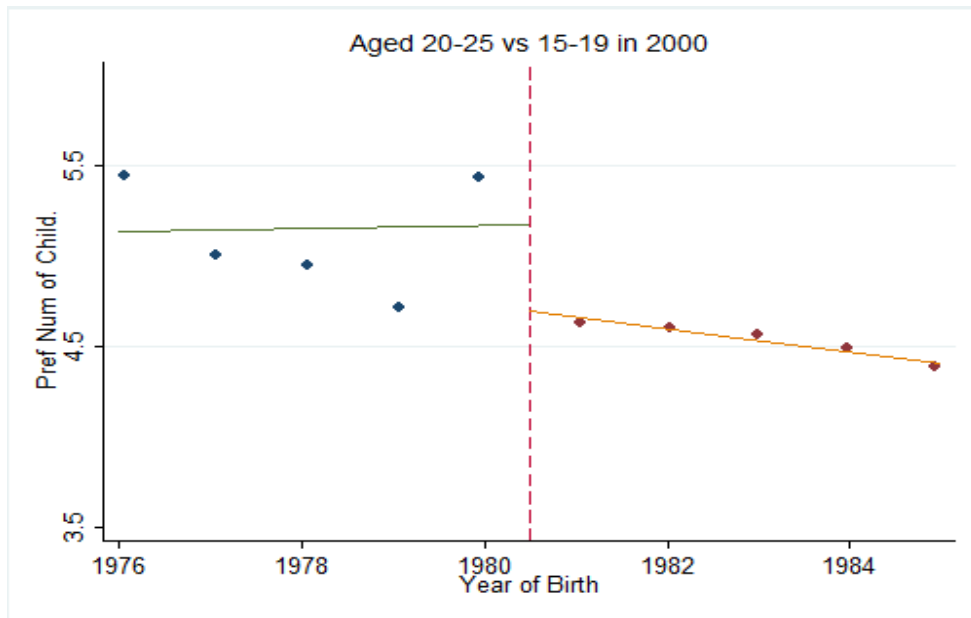


Figure 6c: Never Gave Birth

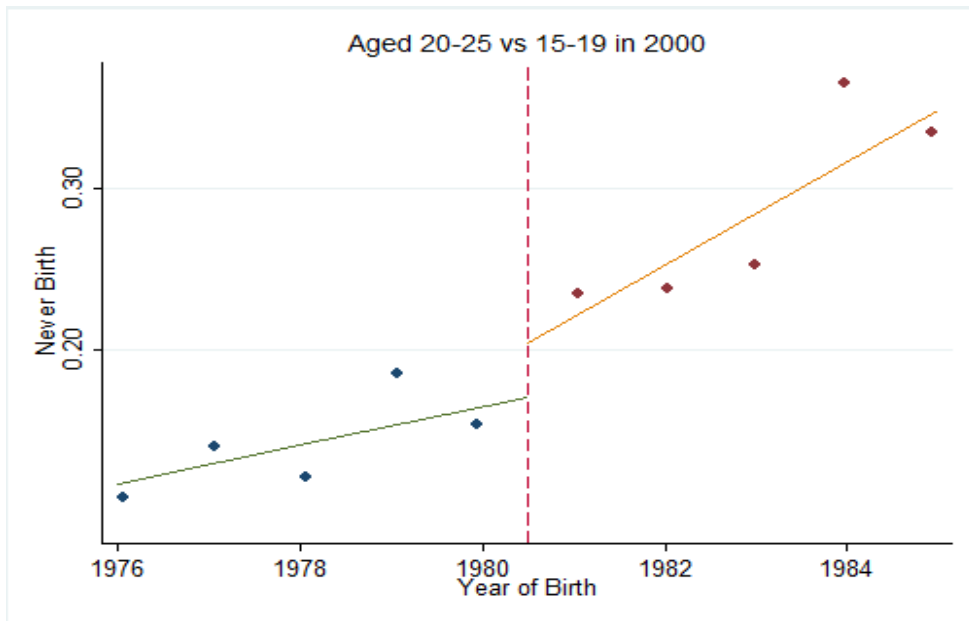
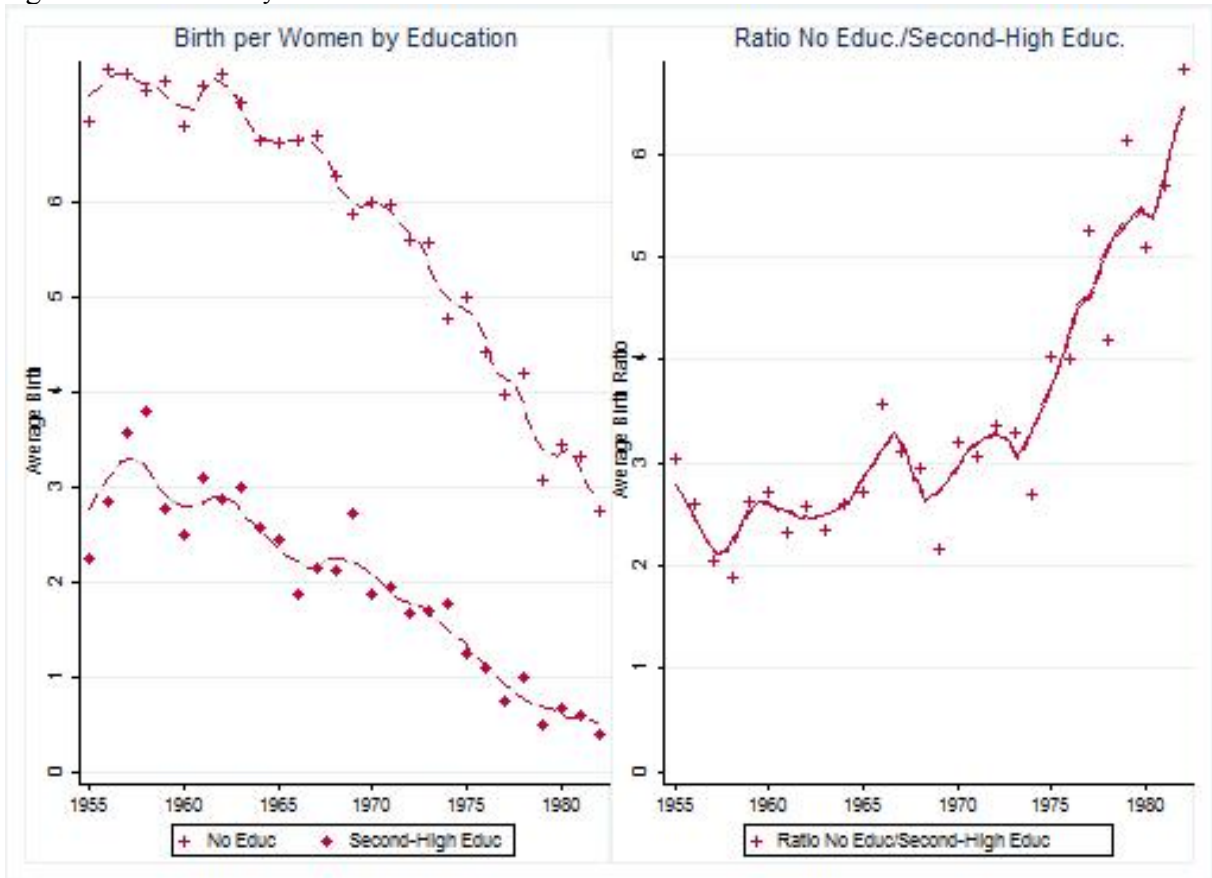


Figure 6d: Intended Number of Births



Figure 7: Birth Ratio by Education Level



Notes: The solid lines represent coefficients from local polynomial regression of number of children per women by birth cohorts, further distinguished by level of education. The dots and crosses are average births per woman grouped at cohort level and by education. The panel on the right represents the ratio between average number of children per women among those with no formal education divided by those with secondary or higher education.

Figure 8a Association between Higher Education and First Age of Sex/Marriage/Birth

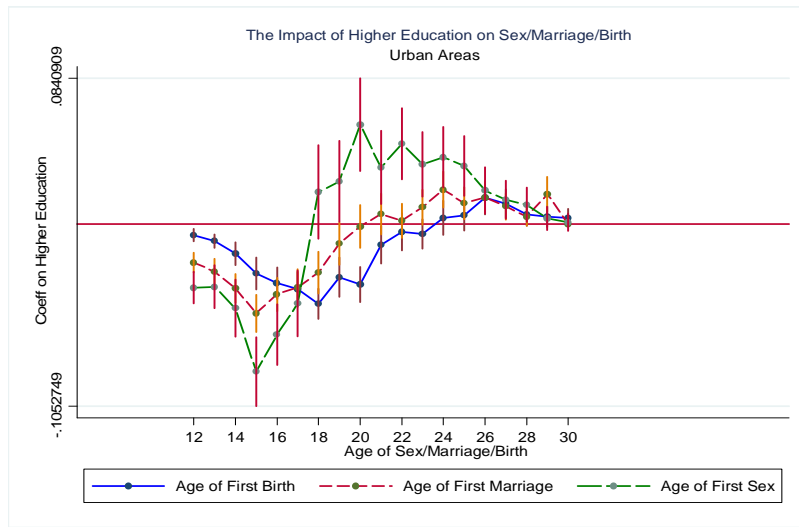
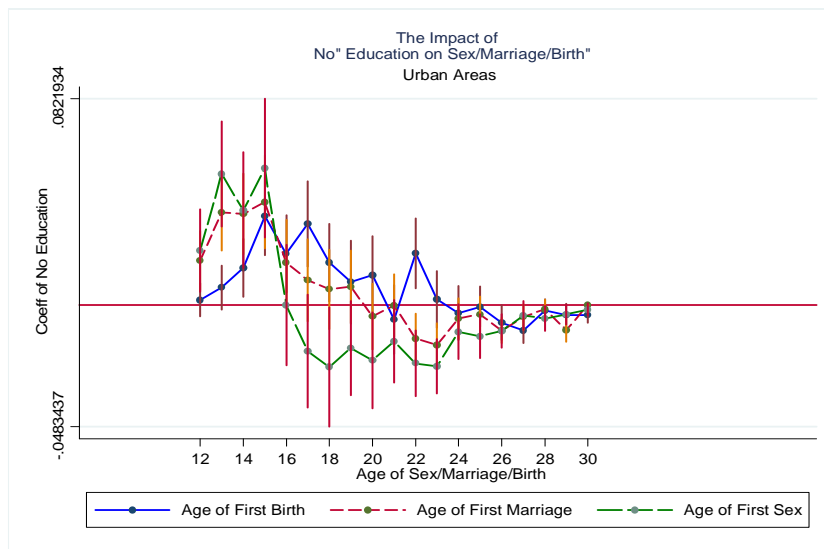
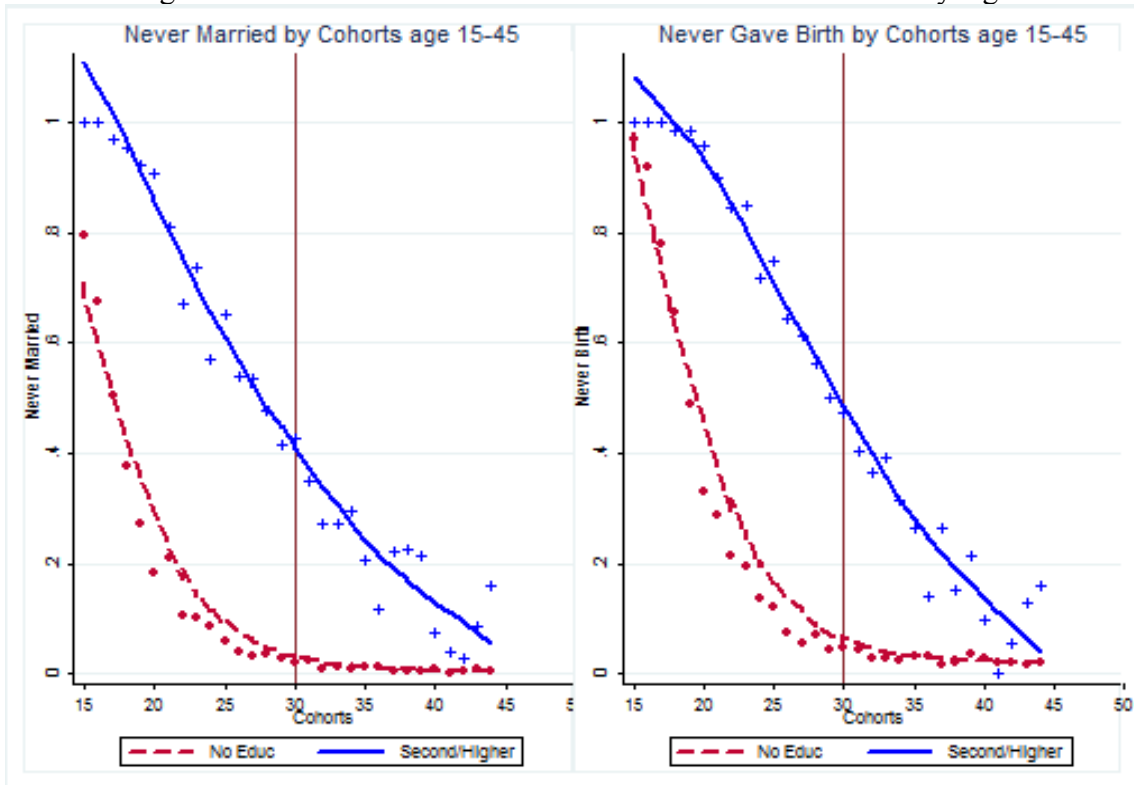


Figure 8b: Association between No Education and First Age of Sex/Marriage/Birth



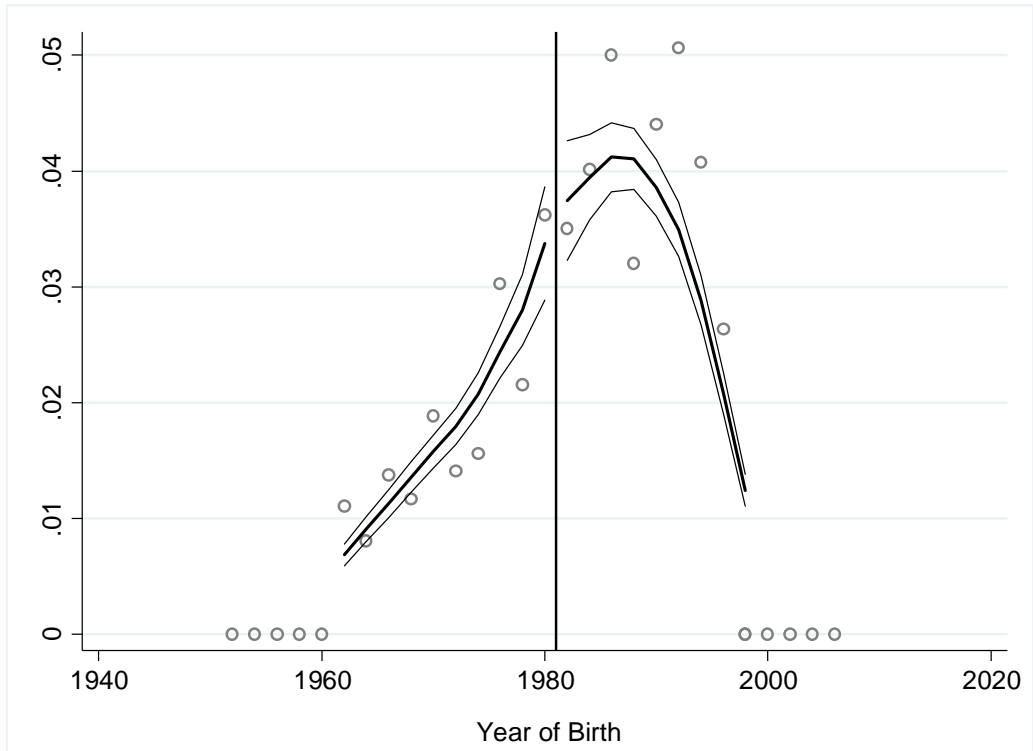
Notes: The solid lines represent coefficients from linear regression of marriage age on an indicator if individual achieved higher education. (or (b) no formal education). All estimates are reported with their CI at 95 percent. Other controls in the regression include wealth, region fixed effects, and urban location.

Figure 9: Trends of Women who Never Married or Gave Birth by Age



Note: The solid lines represent coefficients from local polynomial regression of being “being never married” or “never gave birth” on year of birth further distinguished by level of Education. The coefficients are reported with their CI at 95 percent.

Figure 10: Manipulation of treatment variable



Notes: Theta= -0.001 S.E=0.046 p=0.491 Bin size=2 Bandwidth=10.

Figure 11: Validity Test based on Characteristics of Plausible Mothers

Fig 11a: Total Fertility

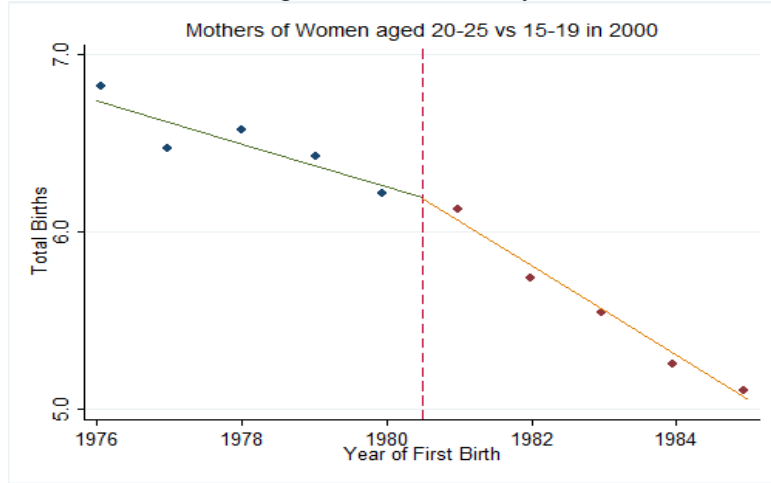


Fig 11b: Preferred Number of Children

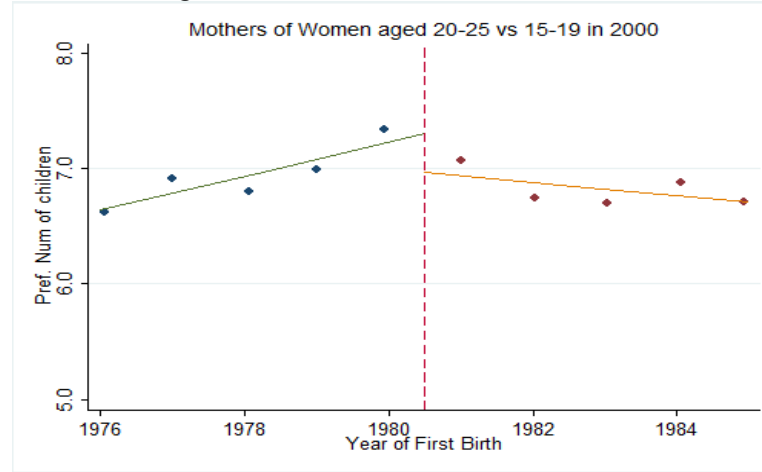


Fig 11c: Years of Education

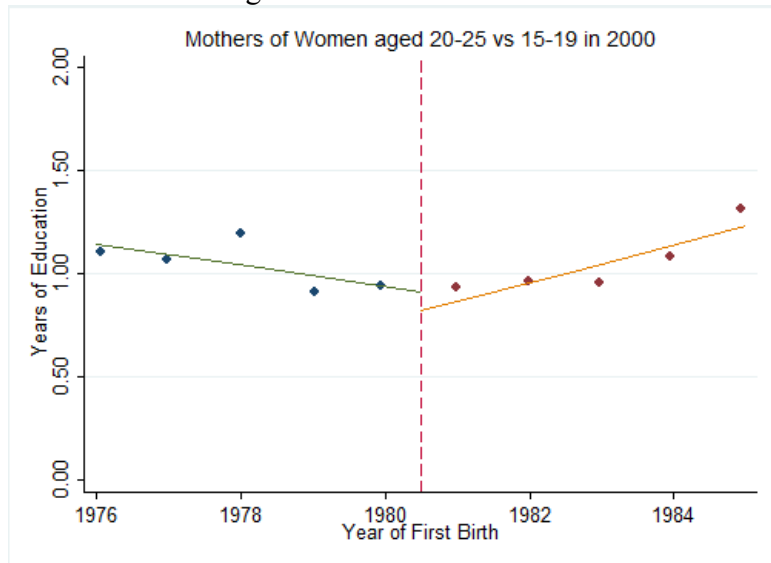


Fig 11d: Body Mass Index

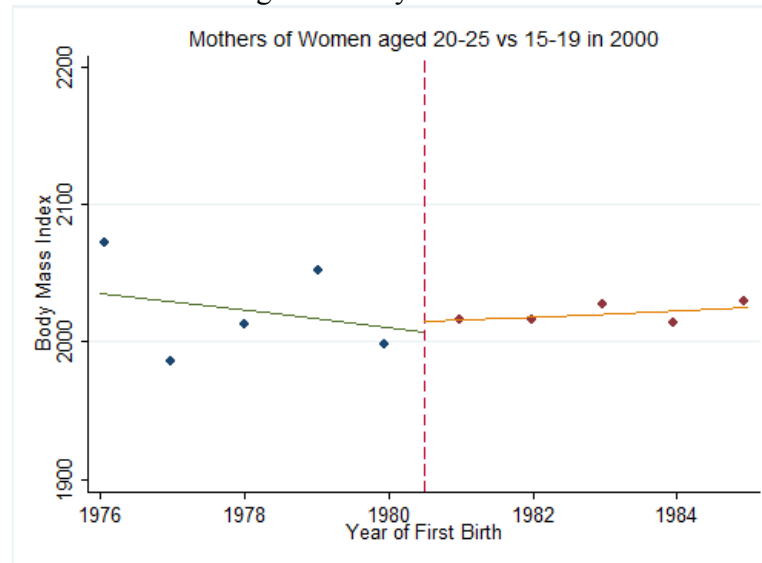
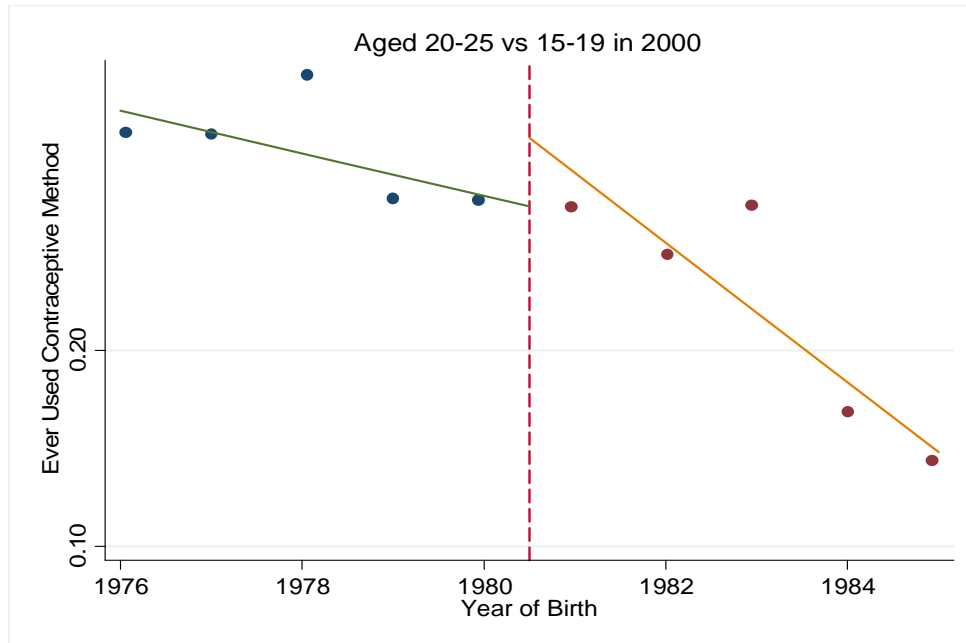


Figure 12 Validity test: Contemporaneous family planning policy



Notes: Average contraceptive use grouped by birth cohort for women. The solid line represents the fitted values from a local second order polynomial regression allowing for an intercept shift at those 19 years old and below in 2000 i.e. women in born in 1981.

Table 1: The Education System in Ethiopia

Pre-School	Primary School		Secondary School		Preparatory-Secondary		Exam	Higher Education
					2nd Cycle			
					2 Years			
Kinder	1st Cycle	2nd Cycle	Exam	1st Cycle	Exam	Technical and Vocational Training		
3 Years	4 Years	4 Years		2 Years		2 Years		

Source: Education Sector Development Program, Ministry of Education, Federal Democratic Republic of Ethiopia, 2001-2006.

Table 2: Enrolment in Higher Education: Public vs Private

Enrolment	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06
Government	26.243	31.723	34.351	34.177	52.327	132.986	143.753	140.426
Non-Government	-	5.472	11.175	12.619	23.670	39.125	47.412	39.691
Total	26.243	37.195	45.526	46.796	75.997	173.111	191.165	180.117
% Non-Government	0	14.7	24.5	27.0	31.1	22.7	24.8	22.0

Source: Education Statistics Annual Abstract, Ministry of Education, Federal Democratic Republic of Ethiopia, 2001-2006.

Table 3: Summary Statistics

	Ages 18-19 (Treated)		Ages 20-21 (Control)	
	Mean	N	Mean	N
A. All				
Age in years	26.12	1904	27.41	2387
	[2.92]		[2.7]	
Years of schooling	3.31	1904	2.34	2387
	[4.75]		[4.1]	
Higher education enrolment	0.07	1904	0.03	2387
	[0.25]		[0.17]	
Total number of children ever born	2.3	1904	2.83	2387
	[1.96]		[2.08]	
Never gave birth	0.24	1904	0.17	2387
	[0.43]		[0.37]	
B. Urban				
Age in years	25.92	709	27.37	709
	[2.88]		[2.75]	
Years of schooling	7.19	709	6.28	709
	[5.22]		[5.16]	
Higher education enrolment	0.16	709	0.09	709
	[0.36]		[0.29]	
Total number of children ever born	1.3	709	1.56	709
	[1.56]		[1.74]	
Never gave birth	0.41	709	0.36	709
	[0.49]		[0.48]	
C. Completed Secondary School				
Age in years	25.63	247	26.94	182
	[2.84]		[2.78]	
Years of schooling	13.15	247	12.99	182
	[1.45]		[1.5]	
Higher education enrolment	0.5	247	0.4	182
	[0.5]		[0.49]	
Total number of children ever born	0.49	247	0.6	182
	[0.86]		[1]	
Never gave birth	0.67	247	0.66	182
	[0.47]		[0.48]	

Notes: Summary statistics compare women who were 18 and 19 years old in 2000 (treated) versus those who were 20-21 years (control). The analysis presents results for all women, urban women and women who completed secondary school. Means and total observations are indicated. Source: DHS 2005 and 2011

Table 4: First Stage: Age Discontinuity and Education

	Years of Schooling			Attended Higher Education		
	Ages 15-24 (1)	Ages 17-22 (2)	Ages 18-21 (3)	Ages 15-24 (4)	Ages 17-22 (5)	Ages 18-21 (6)
A. All women						
Age 19 or less in 2000	0.67*** [0.132]	0.99*** [0.179]	1.19*** [0.235]	0.03*** [0.008]	0.04*** [0.011]	0.05*** [0.015]
Observations	10,400	5,867	4,238	10,400	5,867	4,238
R-squared	0.427	0.446	0.443	0.09	0.098	0.094
Mean	2.988	2.988	2.988	0.0439	0.0439	0.0439
SD	4.246	4.246	4.246	0.205	0.205	0.205
B. Urban						
Age 19 or less in 2000	1.40*** [0.329]	2.05*** [0.432]	2.41*** [0.568]	0.08*** [0.022]	0.10*** [0.030]	0.13*** [0.040]
Observations	3,496	1,976	1,396	3,496	1,976	1,396
R-squared	0.098	0.124	0.128	0.030	0.036	0.038
Mean	6.580	6.580	6.580	0.124	0.124	0.124
SD	4.895	4.895	4.895	0.330	0.330	0.330

Notes: Column headings denote the age windows (bandwidth). All regressions include controls for age in 2000 and a second order polynomial of age in 2000, number of siblings, height, religion and region fixed effects. Robust standard errors, are clustered by enumeration area and household level, in parentheses. Significance level: * at 10%, ** at 5% and ***at 1%. Source: DHS 2005 and 2011

Table 5: Effects of Education on Fertility

Variables	Total Children			Desired Children			Never gave Birth		
	OLS	RD	2SLS	OLS	RD	2SLS	OLS	RD	2SLS
All Women									
Coefficient	-0.11***	-0.26**	-0.21**	-0.07***	-0.55***	-0.43**	0.03***	0.05**	0.05**
	[0.007]	[0.123]	[0.092]	[0.011]	[0.200]	[0.171]	[0.002]	[0.025]	[0.022]
Sample	4,238	4,238	4,238	3,820	3,820	3,820	4,238	4,238	4,238
Mean	2.599	2.599	2.599	4.914	4.914	4.914	0.197	0.197	0.197
SD	2.044	2.044	2.044	3.241	3.241	0.455	0.398	0.398	0.455
<hr/>									
Urban	-0.10***	-0.33*	-0.13*	-0.06***	-0.96***	-0.43**	0.03***	0.08	0.03
Coefficient	[0.007]	[0.173]	[0.075]	[0.012]	[0.268]	[0.171]	[0.003]	[0.054]	[0.024]
Sample	1,396	1,396	1,396	1,309	1,309	1,309	1,396	1,396	1,396
Mean	1.430	1.430	1.430	3.843	3.843	3.843	0.389	0.389	0.389
SD	1.654	1.654	1.654	2.511	2.511	0.455	0.488	0.488	0.455

All regressions include controls for age in 2000 and a second order polynomial of age in 2000, number of siblings, height, religion and region fixed effects. In OLS, coefficient is for years of schooling. RF denotes reduced form, where the coefficient captures discontinuity at age 19. In 2SLS, years of schooling is instrumented using the discontinuity at age 19. Robust standard errors, are clustered by enumeration area and household level, in parentheses. Significance level: * at 10%, ** at 5% and *** at 1%. Source: DHS 2005 and 2011

Table 6: Education and Fertility: Mechanisms

Variables	Age Gap			Education Gap			Working			Never Married				
	OLS	RD	2SLS	OLS	RD	2SLS	OLS	RD	2SLS	OLS	RD	2SLS	OLS	
All Women														
Coefficient	-0.14*** [0.038]	-2.03*** [0.577]	-3.46** [1.701]	-0.35*** [0.020]	-0.27 [0.240]	-0.39 [0.333]	0.01*** [0.002]	0.03 [0.033]	0.02 [0.030]	0.03*** [0.002]	0.06*** [0.023]	0.05** [0.020]	0.01** [0.005]	0.01** [0.005]
Sample	3,168	3,168	3,168	3,568	3,568	3,568	4,227	4,227	4,227	4,238	4,238	4,238	3,172	3,172
Mean	8	8	8	1.561	1.561	1.561	0.460	0.460	0.460	0.149	0.149	0.149	0.170	0.170
SD	7.101	7.101	7.101	3.201	3.201	3.201	0.498	0.498	0.498	0.356	0.356	0.455	0.380	0.380
Urban														
Coefficient	-0.10** [0.045]	-1.89* [0.997]	-1.49 [1.198]	-0.34*** [0.026]	-1.07* [0.580]	-0.72* [0.395]	0.01*** [0.003]	0.11* [0.058]	0.05* [0.029]	0.03*** [0.002]	0.10** [0.052]	0.04* [0.024]	0.01** [0.005]	0.01** [0.005]
Sample	758	758	758	934	934	934	1,390	1,390	1,390	1,396	1,396	1,396	758	758
Mean	7.346	7.346	7.346	2.229	2.229	2.229	0.562	0.562	0.562	0.319	0.319	0.319	0.290	0.290
SD	6.272	6.272	6.272	4.070	4.070	4.070	0.496	0.496	0.496	0.466	0.466	0.455	0.450	0.450

All regressions include controls for age in 2000 and a second order polynomial of age in 2000, number of siblings, height, religion and region fixed effects. RF denotes reduced form, where the coefficient is for the discontinuity at age 19. In 2SLS, years of schooling is instrumented using the discontinuity at age 19. Robust standard errors, are clustered by enumeration area and household level, in parentheses. Significance level: * at 10%, ** at 5% and ***1%. Source: DHS 2005 and 2011

Table 7: Placebo Test, 2SLS: Effects on Ages 20-21 vs Ages 22-23

	Total Children	Desired Children	Never gave Birth	Age Gap	Education Gap	Never Married	Working	Health Decision
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. All Women								
Years of Schooling	10.03	4.58	-0.87	1.20	0.65	-0.57	0.33	-0.11
	[24.067]	[12.171]	[2.129]	[1.683]	[1.430]	[1.413]	[0.785]	[0.114]
Observations	3,888	3,480	3,888	3,018	3,401	3,888	3,881	3,888
B. Urban								
Years of Schooling	1.67	2.10	-0.36	-0.31	0.10	-0.29	-0.15	-0.06
	[3.125]	[5.955]	[0.685]	[0.625]	[0.627]	[0.569]	[0.327]	[0.06]
Observations	1,204	1,129	1,204	684	848	1,204	1,203	1,204

All regressions include controls for age in 2000 and a second order polynomial of age in 2000, number of siblings, height, religion and region fixed effects. In 2SLS, years of schooling is instrumented using the discontinuity at age 19. Robust standard errors, are clustered by enumeration area and household level, in parentheses. Significance level: * at 10%, ** at 5% and ***1%. Source: DHS 2005 and 2011

Appendix

Table A1 First stage: Automatic Bandwidth Selectors

<i>Outcome</i>	Imbens and Kalyanaraman (2012)			Ludwig and Miller (2007)		
	Coefficient	SE	BW (one side)	Coefficient	SE	BW (one side)
Years of schooling	1.85***	[0.316]	2.339	1.85***	[0.316]	2.25

Authors' calculations. Source: DHS 2005 and 2011

Table A2: Education and Fertility: Mechanisms on Intended Birth and Child Well-Being

VARIABLES	Intended Birth			Num Stunt Children <5yrs			Without Vacc Card		
	OLS	RF	2SLS	OLS	RF	2SLS	OLS	RF	2SLS
All Women									
Coefficient	-0.19***	-0.08	-0.07*	-0.22***	-0.01	-0.64	-0.14***	-0.01	-0.36
	[0.042]	[0.054]	[0.042]	[0.044]	[0.042]	[1.834]	[0.037]	[0.063]	[2.618]
Observations	4,238	4,238	4,238	2,008	2,008	2,008	2,840	2,840	2,840
R-squared	0.189	0.178		0.077	0.068		0.194	0.185	
Mean	0.830	0.830	0.830	0.417	0.417	0.417	0.622	0.622	0.622
SD	0.870	0.870	0.870	0.432	0.432	0.432	0.807	0.807	0.807
Urban									
Coefficient	-0.11**	-0.06	-0.46	-0.21***	-0.10	-1.08	-0.14***	-0.04	-0.36
	[0.042]	[0.077]	[0.612]	[0.047]	[0.093]	[1.065]	[0.033]	[0.088]	[0.882]
Observations	1,396	1,396	1,396	385	385	385	580	580	580
R-squared	0.177	0.152		0.125	0.090		0.210	0.194	
Mean	0.417	0.417	0.417	0.272	0.272	0.272	0.215	0.215	0.215
SD	0.696	0.696	0.696	0.415	0.415	0.415	0.568	0.568	0.568

All regressions include controls for age in 2000 and a second order polynomial of age in 2000, number of siblings, height, religion and region fixed effects. RF denotes reduced form, where the coefficient is for the discontinuity at age 19. In 2SLS, years of schooling is instrumented using the discontinuity at age 19. Robust standard errors, are clustered by enumeration area and household level, in parentheses. Significance level: * at 10%, ** at 5% and ***1%. Source: DHS 2005 and 2011

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