The Impacts of Free Secondary Education: Evidence from Kenya

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Education Evidence for Action

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Motivation: free education policies

Almost all countries subsidize basic education

Subsidies are designed to address:

- Positive social returns to education
- Education as a basic human right
  - "Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling"
    - **Millennium development goal #2 (2000)**

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Over a third of Sub-Saharan African countries introduced **free primary education** policies between 1994 and 2015
(Harding and Stasavage 2014, UNESCO 2015)

- These policies have been shown to increase education access and attainment, often among most vulnerable populations
  (Lucas & Mbiti 2012, Al-Samarrai & Zaman 2007, Hoogeveen & Rossi 2013, Deininger 2003, Grogan 2009, Nishimura et al. 2008)

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Countries are now expanding education systems to include **free secondary education (FSE)** programs

(Gambia, Kenya, South Africa, Uganda)

Might face a more muted demand response at the secondary school level:

- Opportunity cost of schooling is likely to be higher
- Returns to education may be low or perceived to be low
- Incentives of parents and children may not align

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If FSE programs do increase educational attainment, they may also impact a range of other outcomes

Motivation: impacts on demographic outcomes

Delaying childbirth in particular could be beneficial

- Early childbearing has been associated with:
  - Higher morbidity and mortality (maternal and child)
    - Pregnancy related deaths are the largest cause of mortality for 15-19 year old females worldwide
    - Accounts for 2/3 of deaths in sub-Saharan Africa (15-19 year old females) (Patton et al. *The Lancet*, 2016)
  - Lower educational attainment
  - Lower family income

(Ferré 2009 and Schultz 2008)

Mixed evidence on **fertility impacts of education**:

- Impacts may be conditional on high initial rates

(Osili & Long 2008, Ferré 2009, Keats 2014, Baird et al. 2010, Ozier 2016, Filmer & Schady 2014, McCrary and Royer 2011)

Overview

Present Study: Measure the impact of FSE using the 2008 introduction in Kenya

Exploit heterogeneity in ex-ante exposure to the program based on the proportion of students dropping out of school after completing primary school.

I measure the impact of the FSE policy on:

- Educational attainment (increased schooling by 0.8 years)
- Academic achievement (no decrease in student test scores)

I also use exposure to FSE as an instrument to measure the impact of secondary schooling on:

- Demographic outcomes (age of first intercourse, birth, marriage)
- Labor market outcomes (occupational choice)

(Extension) (Model)

Context

Education in Kenya

Standardized national examinations following both primary school and secondary school

- Centrally developed and graded
- KCPE is used for admission to secondary school
- KCSE determines admission to tertiary education and is used as a credential on the labor market

Meaningful exams: results are important and students study

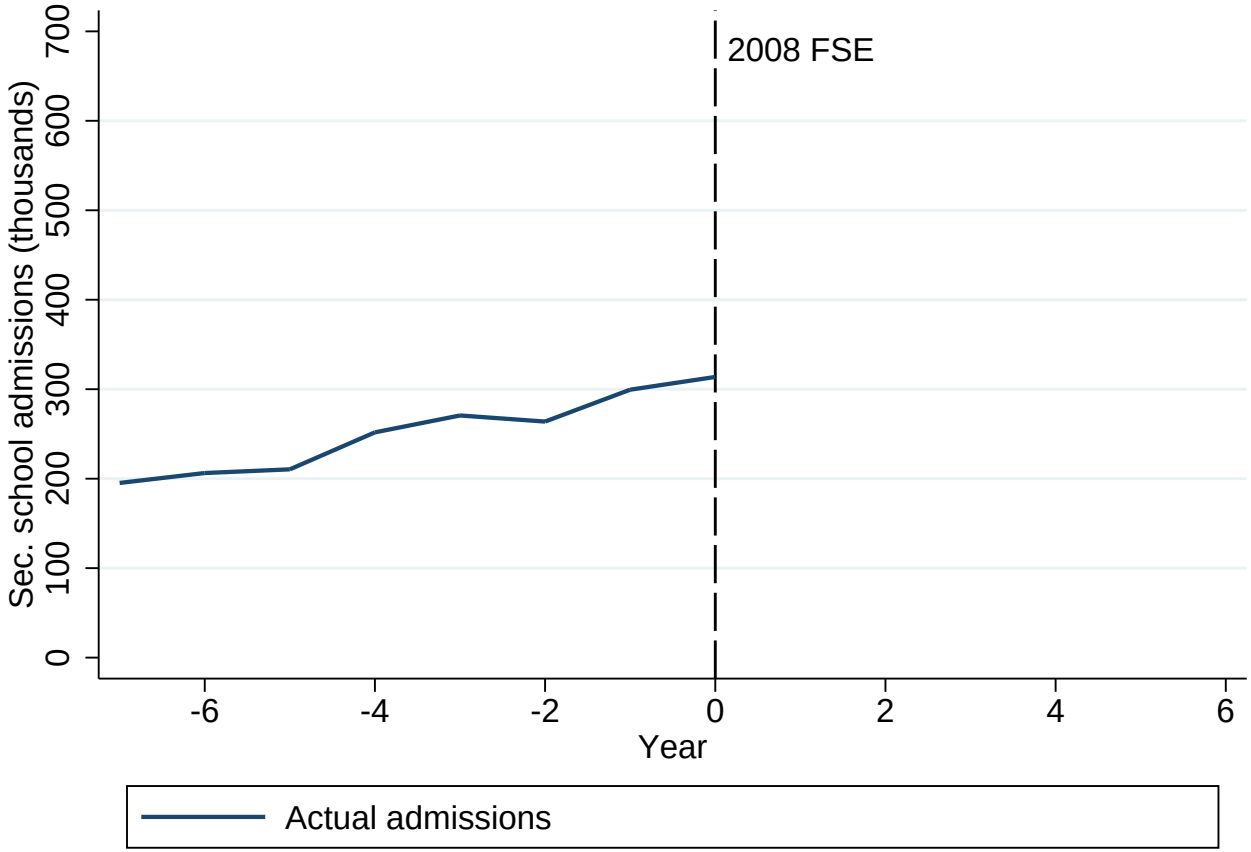
FSE in Kenya

FSE introduced in January 2008

- Covered tuition at public day secondary schools
  - Implemented as a capitation grant for secondary school students
  - Covered KSh10,265 ($\sim$ USD164)
  - Grant equivalent to $\sim$22% of mean per capita household expenditures (Glennerster et al. 2011)
- **Decreased household cost** of secondary schooling
- Government also instructed schools to:
  - Increase number of classes
  - Increase class sizes from 40 to 45

National trends in secondary school admission

Secondary school enrollments prior to FSE



Source: Kenya Economic Surveys (2000-2013).

National trends in secondary school admission

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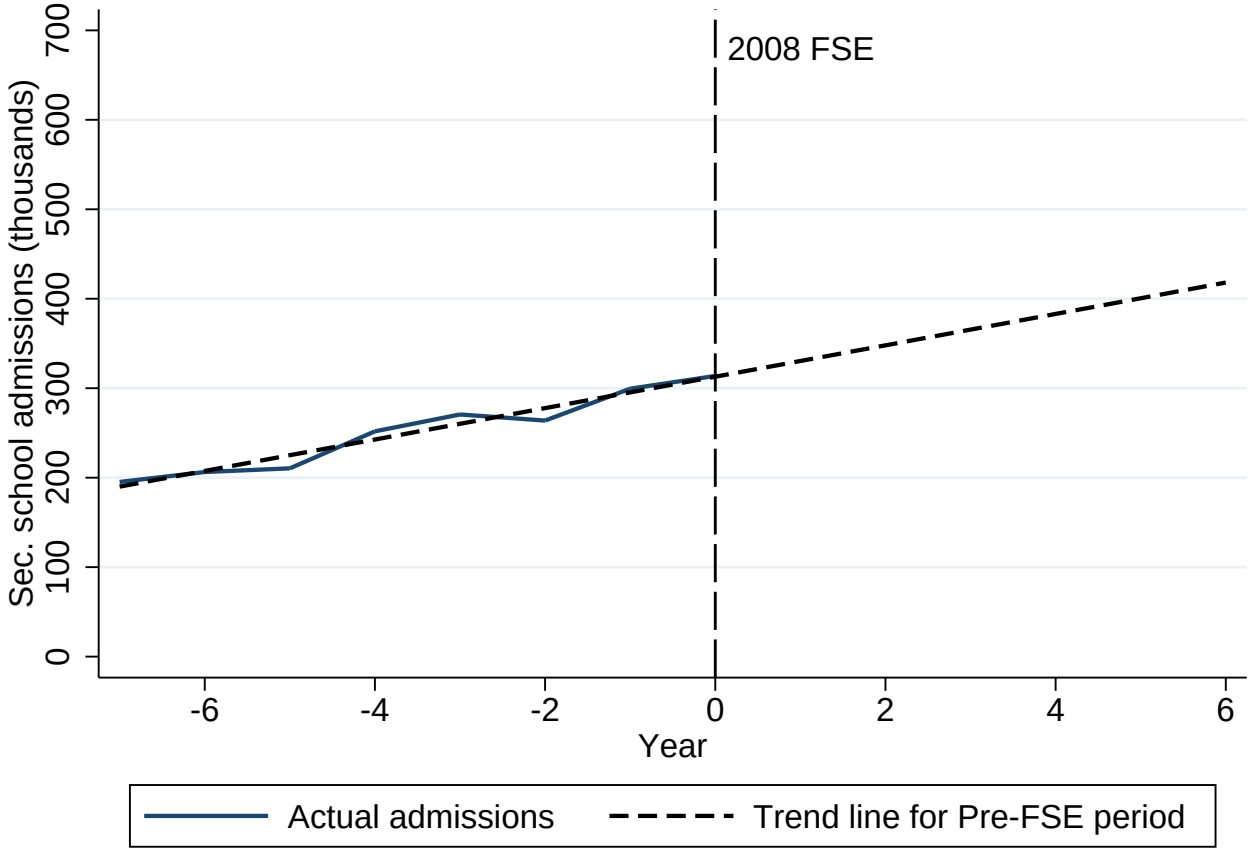
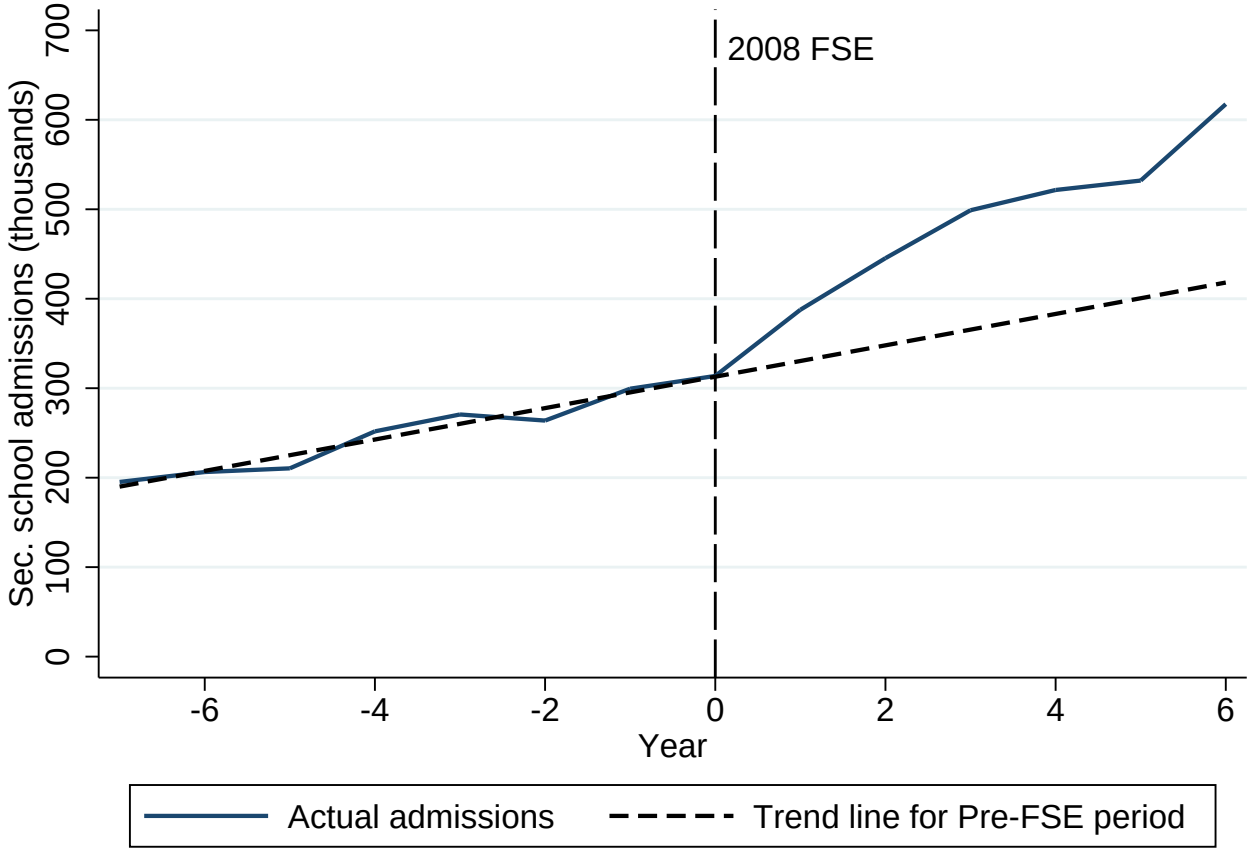


Source: Kenya Economic Surveys (2000-2013).

National trends in secondary school admission

Enrollments increased following program introduction



Source: Kenya Economic Surveys (2000-2013).

Data

Data sources: DHS

Kenya Demographic and Health Survey (2014)

- Nationally representative survey of women aged 15-49
- Focus on individuals born between 1983 and 1996 who have completed primary school
  - Yields a sample of 13,605 individuals (summary statistics)
- **Use to calculate regional treatment intensity and estimate program impact on demographic and labor market outcomes**

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Administrative Test Scores (summary statistics)

- All students who took the KCSE between 2006 and 2015 (no 2012)
- Over 3.3 million individuals
- Exclude students from less than 1% of schools that draw from around the country
- **Use to measure impact on academic performance**

Impacts on Educational Attainment

Identification of FSE Impact

Difference-in-differences comparing regions and cohorts more impacted against those less impacted

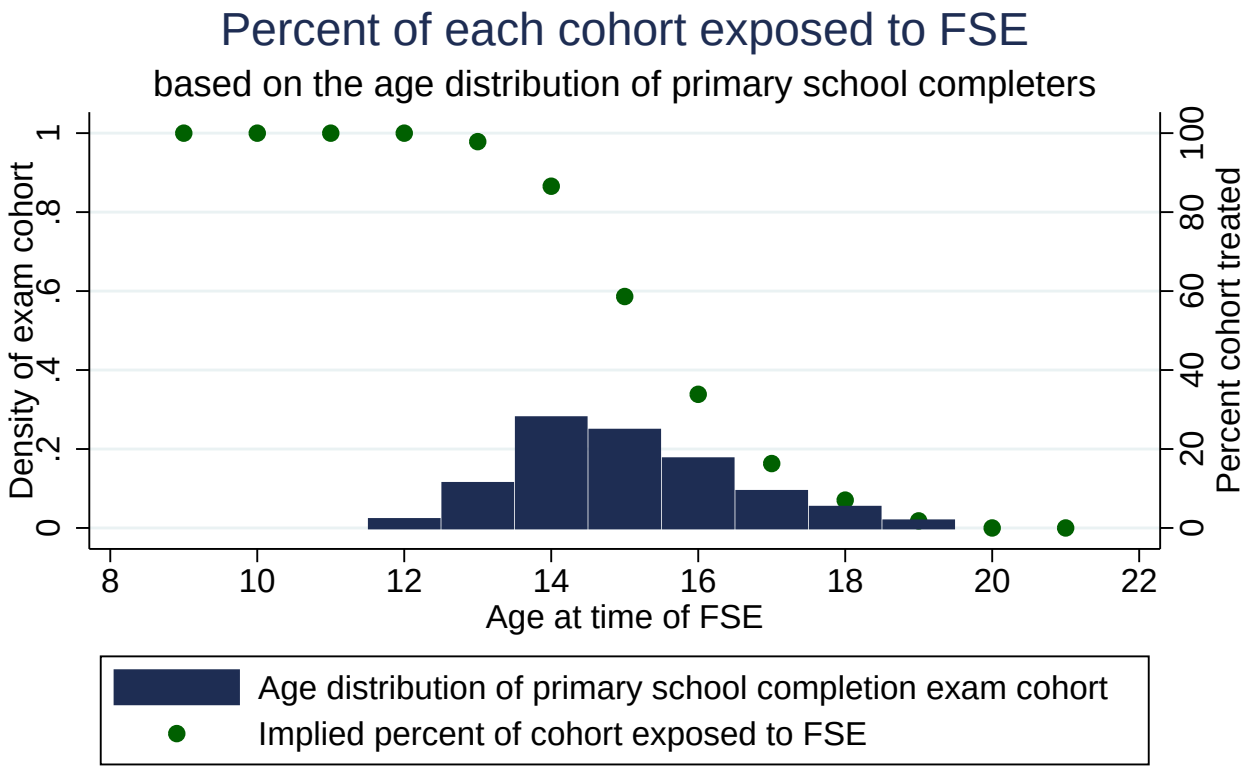
Exposure intensity depends on:

1. **Cohort exposure:** the student's timing of secondary schooling (before/after program implementation)
2. **Regional exposure:** how the program changed the probability of attending school in his/her region
   - In regions where all students attend secondary school, no students can be induced by the program to attend
   - In regions where no students attend secondary school, all students could be induced to attend secondary school
   - Fraction not attending is the fraction that could see an increase in attainment due to the program

Similar to Bleakley 2007/2010, Card & Kruger 1992, Mian & Sufi 2010

DHS cohort exposure implied by registration data

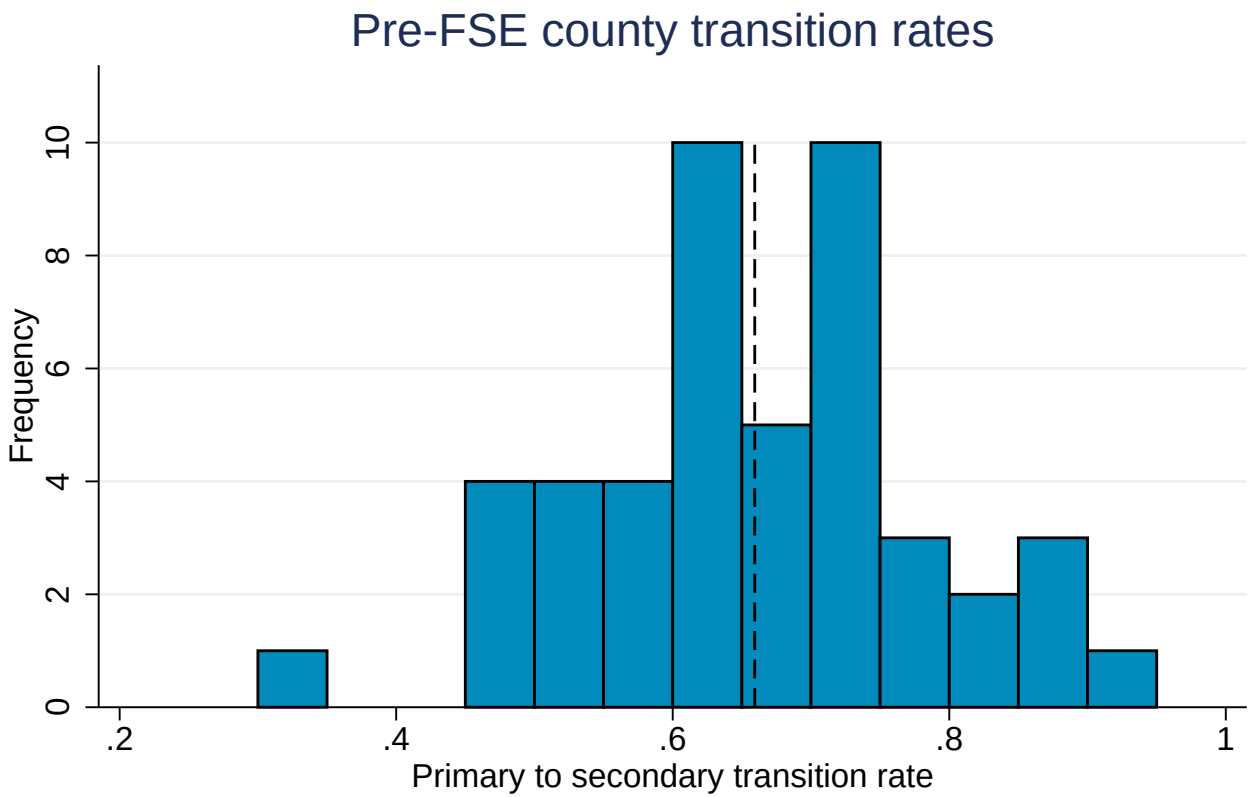
(Return)



Comparison of 2008 cohort and 2014 cohort

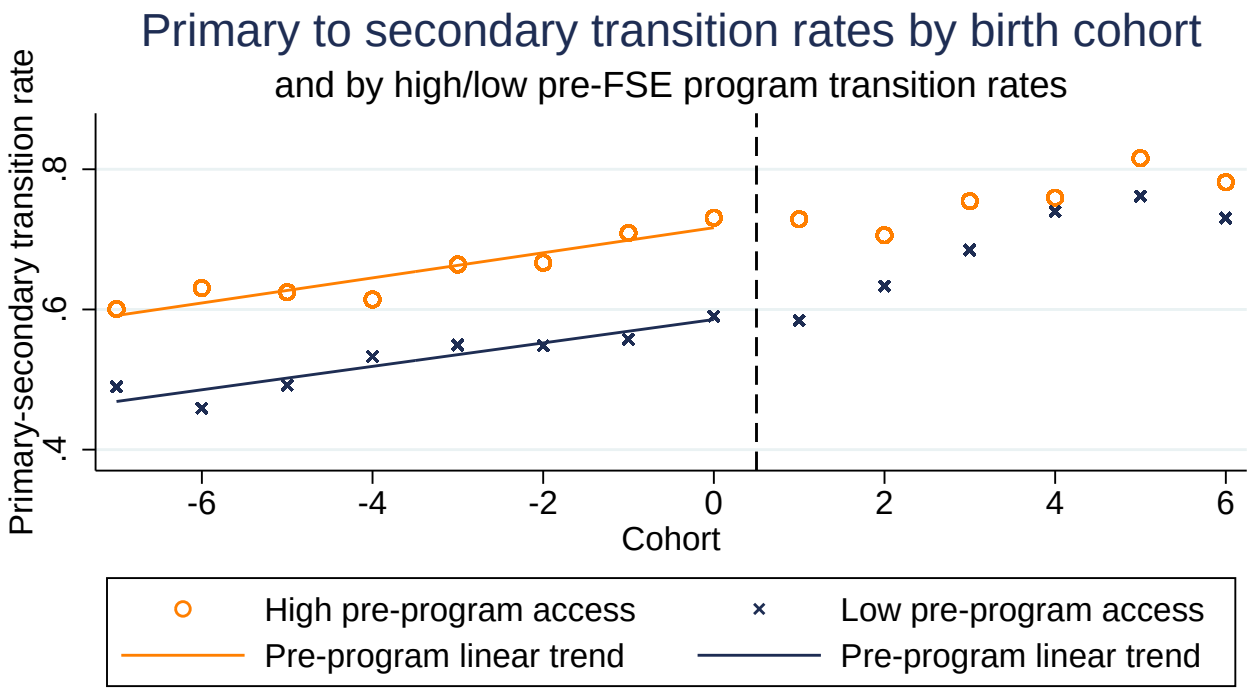
Implies that students aged 16 or younger in 2007 were impacted by the program (born in 1991 or later)

Regional exposure



Source: 2014 Kenya DHS.
Notes: Transition rate measured as students with any secondary schooling as a fraction of primary school graduates. Dashed line indicates mean county transition rate.

Regional exposure trends



Source: 2014 Kenya DHS.
Notes: High/low pre-program access defined as whether county average pri-sec transition rate between 1989 and 1990 was above/below the average transition rate. Pri-sec transition rate defined as share of primary school graduates with at least some secondary schooling. Free secondary education introduced in early 2008 for the 2007 KCPE cohort. 70% of KCPE students in 2014 were 14-16 years old suggesting program first impacted students born between 1991 and 1993.

Diff-in-diff

Return

Summary: impact of FSE on education

At the mean intensity of 0.34, estimates suggest an increase of 0.8 years of education.

- Smaller than primary education estimates (1-1.5 years in Nigeria and Uganda)
- Larger than existing secondary school estimates (0.3 years in the Gambia)

Estimates consistently suggest that FSE would induce $\sim 50\%$ of students to attend and complete secondary school

- Almost equivalent estimates across genders
- No evidence for differential impacts by gender

Impact of FSE on education

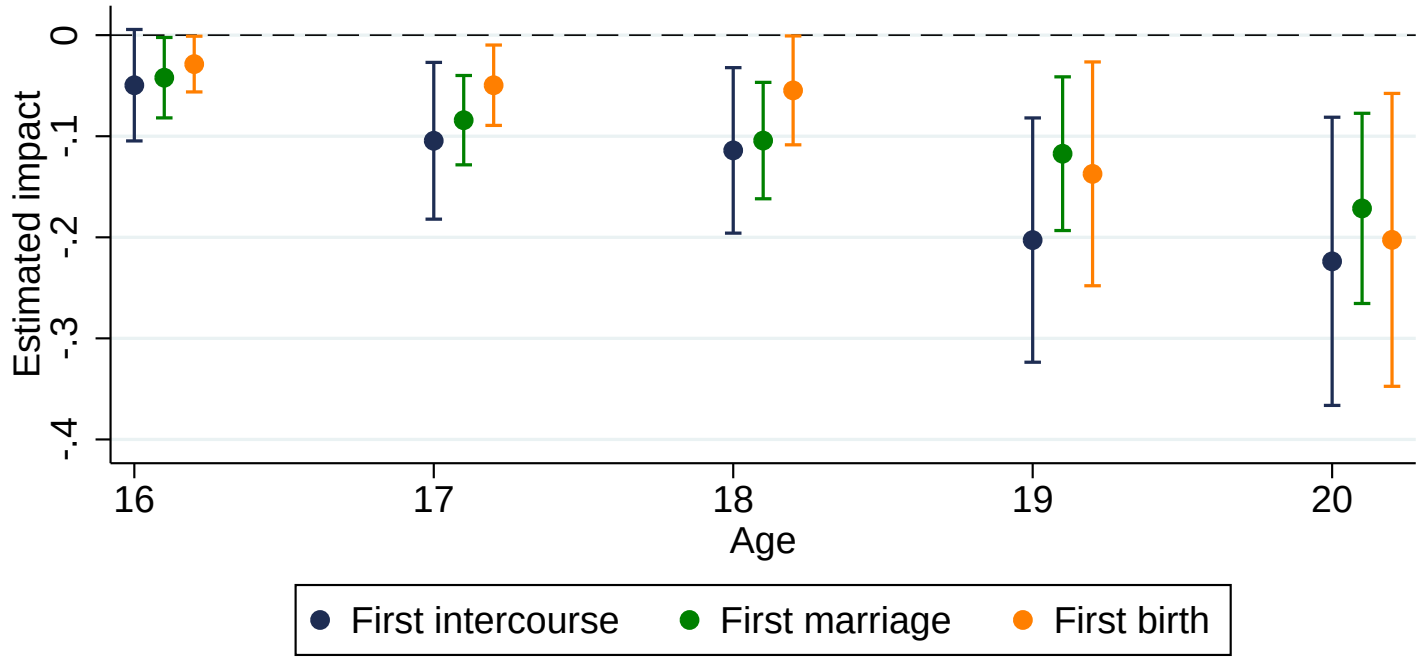
	(1)	(2)	(3)	(4)	(5)
A. Pooled Gender					
(1-transition rate)*FSE period	2.255***	2.256***	2.060***	2.059***	2.134***
	(0.31)	(0.311)	(0.356)	(0.718)	(0.677)
Observations	13605	13605	13605	13605	13605
R^2	0.099	0.101	0.1	0.104	0.106
B. Female Only					
(1-transition rate)*FSE period	2.409***	2.449***	2.221***	2.058**	2.336***
	(0.277)	(0.268)	(0.336)	(0.897)	(0.709)
Observations	9596	9596	9596	9596	9596
R^2	0.091	0.093	0.092	0.096	0.099
C. Male Only					
(1-transition rate)*FSE period	2.047***	2.035***	1.942***	2.374**	2.075
	(0.673)	(0.616)	(0.686)	(1.090)	(1.309)
Observations	4009	4009	4009	4009	4009
R^2	0.125	0.129	0.128	0.14	0.147
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trend				✓	✓

Common trends, Falsification test, No transition cohorts, No cities, No small counties

Impacts of Secondary Education

IV: Impacts of secondary education

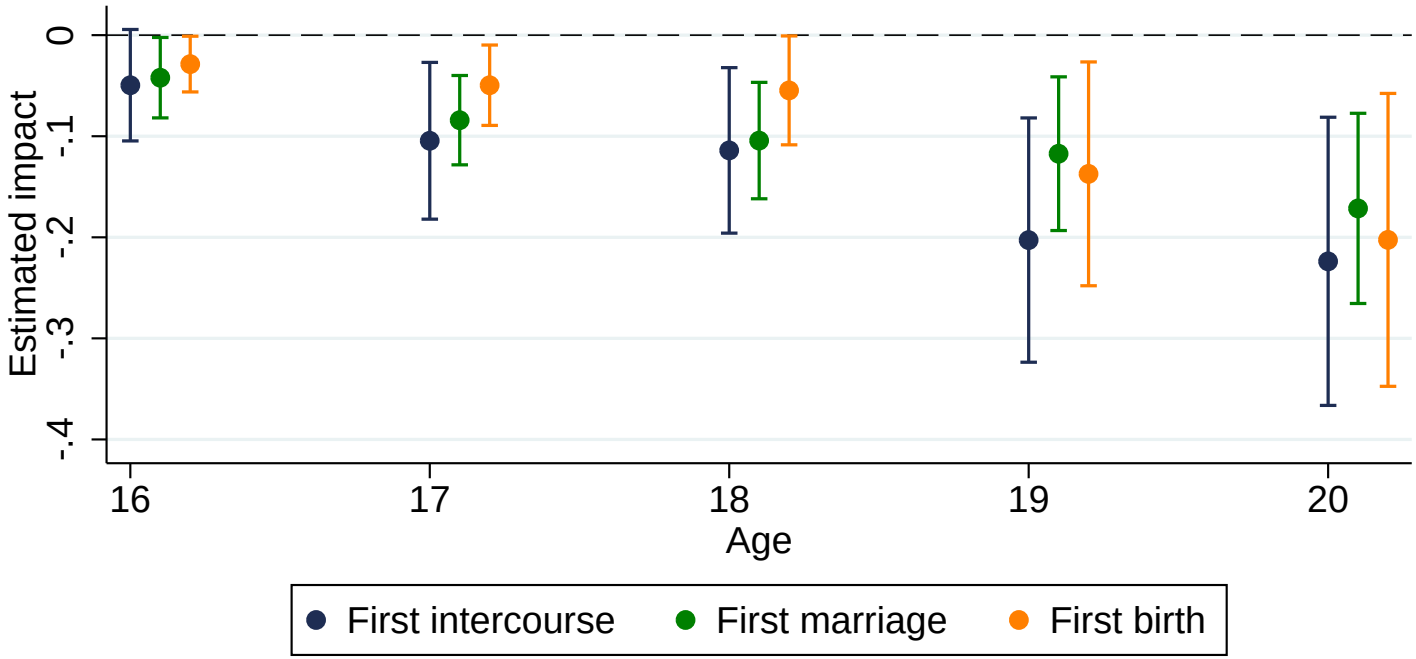
Impact of secondary schooling on women's demographic outcomes



Each point represents the coefficient on years of education from separate regressions where the dependent variables are binary indicators for whether individuals participated in each behavior before age X. Years of education is instrumented with cohort * county level exposure. The bars denote the corresponding 95% confidence intervals, with standard errors clustered by county. The F-statistics for first intercourse and first marriage are 75.78, 75.78, 75.78, 55.04, and 37.47 for age 16, 17, 18, 19, and 20, respectively. First birth F-statistics are 75.78, 75.78, 75.78, 55.04, and 37.47.

IV: Impacts of secondary education

Impact of secondary schooling on women's demographic outcomes



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But no change in contraception usage/access or desired fertility

Table versions

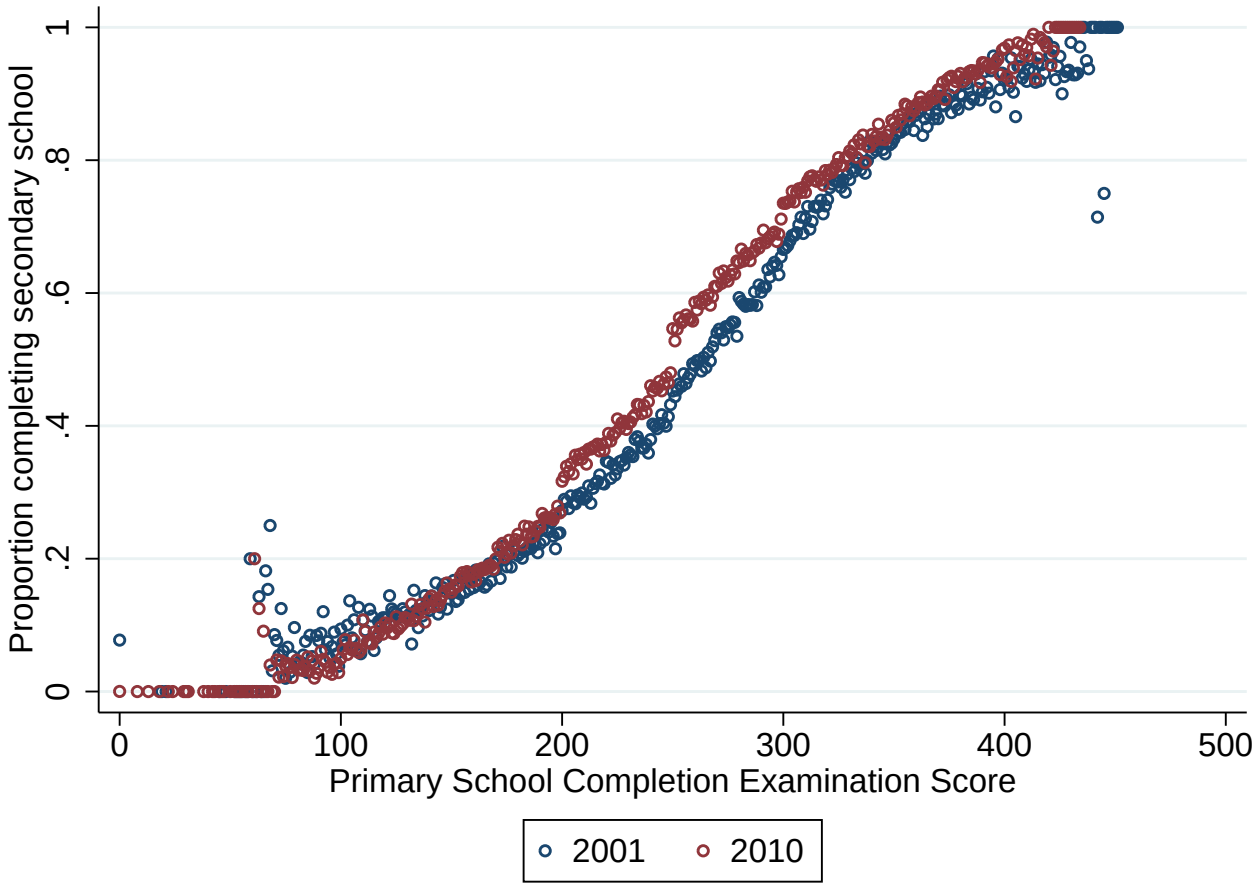
IV: Impacts of secondary education

Impact of secondary schooling on labor market outcomes

	Skilled Work (1)	Unskilled Work (2)	Agricultural Work (3)	No Work (4)
Panel 1. Age 18 and over				
Years of education	0.069***	-0.06	-0.18***	0.171**
	(0.022)	(0.064)	(0.039)	(0.079)
Observations	4525	4525	4525	4525
First stage F-stat:	22.909	22.909	22.909	22.909
Panel 2. Age 19 and over				
Years of education	0.074***	-0.047	-0.169***	0.142**
	(0.023)	(0.059)	(0.037)	(0.07)
Observations	4295	4295	4295	4295
First stage F-stat:	24.347	24.347	24.347	24.347
Panel 3. Age 20 and over				
Years of education	0.082***	-0.037	-0.137***	0.092
	(0.025)	(0.057)	(0.033)	(0.067)
Observations	3935	3935	3935	3935
First stage F-stat:	16.226	16.226	16.226	16.226

Impacts of Academic Achievement

Sample with no composition changes?



Diff-in-diff: impacts on student achievement

Test scores in more impacted regions did not decrease

- Together with a decline in resource quality, suggests that average student ability did not decline
- Suggests the presence of credit constraints

Even among the top performers for whom composition changes are unlikely, test scores did not decrease

- Suggests that lower resource quality and potentially lower ability peers did not decrease test scores

Discussion & Conclusions

Summary

Kenya introduced FSE in 2008

- The policy led to increased educational attainment of about 0.8 years of schooling
- The influx of students accompanying the program did not decrease test scores

Secondary education in Kenya has broad impacts:

- Delays age of first intercourse ($\sim$10-25% at each teenage age)
- Delays age of first marriage ($\sim$50% at each teenage age)
- Delays age of first birth ($\sim$30-50% at each teenage age)
- Increases likelihood of skilled work
- Decreases probability of agricultural work

Conclusions

Are credit constraints holding back investment in education?

- Probably. Rapid increase in attendance following FSE combined with no impact on test scores suggests presence of credit constraints.

Interpreting the demographic and labor market impacts

- Delaying behaviors not unambiguously positive.
  - While there seem to be clear benefits to delaying childbirth
  - Delaying age of first marriage may impact marriage market and match quality (Baird et al., 2016)
- Occupational choice results are encouraging
  - Shifting to higher productivity sectors may promote growth (McMillan and Rodrik, 2011)

Thank you!

Difference-in-differences

Compare more treated regions to less treated regions

$$S_{ijk} = \alpha_0 + \beta_1 (I_k * FSE_j) + X_{ijk} + \eta_k + \gamma_j + \varepsilon_{ijk}$$

- S_{ijk} reflects the schooling of individual i in cohort j in county k
- $I_k = (1 - \text{transition rate})$ is the intensity for county k
- FSE_j is a dummy variable equal to one for individuals born in cohorts impacted by FSE
- X_{ijk} is a vector of ethnicity and religion variables
- η_k represent county fixed effects
- γ_j represent cohort fixed effects

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The interaction coefficient, β_1 is the estimate of the effect of FSE on education

Binary difference-in-differences: primary school

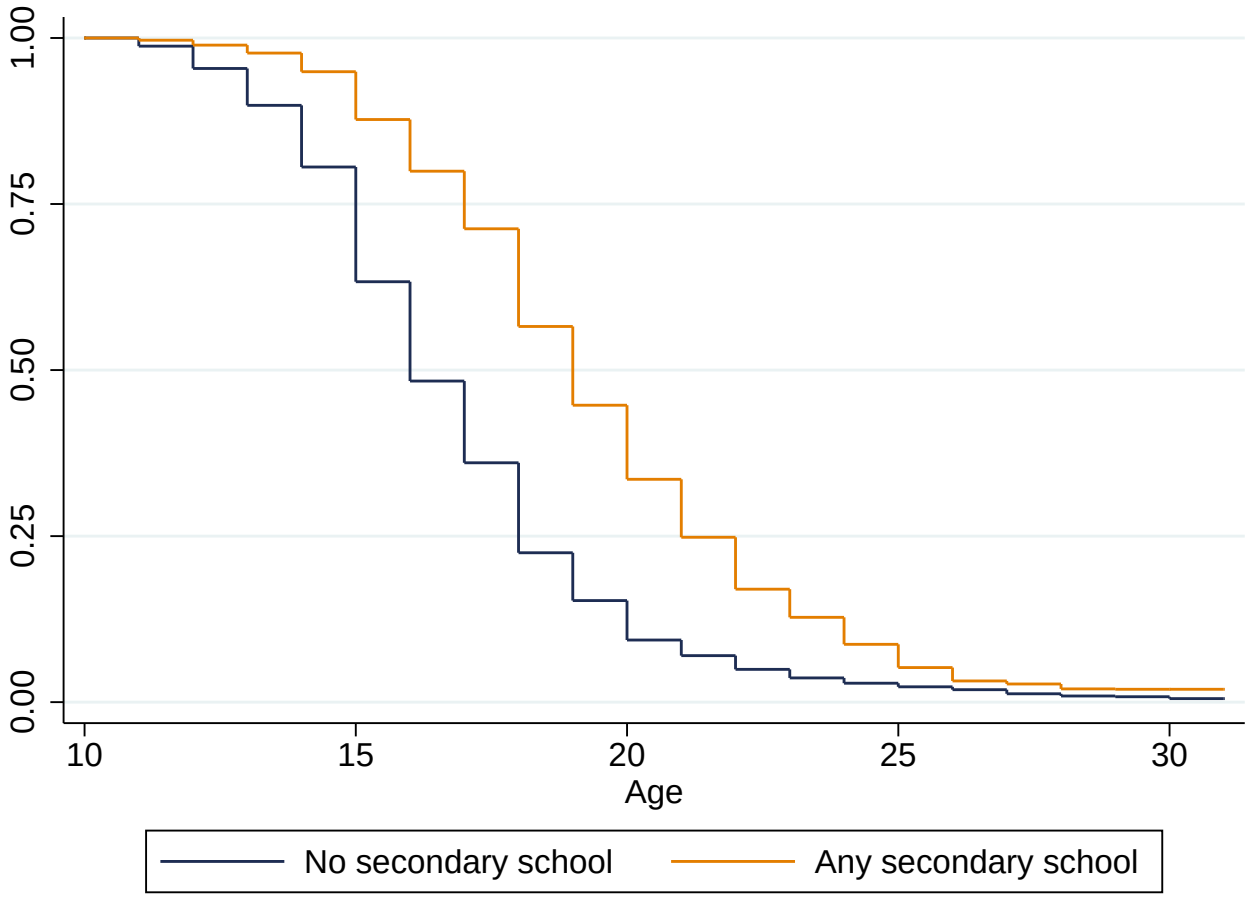
	(1)	(2)	(3)	(4)	(5)
A. Pooled Gender					
High Intensity*FSE period	-0.0005	0.00002	0.007	-0.059***	-0.044*
	(0.013)	(0.013)	(0.014)	(0.023)	(0.023)
Observations	20458	20458	20458	20458	20458
R^2	0.201	0.201	0.201	0.204	0.205
B. Female Only					
High Intensity*FSE period	0.006	0.005	0.014	-0.054*	-0.032
	(0.015)	(0.015)	(0.015)	(0.028)	(0.028)
Observations	14934	14934	14934	14934	14934
R^2	0.228	0.229	0.229	0.232	0.234
C. Male Only					
High Intensity*FSE period	-0.011	-0.006	-0.015	-0.057	-0.066
	(0.026)	(0.026)	(0.027)	(0.038)	(0.04)
Observations	5524	5524	5524	5524	5524
R^2	0.153	0.155	0.155	0.164	0.17
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trends				✓	✓

Primary school difference-in-differences

	(1)	(2)	(3)	(4)	(5)
A. Pooled Gender					
(1-transition rate)*FSE period	0.055	0.06	0.086**	-0.134	-0.06
	(0.044)	(0.044)	(0.043)	(0.083)	(0.083)
Observations	20458	20458	20458	20458	20458
R^2	0.208	0.209	0.209	0.211	0.212
B. Female Only					
(1-transition rate)*FSE period	0.04	0.043	0.082	-0.129	-0.024
	(0.059)	(0.057)	(0.067)	(0.098)	(0.102)
Observations	14934	14934	14934	14934	14934
R^2	0.228	0.229	0.229	0.232	0.234
C. Male Only					
(1-transition rate)*FSE period	0.116	0.124	0.122	-0.143	-0.148
	(0.105)	(0.107)	(0.112)	(0.152)	(0.165)
Observations	5524	5524	5524	5524	5524
R^2	0.153	0.156	0.155	0.164	0.169
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trends				✓	✓

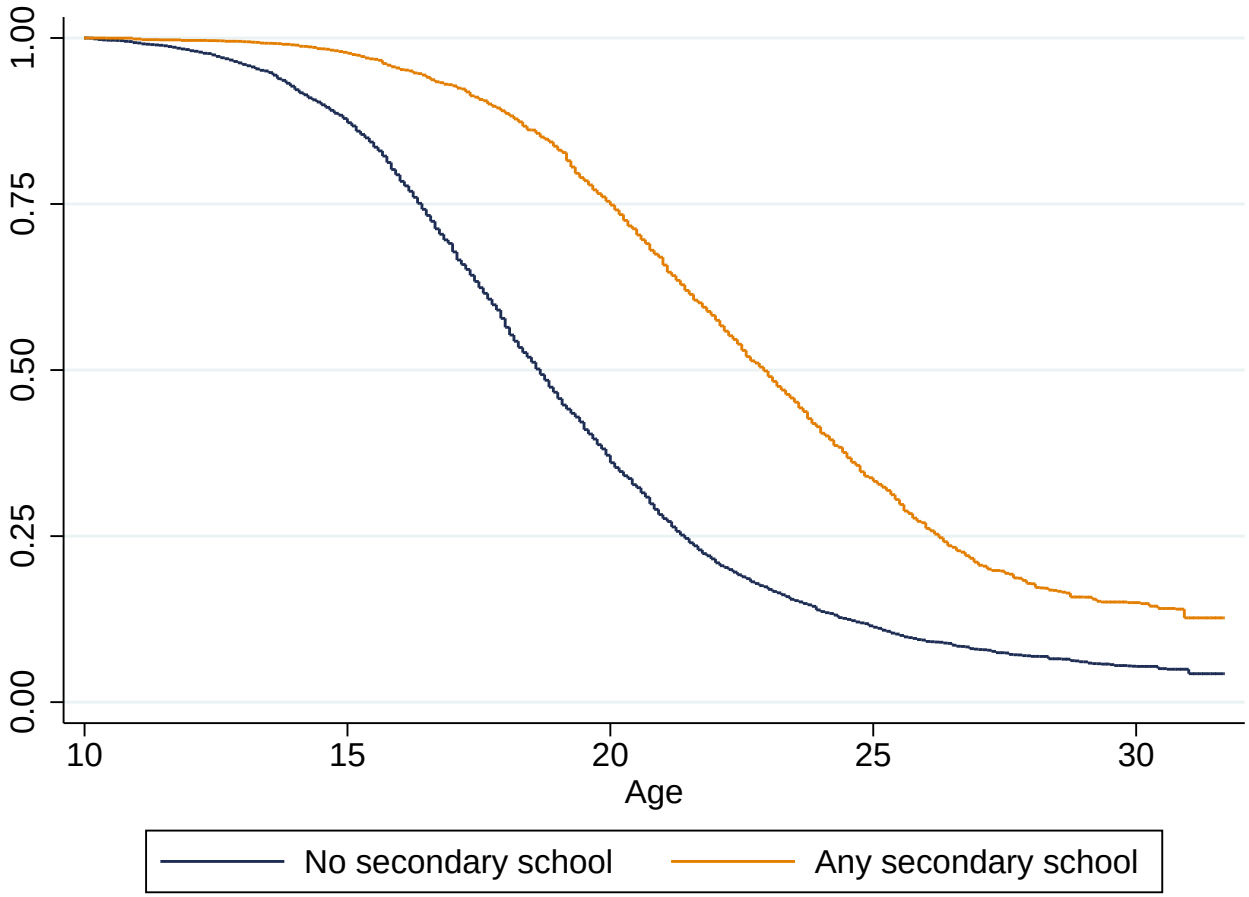
Note: Dependent variable is a binary variable equal to one if an individual has completed primary school. All regressions include birth year, county, and ethnicity/religion fixed effects. Standard errors are clustered at the county level. Regressions are weighted using DHS survey weights. Transition rate defined as the percentage of primary school graduates who attend secondary school. Initial transition rate defined as the average transition rate in each county for students born in either 1989 or 1990. FSE period defined as birth cohorts after and including 1991. *** indicates significance at the 99 percent level; ** indicates significance at the 95 percent level; and * indicates significance at the 90 percent level.

Kaplan-Meier survival: age of first intercourse



Return

Kaplan-Meier survival: age of first marriage



Return

DHS cohort exposure (Return)

Official protocol calls for students to complete primary school **aged 13-14**

- Implies first FSE cohort born in 1993 and 1994
- However, school entry age is not regularly followed and primary grade repetition rates are high
- Older cohorts may have also been impacted

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Official protocol calls for students to complete primary school **aged 13-14**

- Implies first FSE cohort born in 1993 and 1994
- However, school entry age is not regularly followed and primary grade repetition rates are high
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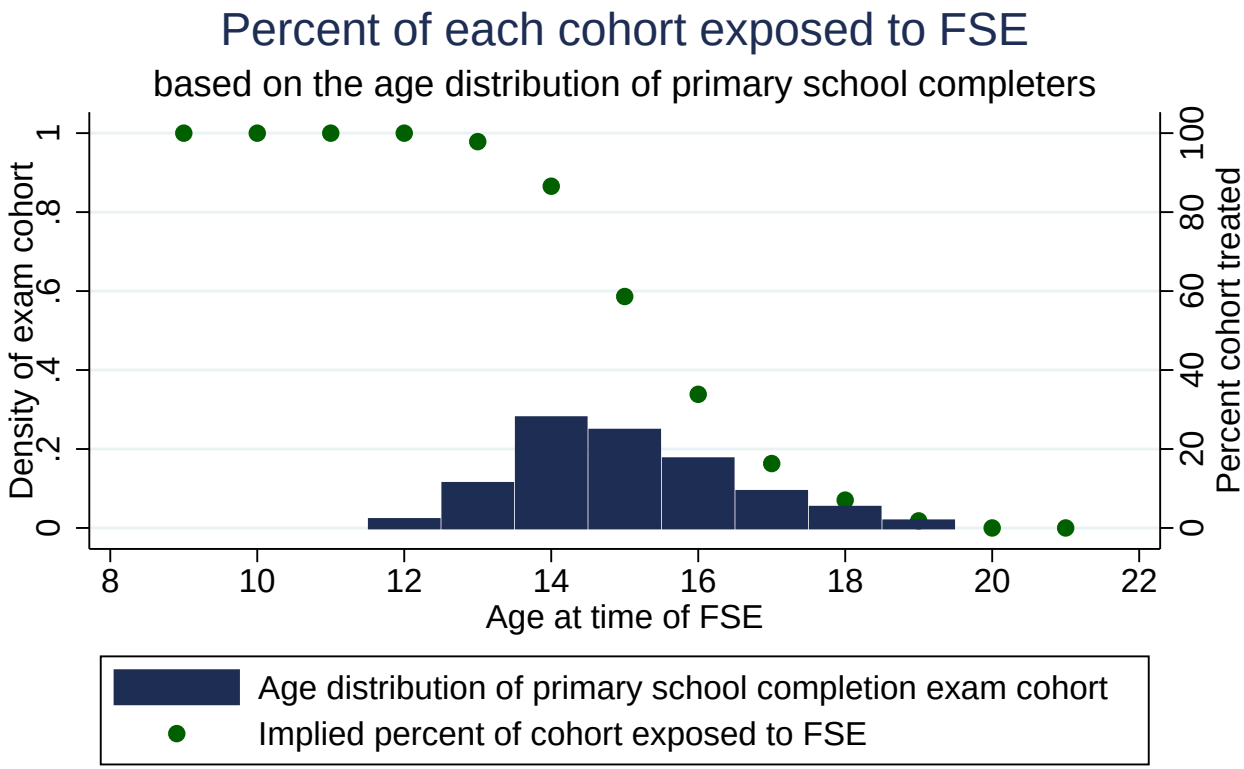
Use registration data for the KCPE to see age of birth of primary school completers

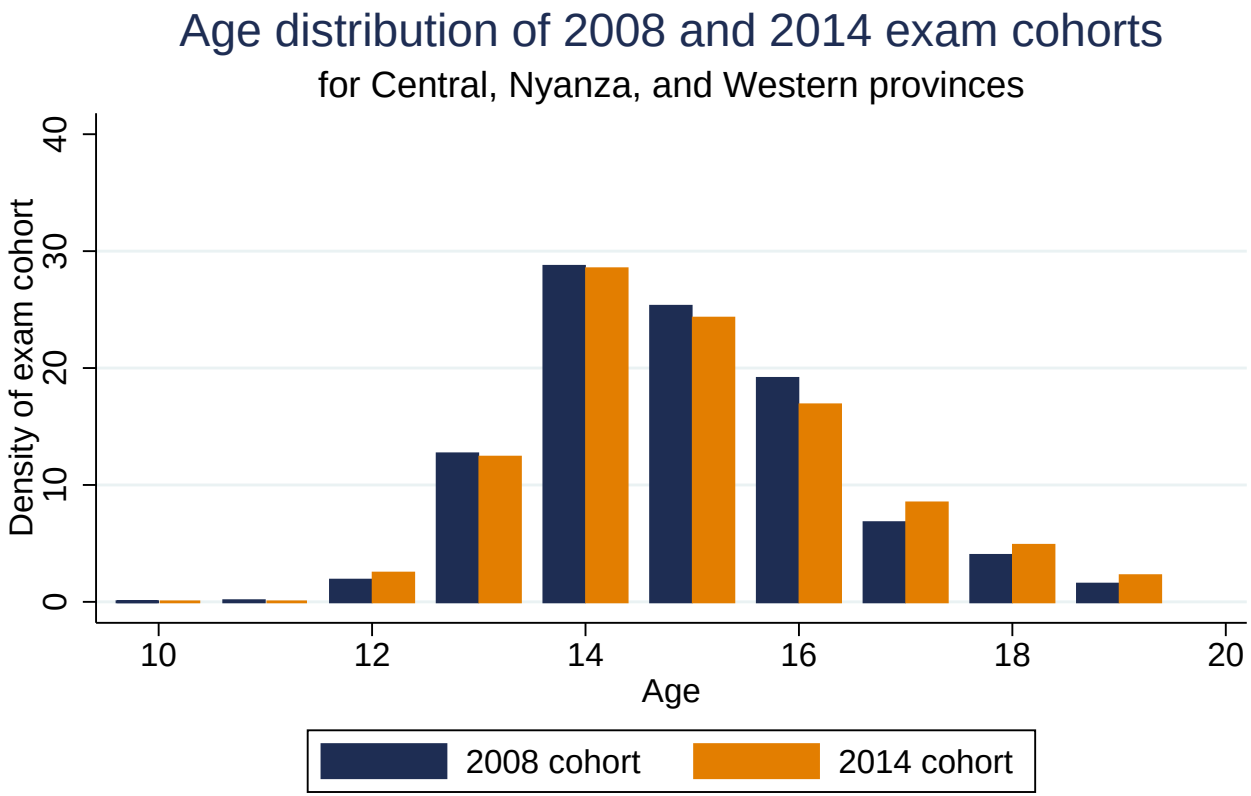
DHS cohort exposure implied by registration data

(Return)



Comparison of 2008 cohort and 2014 cohort

2008 and 2014 Cohort Age Structure (Return)



Source: 2008 and 2014 KCPE data.
Notes: 2008 data are only available for Central, Nyanza, and Western provinces. The 2014 data are restricted to the same provinces. Data restricted to first time test takers.

Examination data cohort exposure (Return)

In full examination dataset:

- No birth cohort
- Treatment definition based on examination cohort

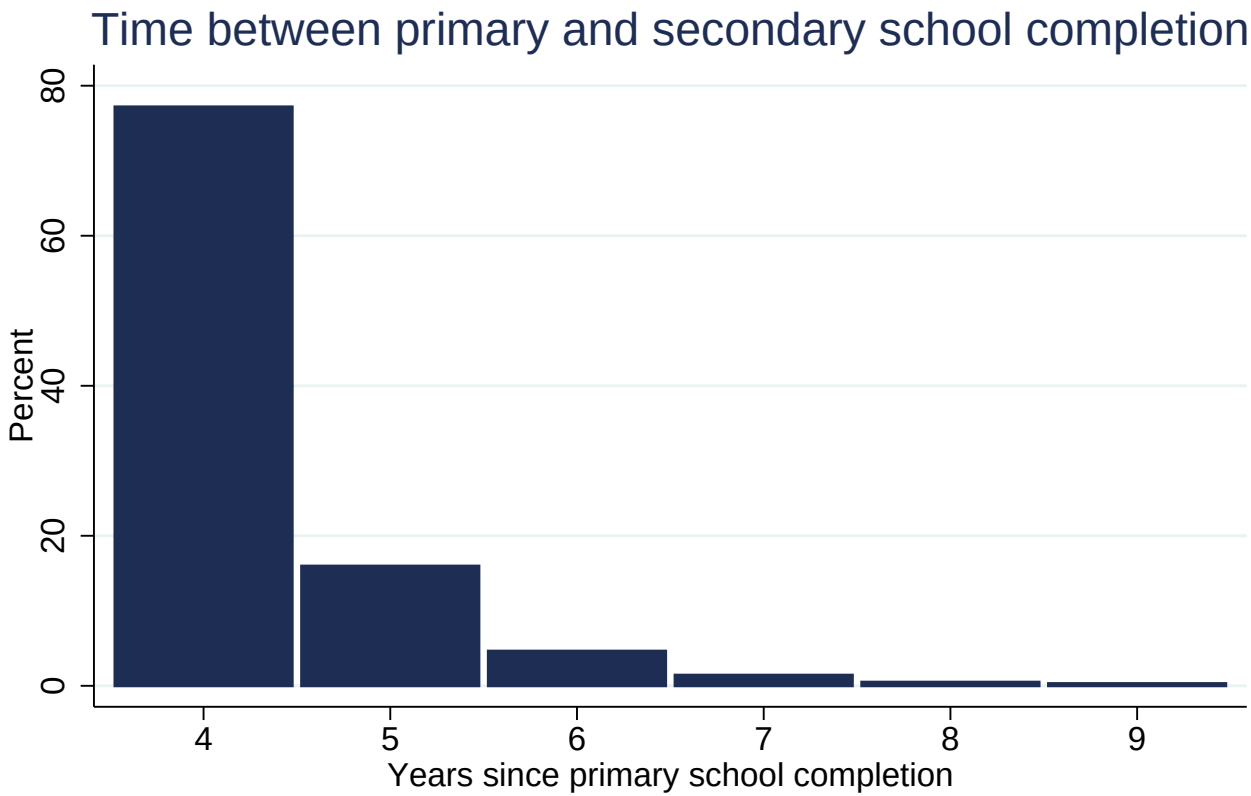
Examination data cohort exposure (Return)

In full examination dataset:

- No birth cohort
- Treatment definition based on examination cohort
- Without grade repetition, first FSE cohort took KCSE in 2011
- Grade repetition is a potential threat, but is relatively low at the secondary school level
  - Matched KCPE/KCSE data indicate that 80% of students complete secondary school in 4 years
- Consider cohorts who took the KCSE in 2011 or later as treated

Histogram of time to completion

Time between primary and secondary school completion (Return)



Source: 2014 KCSE Registration Data
Note: Fewer than 2% of test takers complete secondary school more than 7 years after primary school.

Administrative data: a cautionary tale (Return)

SECONDARY SCHOOLS ENROLMENT BY COUNTY, 2007 - 2012

Table 151 — Number

COUNTY	ENROLMENTS					
	2007	2008	2009	2010	2011	2012*
BARINGO	17,157	19,419	21,406	24,034	25,343	27,803
BOMET	26,413	29,895	32,954	36,999	38,997	42,812
BUNGOMA	53,867	60,969	67,208	75,458	78,835	87,557
BUSIA	21,524	24,362	26,855	30,152	31,398	35,308
ELGEYO MARAKWET	14,676	16,610	18,310	20,558	21,981	24,000
EMBU	22,488	25,453	28,058	31,502	34,494	35,752
GARISSA	4,694	5,313	5,856	6,575	6,641	7,606
HOMABAY	39,085	44,238	48,765	54,751	56,972	63,569
ISIOLO	2,002	2,266	2,498	2,805	2,814	3,309
KAJIADO	9,470	10,718	11,815	13,265	13,929	15,538
KAKAMEGA	61,489	69,595	76,718	86,135	93,295	100,265
KERICHO	28,393	32,136	35,425	39,773	41,964	46,107
KIAMBU	58,410	66,111	72,877	81,822	89,065	94,682
KILIFI	22,339	25,285	27,872	31,293	32,855	36,233
KIRINYAGA	22,287	25,225	27,807	31,220	33,879	36,073

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BOMET	26,413	29,895	32,954	36,999	38,997	42,812
BUNGOMA	53,867	60,969	67,208	75,458	78,835	87,557
BUSIA	21,524	24,362	26,855	30,152	31,398	35,308
ELGEYO MARAKWET	14,676	16,610	18,310	20,558	21,981	24,000
EMBU	22,488	25,453	28,058	31,502	34,494	35,752
GARISSA	4,694	5,313	5,856	6,575	6,641	7,606
HOMABAY	39,085	44,238	48,765	54,751	56,972	63,569
ISIOLO	2,002	2,266	2,498	2,805	2,814	3,309
KAJIADO	9,470	10,718	11,815	13,265	13,929	15,538
KAKAMEGA	61,489	69,595	76,718	86,135	93,295	100,265
KERICHO	28,393	32,136	35,425	39,773	41,964	46,107
KIAMBU	58,410	66,111	72,877	81,822	89,065	94,682
KILIFI	22,339	25,285	27,872	31,293	32,855	36,233
KIRINYAGA	22,287	25,225	27,807	31,220	33,879	36,073

Administrative data: a cautionary tale (Return)

SECONDARY SCHOOLS ENROLMENT BY COUNTY, 2007 - 2012

Table 151 — Number

COUNTY	ENROLMENTS 2007	2008	2009	2010	2011	2012*
BARINGO	17,157	19,419	21,406	24,034	25,343	27,803
BOMET	26,413	29,895	32,954	36,999	38,997	42,812
BUNGOMA	53,867	60,969	67,208	75,458	78,835	87,557
BUSIA	21,524	24,362	26,855	30,152	31,398	35,308
ELGEYO MARAKWET	14,676	16,610	18,310	20,558	21,981	24,000
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KERICHO	28,393	32,136	35,425	39,773	41,964	46,107
KIAMBU	58,410	66,111	72,877	81,822	89,065	94,682
KILIFI	22,339	25,285	27,872	31,293	32,855	36,233
KIRINYAGA	22,287	25,225	27,807	31,220	33,879	36,073

x 1.1318 = x 1.1032 = x 1.227 =

Identification: impacts of secondary education (Return)

Figure suggests using:

$$f\left(I_{ijk}\right) = \sum_{j=1}^{6} \xi_{1j}\left(I_k \times \gamma_j\right)$$

where:

- $I_k \times \gamma_j$ is the interaction between the treatment intensity of county k and the cohort j

Similar to Duflo 2004

Identification: impacts of secondary education (Return)

Figure suggests using:

$$f\left(I_{ijk}\right) = \sum_{j=1}^{6} \xi_{1j}\left(I_k \times \gamma_j\right)$$

where:

- $I_k \times \gamma_j$ is the interaction between the treatment intensity of county k and the cohort j

Similar to Duflo 2004

Identifying assumption is that FSE intensity only impacts demographic or labor market variables through education

Baseline model (Return)

- Two-period model for primary school graduates
  - Period 0: individuals can either attend school or enter labor force
  - Period 1: students who attended school earn wage premium
- Utility is over consumption in the two periods
  - $U = u(c_0) + \delta u(c_1)$
- Utility from working/attending school is:
  - $U_w = u(c_0) + \delta u(c_1) = u(1) + \delta u(1)$
  - $U_s(a) = u(c_0) + \delta u(c_1) = \delta u(h(a) - R \cdot p)$

where a is individual ability, $h(a)$ is the premium on accumulated human capital, p is the cost of schooling (tuition and fees), and R is a gross interest rate

Individuals attend school if $U_s(a) \geq U_w$

Model specifics (Return)

- Let $a_p^\star$ satisfy $U_s(a) = U_w$
- All students with $a > a_p^\star$ attain greater utility from attending school than from working
- Mean ability of students attending school is:

$$\bar{A}_p = \frac{\int_{a_p^\star}^{a_{max}} af(a)\,da}{\int_{a_p^\star}^{a_{max}} f(a)\,da}$$

Eliminating tuition in this scenario lowers the price from p to p_f.

- Lowers a^* so that $a_{p_f}^* < a_p^*$
- Induces $a_{p_f}^* \leq a < a_p^*$ to attend school
- Lower ability students now attend secondary school

$$\bar{A}_{p_f} = \frac{\int_{a_{p_f}^\star}^{a_{max}} af(a)\,da}{\int_{a_{p_f}^\star}^{a_{max}} f(a)\,da} < \bar{A}_p$$

Model specifics with credit constraints (Return)

- A fraction of individuals, w, come from wealthy families while the remainder, $1-w$, come from poor families.
- Individuals from poor families are restricted to borrowing $\bar{p}(a)$ with $\bar{p}'(\cdot) > 0$
- $\forall a \in A$, $\bar{p}(a) < p$ so that the original price of schooling precludes all poor students from attending school
- Lowering the price of schooling from $p \rightarrow p_f$
  - Induces $a^*_{p_f} \leq a < a^*_p$ from wealthy families to attend school
  - Induces students from poor families with $a > a^\star_{cc}$ for whom the lower price eases the credit constraint to attend school

$$\hat{A}_p = \frac{w \cdot \int_{a^\star_{p_f}}^{a_{max}} af(a)\,da + (1-w) \cdot \int_{a^\star_{cc}}^{a_{max}} af(a)\,da}{w \cdot \int_{a^\star_{p_f}}^{a_{max}} f(a)\,da + (1-w) \cdot \int_{a^\star_{cc}}^{a_{max}} f(a)\,da}$$

Increases access, ambiguous impact on average ability

Model specifics with fertility (Return)

Utility now depends on both consumption and the quantity of unprotected sex:

- Benefit, absent a pregnancy, of $\mu(s)$
  - $\mu'(\cdot) > 0$ for $s < \bar{s}$, $\mu'(\cdot) < 0$ for $s \geq \bar{s}$, and $\mu''(\cdot) < 0$: that is, utility is increasing in unprotected sex to a certain level, $\bar{s}$, above which utility is decreasing in s
- Pregnancy yields a utility benefit, $B > 0$, and occurs with a probability $v(s_i)$
- Individuals select a level of initial period unprotected sex, realize the pregnancy outcome, and then in the absence of a birth, select initial period schooling or labor
- Low ability individuals have no trade off and select a high level of sex
- High ability individuals face a trade off between sex and the possibility of not being able to attend school

Binary difference-in-differences: common trends (Return)

Explicit test of common trends using pre-treatment data:

$$S_{ijk} = \alpha_0 + \beta_1 (\text{High}_k * \text{Trend}) + \beta_2 \text{Trend} + X_i jk + \eta_k + \varepsilon_{ijk}$$

Binary difference-in-differences: common trends (Return)

Explicit test of common trends using pre-treatment data:

$$S_{ijk} = \alpha_0 + \beta_1 (\text{High}_k * \text{Trend}) + \beta_2 \text{Trend} + X_i jk + \eta_k + \varepsilon_{ijk}$$

	Overall (1)	**Female (2)**	**Male (3)**
High*trend	-0.025	-0.012	-0.067
	(0.034)	(0.039)	(0.062)
Observations	12022	8971	3051
R^2	0.311	0.333	0.229

Binary falsification test (Return)

	(1)	(2)	(3)	(4)	(5)
A. Falsification for program introduced in 1986					
High Intensity*FSE period	0.198*	0.139	0.224*	0.229	0.162
	(0.119)	(0.094)	(0.126)	(0.2)	(0.214)
Observations	10324	10324	10324	10324	10324
R^2	0.112	0.115	0.112	0.117	0.12
B. Falsification for program introduced in 1985					
High Intensity*FSE period	0.184	0.126	0.222	0.152	0.121
	(0.13)	(0.114)	(0.14)	(0.214)	(0.204)
Observations	11142	11142	11142	11142	11142
R^2	0.111	0.114	0.111	0.117	0.12
C. Falsification for program introduced in 1984					
High Intensity*FSE period	0.095	0.044	0.104	-0.047	-0.157
	(0.104)	(0.086)	(0.1)	(0.203)	(0.21)
Observations	10643	10643	10643	10643	10643
R^2	0.111	0.114	0.111	0.116	0.119
D. Falsification for program introduced in 1983					
High Intensity*FSE period	0.062	0.002	0.082	-0.03	-0.06
	(0.116)	(0.12)	(0.111)	(0.246)	(0.231)
Observations	10264	10264	10264	10264	10264
R^2	0.113	0.117	0.114	0.118	0.121
E. Falsification for program introduced in 1982					
High Intensity*FSE period	0.04	0.07	0.085	0.385*	0.504**
	(0.133)	(0.145)	(0.125)	(0.207)	(0.232)
Observations	9760	9760	9760	9760	9760
R^2	0.113	0.115	0.114	0.118	0.121
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trend				✓	✓

Difference-in-differences: no transition cohorts (Return)

	(1)	(2)	(3)	(4)	(5)
Panel 1: years of education					
A. Pooled Gender					
High Intensity*FSE period	0.346**	0.39***	0.332**	0.578***	0.605***
	(0.146)	(0.147)	(0.153)	(0.192)	(0.186)
Observations	11684	11684	11684	11684	11684
R^2	0.093	0.101	0.1	0.106	0.109
B. Female Only					
High Intensity*FSE period	0.356**	0.416***	0.319**	0.725***	0.852***
	(0.15)	(0.147)	(0.155)	(0.234)	(0.204)
Observations	8246	8246	8246	8246	8246
R^2	0.089	0.095	0.095	0.102	0.104
C. Male Only					
High Intensity*FSE period	0.322*	0.389**	0.407*	0.274	0.151
	(0.194)	(0.188)	(0.208)	(0.459)	(0.473)
Observations	3438	3438	3438	3438	3438
R^2	0.117	0.136	0.135	0.147	0.155
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trend				✓	✓

Difference-in-differences: common trends (Return)

Explicit test of common trends using pre-treatment data:

$$S_{ijk} = \alpha_0 + \beta_1 (I_k * \text{Trend}) + \beta_2 \text{Trend} + X_i jk + \eta_k + \varepsilon_{ijk}$$

	Overall (1)	Female (2)	Male (3)
High*trend	0.068	0.029	0.188
	(0.123)	(0.139)	(0.211)
Observations	12022	8971	3051
R^2	0.311	0.333	0.229

Falsification test (Return)

	(1)	(2)	(3)	(4)	(5)
A. Pooled Gender					
(1-transition rate)*FSE period	0.713	0.462	0.737	1.418	1.034
	(0.45)	(0.357)	(0.478)	(1.028)	(1.081)
Observations	7661	7661	7661	7661	7661
R^2	0.108	0.11	0.108	0.113	0.114
B. Female Only					
(1-transition rate)*FSE period	0.718	0.475	0.731	1.062	1.092
	(0.674)	(0.548)	(0.664)	(1.147)	(1.323)
Observations	5484	5484	5484	5484	5484
R^2	0.099	0.101	0.1	0.105	0.107
C. Male Only					
(1-transition rate)*FSE period	0.517	0.289	0.668	2.482*	1.193
	(0.877)	(1.037)	(0.92)	(1.484)	(1.922)
Observations	2177	2177	2177	2177	2177
R^2	0.12	0.124	0.122	0.142	0.147
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County specific linear trends				✓	✓

Difference-in-differences: no transition cohorts (Return)

	(1)	(2)	(3)	(4)	(5)
Panel 1: years of education					
A. Pooled Gender					
Intensity*FSE period	2.274***	2.475***	2.291***	2.768***	2.829***
	(0.392)	(0.397)	(0.414)	(0.669)	(0.584)
Observations	11684	11684	11684	11684	11684
R^2	0.095	0.103	0.101	0.106	0.109
B. Female Only					
Intensity*FSE period	2.506***	2.710***	2.398***	2.678***	2.941***
	(0.333)	(0.323)	(0.38)	(0.992)	(0.706)
Observations	8246	8246	8246	8246	8246
R^2	0.091	0.098	0.097	0.101	0.104
C. Male Only					
Intensity*FSE period	1.697**	2.119***	2.174**	3.251**	2.976**
	(0.761)	(0.734)	(0.872)	(1.380)	(1.357)
Observations	3438	3438	3438	3438	3438
R^2	0.117	0.137	0.136	0.148	0.155
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County linear trend				✓	✓

Drop Nairobi and Mombasa (Return)

	(1)	(2)	(3)	(4)	(5)
Panel 1: years of schooling					
(1-transition rate)*FSE period	2.086***	2.064***	2.024***	2.760***	2.560**
	(0.438)	(0.442)	(0.45)	(1.039)	(1.028)
Observations	12485	12485	12485	12485	12485
R^2	0.092	0.094	0.093	0.098	0.102
Panel 2: completed secondary school					
(1-transition rate)*FSE period	0.153	0.15	0.151	0.188	0.163
	(0.109)	(0.106)	(0.112)	(0.252)	(0.226)
Observations	12485	12485	12485	12485	12485
R^2	0.102	0.104	0.104	0.106	0.109
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County specific linear trends				✓	✓

Drop small counties (Return)

	(1)	(2)	(3)	(4)	(5)
Panel 1: years of schooling					
(1-transition rate)*FSE period	2.252***	2.255***	1.970***	2.029***	2.176***
	(0.316)	(0.318)	(0.369)	(0.731)	(0.688)
Observations	12970	12970	12970	12970	12970
R^2	0.099	0.101	0.1	0.104	0.106
Panel 2: completed secondary school					
(1-transition rate)*FSE period	0.124*	0.143**	0.092	0.157	0.182
	(0.073)	(0.068)	(0.094)	(0.139)	(0.13)
Observations	12970	12970	12970	12970	12970
R^2	0.104	0.105	0.104	0.107	0.109
Control variables:					
Constituency development funds * birth year		✓			✓
2009 unemployment rate * birth year			✓		✓
County specific linear trends				✓	✓

Note: All regressions include birth year, county, and ethnicity/religion fixed effects. Standard errors are clustered at the county level. Regressions are weighted using DHS survey weights. Transition rate defined as the percentage of primary school graduates who attend secondary school. Initial transition rate defined as the average transition rate in each county for students born in either 1989 or 1990. FSE period defined as birth cohorts after and including 1991. Small counties excluded are Garissa, Mandera, Marsabit, Samburu, Turkana, and Wajir.

Test data: common trends (Return)

$$S_{ijk} = \alpha_0 + \beta_1 (I_k * \text{Trend}) + \beta_2 \text{Trend} + \varepsilon_{ijk}$$

where S_{ijk} is the scaled county size

	Binary high intensity			Continuous intensity measure		
	Both	Female	Male	Both	Female	Male
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
(1-transition rate)*FSE period	0.002	0.002	0.002	0.034	0.021	0.044*
	(0.008)	(0.008)	(0.008)	(0.022)	(0.026)	(0.023)
Observations	235	235	235	235	235	235
R^2	0.696	0.624	0.721	0.693	0.618	0.723

Identification: impacts of secondary education

Use established relationship between FSE exposure and education in instrumental variables framework:

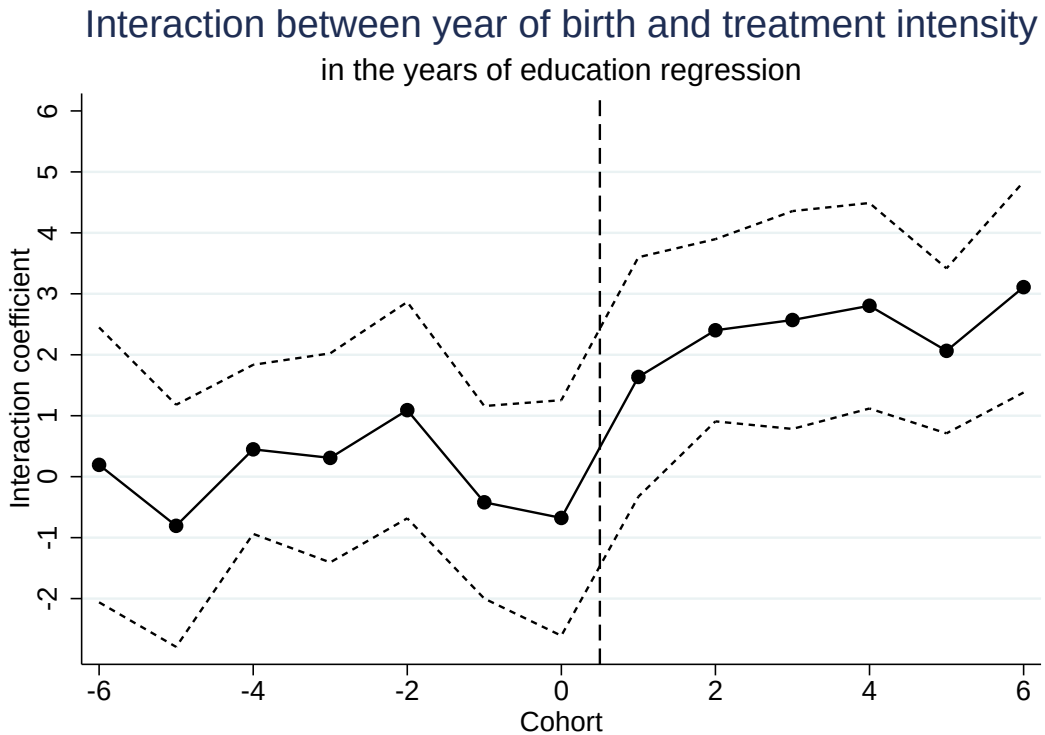
$$S_{ijk} = \alpha_1 + f\left(I_{ijk}\right) + \beta_1 X_{ijk} + \eta_{1k} + \gamma_{1j} + \varepsilon_{ijk}$$

$$P_{ijk} = \alpha_2 + \xi_2 \hat{S}_{ijk} + \beta_2 X_{ijk} + \eta_{2k} + \gamma_{2j} + \upsilon_{ijk}$$

where:

- P_{ijk} is an individual level outcome (demographic or labor market)
- S_{ijk} is the endogenous schooling level instrumented with exposure to FSE
- $\hat{S}_{ijk}$ is the predicted value of schooling based on the first stage

Identification: impacts of secondary education



Demographic outcomes: first intercourse (Return)

	Mean dep. var		Est. treatment effect	
	Pooled	Female	Pooled	Female
	(1)	**(2)**	**(3)**	**(4)**
First intercourse before age:				
16	0.226	0.186	-0.020	-0.046*
			(0.016)	(0.024)
17	0.341	0.302	-0.055**	-0.095***
			(0.024)	(0.033)
18	0.460	0.425	-0.071**	-0.098***
			(0.034)	(0.035)
19	0.604	0.573	-0.157***	-0.181***
			(0.049)	(0.052)
20	0.700	0.678	-0.161***	-0.205***
			(0.055)	(0.068)

Note: Dependent variable is equal to one if the event (intercourse/marriage/birth) happened before the individual turned age X. Reported values are the estimated coefficients on years of education where years of education is instrumented with cohort * county level exposure. The F-statistics for the pooled sample are 10.46, 10.46, 10.46, 12.43, and 14.38 for age 16, 17, 18, 19, and 20, respectively. The first birth F-statistics are 18.08, 18.08, 18.08, 22.76, and 13.34. Standard errors clustered at the county level are reported in parenthesis. Sample restricted to individuals who have completed at least primary school. All regressions include birth year, county, and ethnicity/religion fixed effects. Regressions are weighted using DHS survey weights. *** indicates significance at the 99 percent level; ** indicates significance at the 95 percent level; and * indicates significance at the 90 percent level.

Demographic outcomes: first marriage (Return)

	Mean dep. var		Est. treatment effect	
	Pooled	Female	Pooled	Female
	(1)	**(2)**	**(3)**	**(4)**
First marriage before age:				
16	0.046	0.063	-0.024*	-0.038**
			(0.013)	(0.018)
17	0.080	0.109	-0.050***	-0.076***
			(0.014)	(0.019)
18	0.130	0.176	-0.067***	-0.096***
			(0.018)	(0.024)
19	0.197	0.262	-0.090***	-0.109***
			(0.028)	(0.029)
20	0.281	0.364	-0.133***	-0.157***
			(0.033)	(0.044)

Note: Dependent variable is equal to one if the event (intercourse/marriage/birth) happened before the individual turned age X. Reported values are the estimated coefficients on years of education where years of education is instrumented with cohort * county level exposure. The F-statistics for the pooled sample are 10.46, 10.46, 10.46, 12.43, and 14.38 for age 16, 17, 18, 19, and 20, respectively. The first birth F-statistics are 18.08, 18.08, 18.08, 22.76, and 13.34. Standard errors clustered at the county level are reported in parenthesis. Sample restricted to individuals who have completed at least primary school. All regressions include birth year, county, and ethnicity/religion fixed effects. Regressions are weighted using DHS survey weights. *** indicates significance at the 99 percent level; ** indicates significance at the 95 percent level; and * indicates significance at the 90 percent level.

Demographic outcomes: first birth (Return)

	Mean dep. var		Est. treatment effect	
	Pooled	Female	Pooled	Female
	(1)	**(2)**	**(3)**	**(4)**
First birth before age:				
16		0.052		-0.023
				(0.014)
17		0.099		-0.035*
				(0.019)
18		0.175		-0.034
				(0.026)
19		0.273		-0.096***
				(0.037)
20		0.384		-0.149***
				(0.053)

Note: Dependent variable is equal to one if the event (intercourse/marriage/birth) happened before the individual turned age X. Reported values are the estimated coefficients on years of education where years of education is instrumented with cohort * county level exposure. The F-statistics for the pooled sample are 10.46, 10.46, 10.46, 12.43, and 14.38 for age 16, 17, 18, 19, and 20, respectively. The first birth F-statistics are 18.08, 18.08, 18.08, 22.76, and 13.34. Standard errors clustered at the county level are reported in parenthesis. Sample restricted to individuals who have completed at least primary school. All regressions include birth year, county, and ethnicity/religion fixed effects. Regressions are weighted using DHS survey weights. *** indicates significance at the 99 percent level; ** indicates significance at the 95 percent level; and * indicates significance at the 90 percent level.

Simulation specifics (Return)

- Keep all pre-FSE period students
- For the post-FSE period, keep the highest performing students in each county where the number of students kept is equal to the 2010 county cohort size
- Add any students observed in the exam but not included in this sample to the sample with an assigned score of 0.
- For all post-FSE individuals I then randomly draw a value from a uniform [0,1] distribution which is added to their score.
- Rescale the post-FSE grades to match the empirical pre-FSE distribution.

The high performing students are of the same size and distribution across counties as the last pre-FSE cohort and all new students are assigned random grades and across counties in proportion to actual student body growth.
I bootstrap this process 1,000 times.

Simulation (Return)

	(1)	(2)
(1-transition rate)*FSE period	-0.303***	-0.335***
	(0.001)	(0.001)
Observations	3326790	3073281
R^2	0.019	0.213
Control variables:		
Constituency development funds * birth year		✓
2009 unemployment rate * birth year		✓
County linear trend		✓

Note: Dependent variable is adjusted standardized KCSE score. Scores in post-FSE period simulated assuming all additional students in a county beyond 2010 county registration are the lowest performing students in the county. Scores were randomly generated for these students and then normalized to match the 2010 score distribution. All columns include county fixed effects. Estimates obtained from bootstrapped simulation. R^2 from single run. *** indicates significance at the 99 percent level; ** indicates significance at the 95 percent level; and * indicates significance at the 90 percent level.

Table: **Estimated Treatment Coefficients by School Size**

	English			Swahili				
	Overall	Male	Female	Overall	Male	Female	Overall	M
High dollar per student	0.18	0.461*	-0.065	-0.059	0.328	-0.39*	-0.114	0
	(0.142)	(0.238)	(0.149)	(0.197)	(0.311)	(0.231)	(0.191)	(0
Low dollar per student	0.174	0.362**	0.003	0.187	0.587**	-0.185	0.022	0
	(0.116)	(0.16)	(0.163)	(0.183)	(0.241)	(0.262)	(0.189)	(0
Constant	7.309***	7.416***	8.887***	6.740***	6.795***	7.684***	6.838***	6.98
	(0.043)	(0.066)	(0.054)	(0.054)	(0.07)	(0.078)	(0.056)	(0
Observations	132486	66235	66251	132518	66246	66272	132586	6
R^2	0.298	0.287	0.309	0.263	0.266	0.264	0.203	0
F-test: high=low (p-value)	0.972	0.698	0.734	0.316	0.479	0.526	0.569	0

Note: All regressions include cohort size as an additional independent variable as well as year and school fixed effects. Standard errors are clustere
binary variable equal to one for schools with a student body less (more) than the median student body once the school received its national school
schools that were upgraded as well as students at schools that were eligible but not upgraded.

Motivation: impacts on demographic outcomes (Return)

Secondary education may impact demographic outcomes

A variety of potential mechanisms:

- Students may learn about contraceptive methods
- Education may shift preferences towards fewer children
- If having a child precludes schooling, women may delay childbearing

  (Becker 1974, Ferré 2009, and Grossman 2006)

These mechanisms likely to **delay childbearing/lower fertility levels.**

Motivation: impacts on demographic outcomes (Return)

Delaying childbirth in particular could be beneficial

- Early childbearing has been associated with:
  - Higher morbidity and mortality (maternal and child)
    - Pregnancy related deaths are the largest cause of mortality for 15-19 year old females worldwide
    - Accounts for 2/3 of deaths in sub-Saharan Africa (15-19 year old females) (Patton et al. *The Lancet*, 2016)
  - Lower educational attainment
  - Lower family income

  (Ferré 2009 and Schultz 2008)

Mixed evidence on **fertility impacts of education**:

- Impacts may be conditional on high initial rates

  (Osili & Long 2008, Ferré 2009, Keats 2014, Baird et al. 2010, Ozier 2016, Filmer & Schady 2014, McCrary and Royer 2011)

Motivation: impacts on labor market outcomes (Return)

Secondary education also likely to impact labor market outcomes

Education plays a key role in labor market outcomes (Hanushek and Wößmann 2008, Harmon, Oosterbeek, and Walker 2003, Heckman, Lochner, and Todd 2006, Psacharopoulos and Patrinos 2004)

- Increased human capital
- Signaling

Quasi-experimental estimates suggest important impacts in developing country contexts:

- Education increases income and formality for males in Indonesia and Kenya (Duflo 2004, Ozier 2016)

Motivation: impacts on education quality (Return)

Caveat: FSE may also impact student achievement

- The program could dilute existing resources available to students such as:
  - Teacher time/effort/attention, Textbooks/desks

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  - Students induced to enroll by free day secondary education are different than students who would enroll in the absence of the program
  - Possibility of peer effects

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Combination yields an unclear impact on student outcomes

- **Limited but encouraging results** on the impact of free education programs on student achievement (Blimpo et al. 2015, Lucas & Mbiti 2012, Valente 2015)

Conceptual framework (Return)

Consider a two period model where primary school graduates, each with ability a, can either:

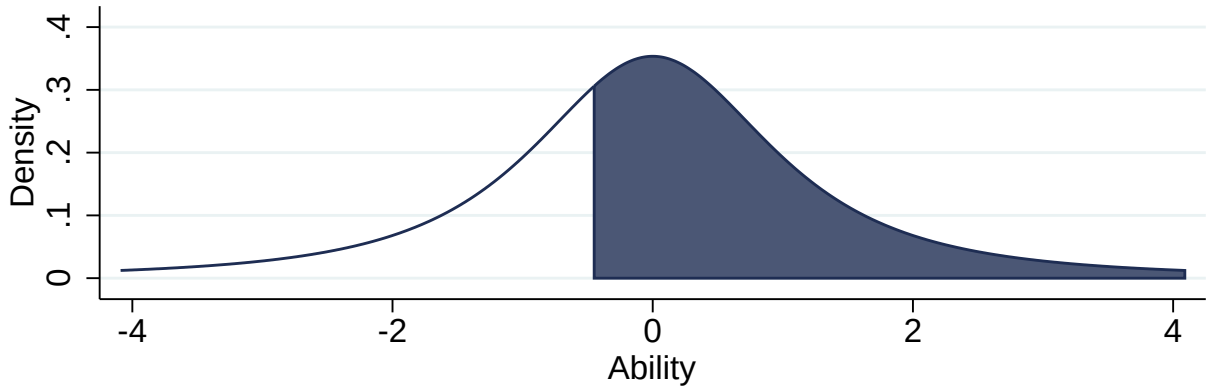
- Work in both periods or
- Attend secondary school in the first and work in the second period

Secondary school provides a return increasing in ability but costs p

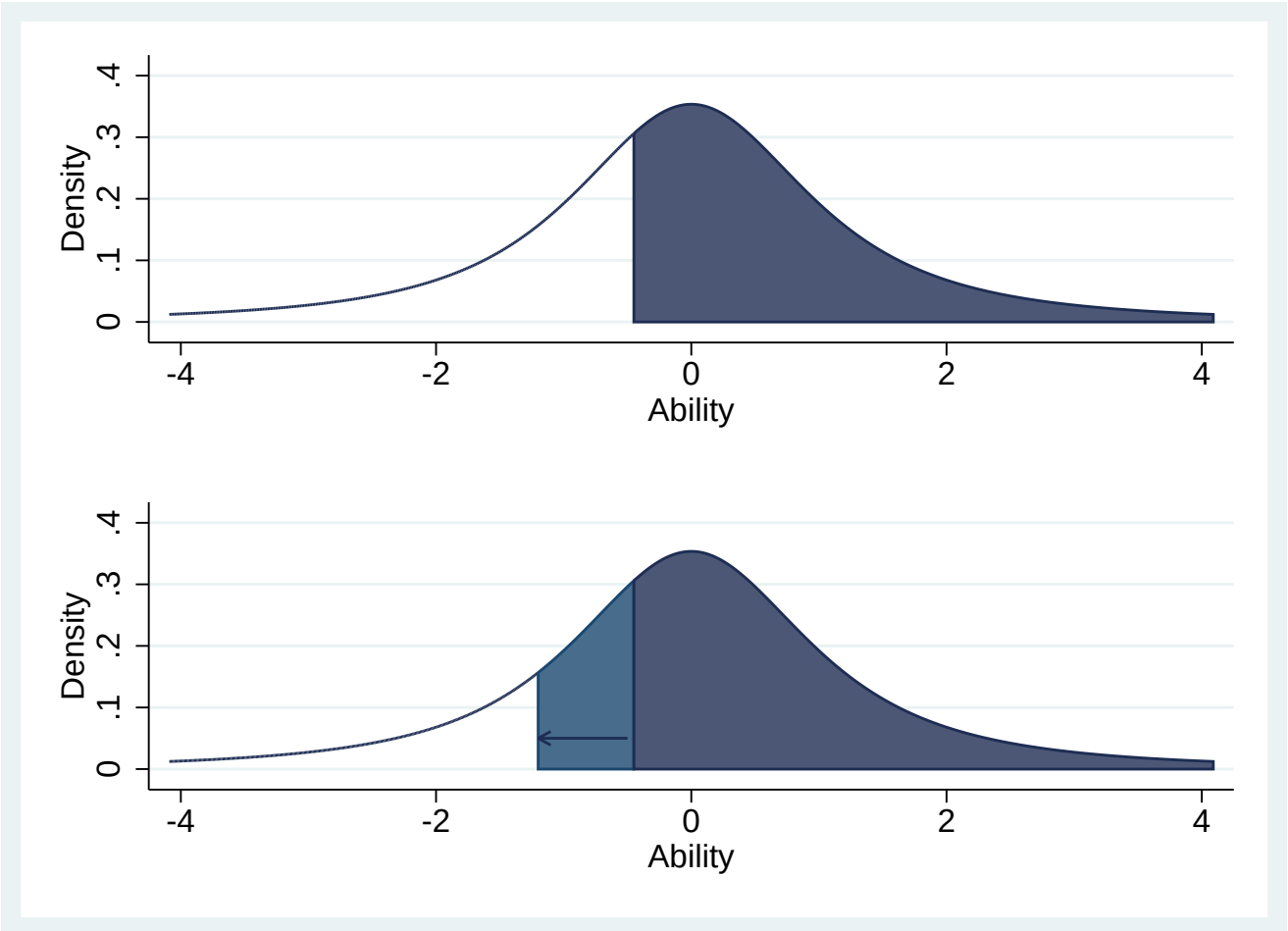
- Trade-off between wage in first period or return in second period
- High ability individuals will want to attend school
- Low ability individuals will want to work

Adapted from Lochner and Monge-Narangjo 2011 and Duflo et al. 2015

Baseline (Return)



Baseline with price decrease (Return)



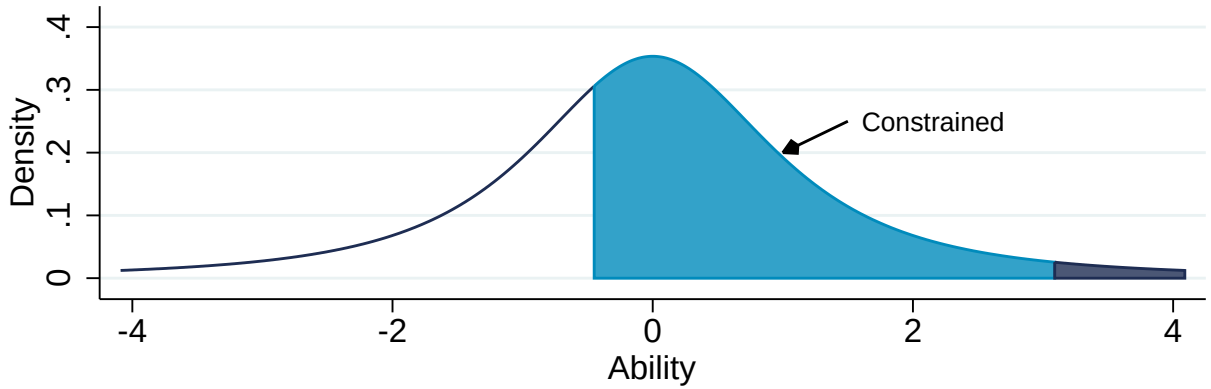
Lower price increases educational attainment and **lowers the average ability of students**

Add credit constraints (Return)

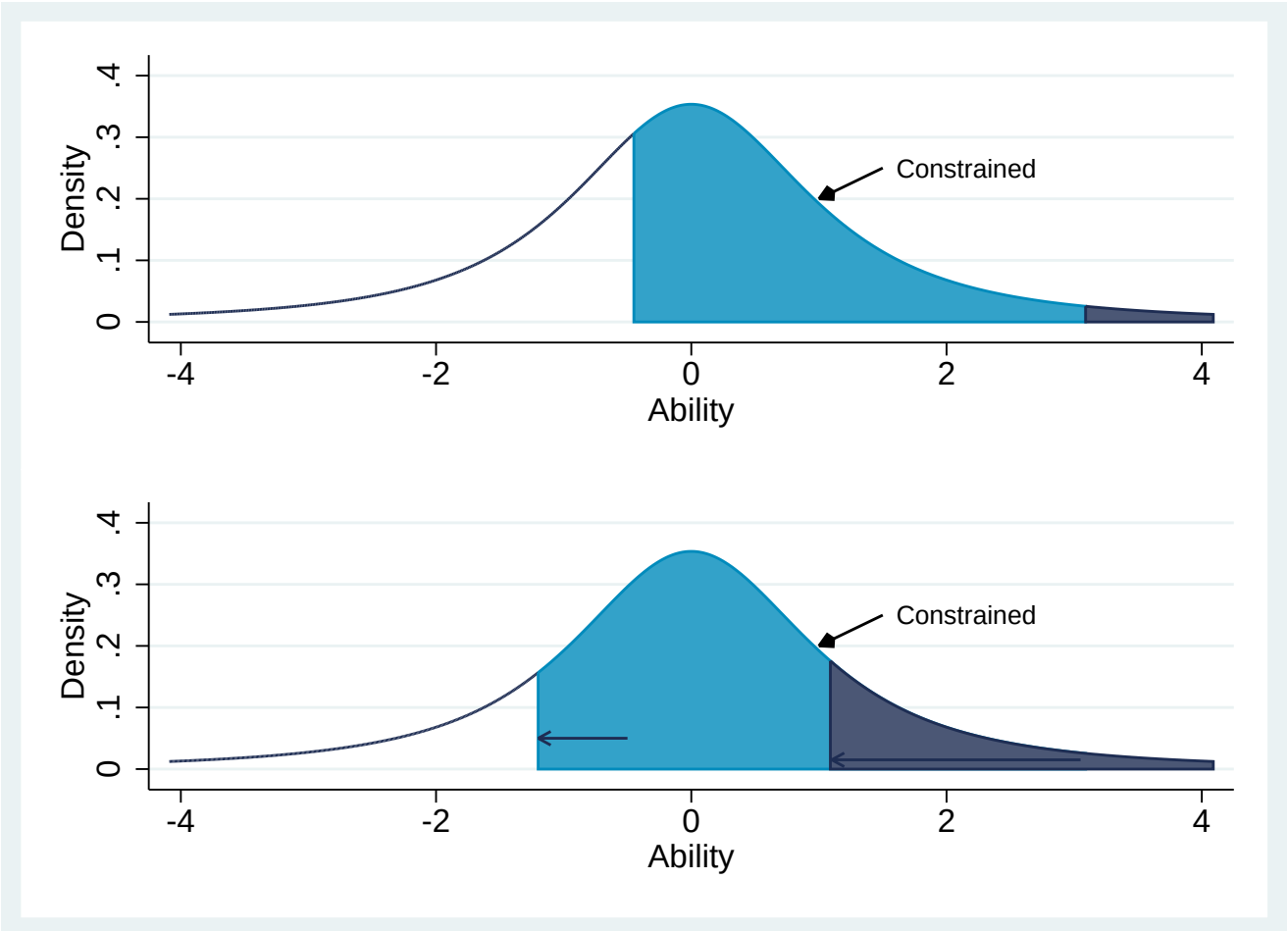
Suppose that students are either from wealthy or poor families

- Students from wealthy families behave as before
- Students from poor families are potentially credit constrained
  - Borrowing constraint that depends on ability
  - Ex-ante would like to attend subject to the ability threshold
  - If the borrowing limit is less than tuition for some high ability individuals, they would be precluded from attending school

Credit constraints illustration (Return)



Credit constraints illustration (Return)



Lower price increases educational attainment and has an **ambiguous impact on the average ability of students**

Conceptual framework predictions (Return)

Free secondary education will:

- Increase educational attainment
- Have impacts on average student ability contingent on the presence of credit constraints
  - Without credit constraints, the average ability must decrease
  - With credit constraints, the average ability could increase, decrease, or stay the same
- Have impacts on academic achievement
  - Academic achievement is a combination of ability and resources
  - Resource quality decreases, so **impact on academic achievement is an indirect test of credit constraints**
- Individuals will decrease risky behaviors that would potentially preclude further schooling
  - High ability individuals need to balance utility from behavior (e.g. sex) against loss from being unable to attend school

Data sources: DHS (Return)

	Obs.	Mean	S.D.	Median	Min.	Max.
Female	13605	0.71	0.46	1	0	1
Age	13605	23.97	3.90	24	18	31
Years of education	13605	10.49	2.35	10	8	19
Completed primary school	13605	1.00	0.00	1	1	1
Attended some secondary school	13605	0.65	0.48	1	0	1
Completed secondary school	13605	0.42	0.49	0	0	1
Female fertility behaviors:						
Age at first intercourse	8298	17.72	2.85	18	5	30
Age at first birth	6432	19.54	3.08	19	11	31
Age at first marriage/cohabitation	6097	19.47	3.23	19	10	31
Male fertility behaviors:						
Age at first intercourse	3446	16.45	3.38	16	5	30
Age at first marriage/cohabitation	1454	22.46	3.13	23	13	30
Employment sector:						
Not working	8499	0.28	0.45	0	0	1
Agricultural work	8499	0.17	0.38	0	0	1
Unskilled work	8499	0.37	0.48	0	0	1
Skilled work	8499	0.18	0.38	0	0	1

Data sources: KNEC (Return)

Administrative Test Scores

	Pre-FSE (2008-2010) (1)	Post-FSE (2011-2015) (2)
Number of schools:	5141	7445
Public schools:	4346	6213
Private schools:	795	1232
Number of test takers per year:	300355	437049
Public schools:	262995	384756
Private schools:	37360	52294
Number of test takers per school:	88.94	92.32
Public schools:	90.23	94.76
Private schools:	79.89	74.38
Standardized KCSE score:	-0.051	-0.066
Public schools:	-0.022	-0.050
Private schools:	-0.254	-0.205

Difference-in-differences (Return)

Identification Assumptions

- Selection bias is attributable to unchanging characteristics
- Common trends

Evidence

- Transition rate potentially determined by regional capacity constraints, school quality, etc.
- Without large changes, likely to be serially correlated
- Treatment intensities calculated over 2, 10 years are highly correlated
- Common trends (pre-treatment) testable with multiple years of pre-treatment data