Maternal Education and Maternal Mortality

Evidence from a Large Panel and Various Natural Experiments

Sonia Bhalotra[1] Damian Clarke[2]

[1]University of Essex

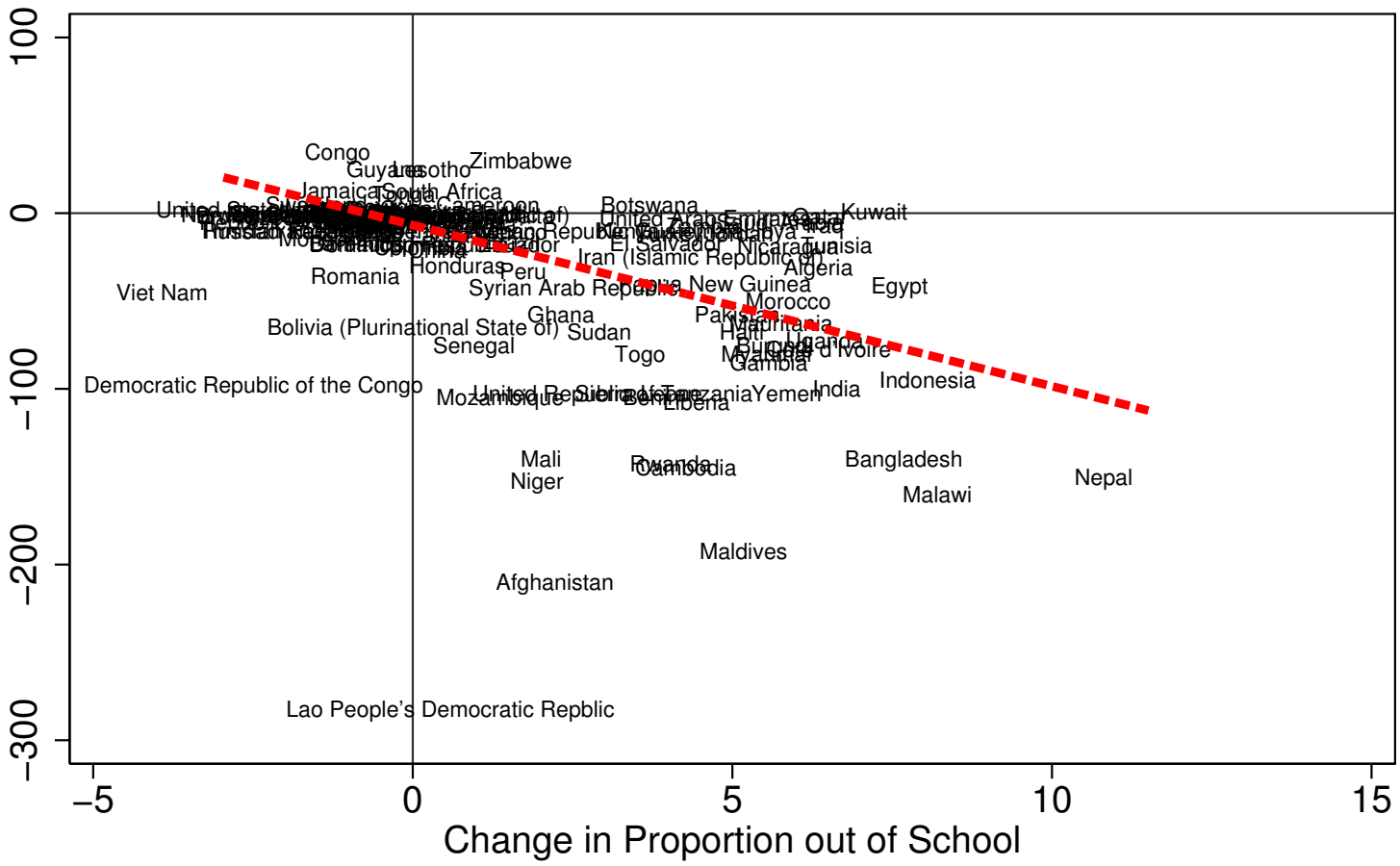
[2]University of Santiago de Chile

June 5, 2016

Take Away Points

1. The probability that a mother dies in child birth is negatively related to her education
2. This finding is robust: it turns up in 'long' panel data and in micro data from plausibly exogenous increases in education
3. The relevant margin is *extensive*: moving from 0 to 1 years of education reduces maternal mortality ratio (MMR) by 166 per 100,000 live births
4. But smaller effects from intensive changes: moving from 7 to 8 years reduces MMR by 20 per 100,000 live births

Figure 1: Changes in Education and Changes in Maternal Mortality



Slope = −9.172 (p−value = 0.000)

Motivation

Introduction

- Every day 830 women die from preventable causes related to pregnancy and childbirth (WHO 2012)
- MMR in developing countries is 240 per 100,000 live births, compared with 16 per 100,000 in developed
- 'Main sources' of maternal mortality:
  - Poverty
  - Limited access to public services
  - Cultural practices
  - Lack of information
- This paper: Does education play a role in maternal mortality rates?

Health and Education

There is a lively literature in economics that documents a positive correlation between education and other indicators of health

- Smoking and drinking less, likelihood of prenatal care, adoption of new drugs (Cutler, Currie, Lleras-Muney among others)...
- Consistent with education conferring efficacy in acquiring and processing information (Rosenzweig, 1995)
- Education may also influence health via income, though results generally hold conditional on income

This Paper

Despite these well-studied relationships, both academic and policy literature have very little to say about the link between education and maternal mortality.

- We examine whether there is a causal relationship between education and MMR
- We identify using
  1. A large panel, and
  2. A number of country-specific policy experiments
- We find consistent evidence to suggest that education has played an *important and sizeable* role in recent reductions of the MMR

Identification

Panel

We run the following on a panel of 108 countries from 1990-2010:

$$MMR_{it} = \alpha_i + \mathbf{educ}_{it}\beta + \mathbf{W}_{it}\gamma + \delta_t + \varepsilon_{it}, \tag{1}$$

- We are intersted in $\hat{\beta}$, which is identified under typical (fixed-effect) panel assumptions
- Include a continously more demanding set of time-varying controls $\mathbf{W}_{it}$, linear trends
- Examine various functional forms and measures of female education (conditional and unconditional on male education)

Country-Specific Reforms

However, we may be concerned that additional time-varying factors are omitted from (1). So:

$$\begin{aligned} y_{ijk} \quad = \quad & \alpha + \beta \text{ UPE Cohort}_{jk} + \gamma \text{UPE Input}_k + \\ & \delta(\text{UPE Input}_k \times \text{UPE Cohort}_{jk}) + \mathbf{X}'_{ijk}\theta + \varepsilon_{ijk}. \end{aligned} \tag{2}$$

We run similar regressions for a number of country-specific contexts:

- Nigeria (above): Universal Primary Education, 1976
- Zimbabwe: Extensions of availability after independence, 1980
- Kenya: Rearrangement of years to obtain KCPE, 1985

Data

Data

We compile a cross-country dataset consisting of:

- educational outcomes from Barro and Lee (2010, 2013)
- maternal mortality ratios (MMR) from WHO 2012
- additional controls from World Bank Data Bank, and constructed from DHS (Summary Statistics)

For country-specific estimates we use the DHS:

- Education comes from female respondents of 4 or 5 waves of surveys in each country (Summary Statistics)
- Maternal mortality is calculated by the sisterhood method
- This allows us to calculate country sub-region averages by cohort

Results

Table 1: Cross-Country Results: MMR and Female Education

VARIABLES	(1) MMR	(2) MMR	(3) MMR	(4) MMR	(5) MMR	(6) MMR	(7) MMR	(8) MMR
Primary Education (% Pop)	-10.06***	-10.52***	-8.703***	-8.835***	-8.147***	-7.805***	-8.047***	-7.516***
	(1.407)	(1.535)	(1.458)	(1.433)	(1.474)	(1.564)	(1.834)	(1.633)
Secondary Education (% Pop)	-9.696***	-9.797***	-6.441***	-6.361***	-5.588***	-5.045***	-5.299***	-4.739***
	(1.214)	(1.284)	(1.376)	(1.361)	(1.364)	(1.514)	(1.737)	(1.539)
Tertiary Education (% Pop)	-9.521***	-10.12***	-4.126**	-3.621*	-3.413*	-3.068	-3.154	-2.882
	(1.238)	(1.369)	(1.964)	(1.956)	(1.773)	(1.870)	(1.919)	(1.774)
log GDP per capita				-65.08*	-66.41**	-60.79**	-58.34*	-60.62*
				(36.96)	(32.46)	(29.34)	(30.42)	(31.21)
Immunization (DPT)					-2.577***	-2.461***	-2.530***	-2.423***
					(0.835)	(0.847)	(0.877)	(0.873)
Attended Births						-1.007	-1.135	-1.490**
						(0.745)	(0.696)	(0.706)
Fertility							-10.01	-26.12
							(22.66)	(23.38)
Teen births								2.037***
								(0.743)
Constant	1,022***	1,048***	818.6***	1,321***	1,483***	1,467***	1,518***	1,444***
	(100.4)	(110.2)	(111.6)	(312.2)	(261.7)	(246.9)	(270.5)	(286.3)
Observations	710	426	426	426	426	426	426	426
R-squared	0.344	0.447	0.493	0.504	0.546	0.552	0.553	0.570
Number of countries	142	108	108	108	108	108	108	108

Table 2: Cross-Country Results: MMR and Female versus Male Education

VARIABLES	(1) MMR	(2) MMR	(3) MMR	(4) MMR	(5) MMR	(6) MMR	(7) MMR	(8) MMR
Primary Education (% Females)	-14.32***	-14.64***	-12.71***	-13.08***	-12.41***	-11.98***	-12.25***	-11.50***
	(2.649)	(3.242)	(2.994)	(3.090)	(3.002)	(3.047)	(3.154)	(2.987)
Secondary Education (% Females)	-8.331***	-12.05***	-8.097***	-8.300***	-7.404***	-7.069***	-7.565***	-7.529***
	(2.272)	(2.751)	(2.689)	(2.715)	(2.446)	(2.476)	(2.594)	(2.410)
Tertiary Education (% Females)	-7.834***	-10.21***	-1.556	-1.946	-1.745	-1.672	-1.821	-2.135
	(2.723)	(2.704)	(3.712)	(3.947)	(3.588)	(3.637)	(3.622)	(3.637)
Primary Education (% Males)	4.867	6.099	6.011*	6.368*	6.341*	6.143*	6.170*	5.919*
	(3.194)	(3.996)	(3.549)	(3.694)	(3.364)	(3.339)	(3.334)	(3.278)
Secondary Education (% Males)	-1.437	3.690	3.097	3.489	3.314	3.414	3.664	4.254
	(2.946)	(3.546)	(3.110)	(3.175)	(2.748)	(2.774)	(2.751)	(2.690)
Tertiary Education (% Males)	-2.036	0.986	-2.263	-1.048	-1.049	-0.812	-0.742	-0.0189
	(3.734)	(3.926)	(4.039)	(4.355)	(3.923)	(3.983)	(3.986)	(4.032)
Observations	710	426	426	426	426	426	426	426
R-squared	0.370	0.468	0.522	0.532	0.574	0.577	0.578	0.593
Number of countries	142	108	108	108	108	108	108	108

Education During Fertile Period Affects Maternal Mortality

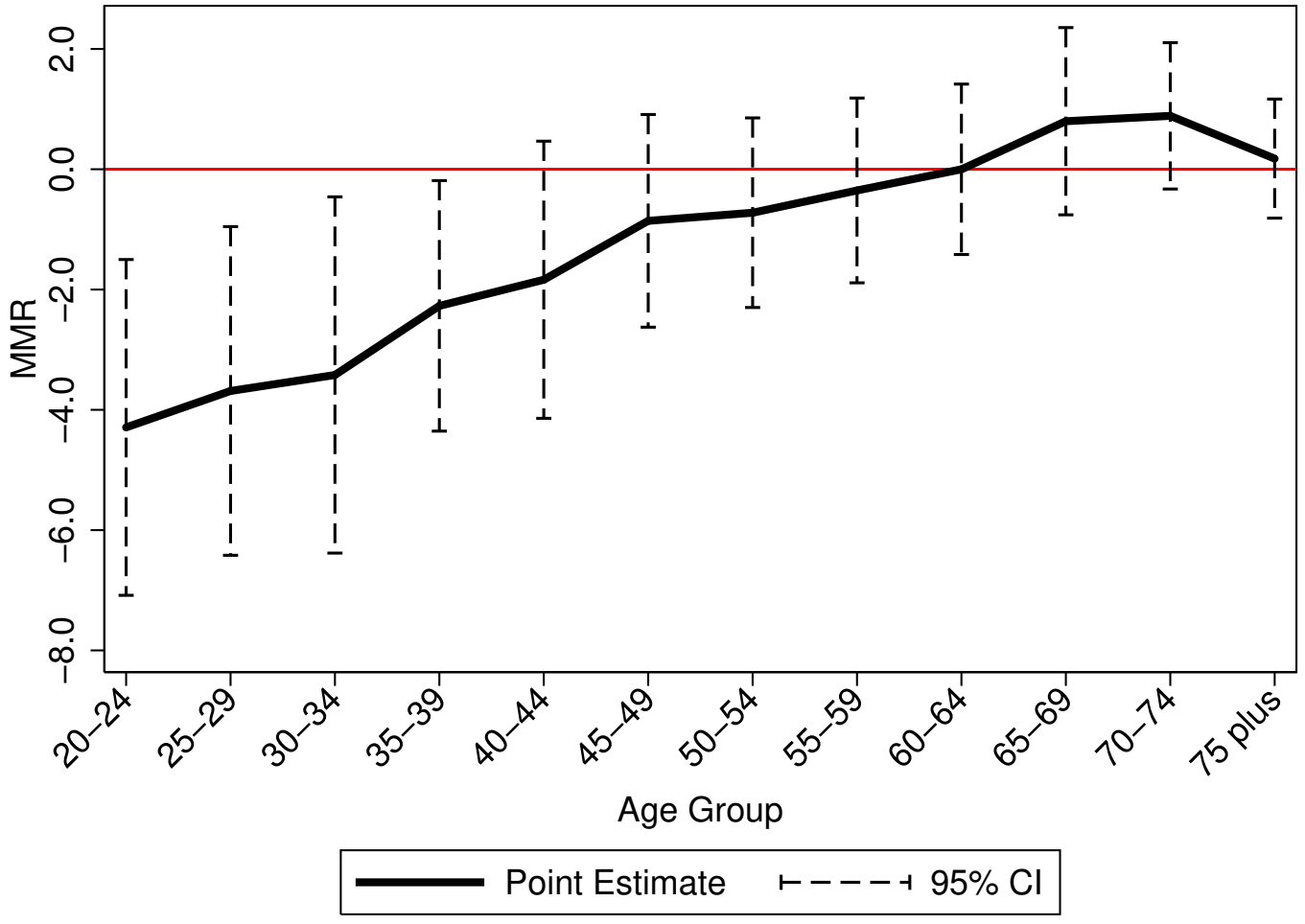


Figure 2: Effect of Primary Education on MMR by Women's Age

Educational Reforms

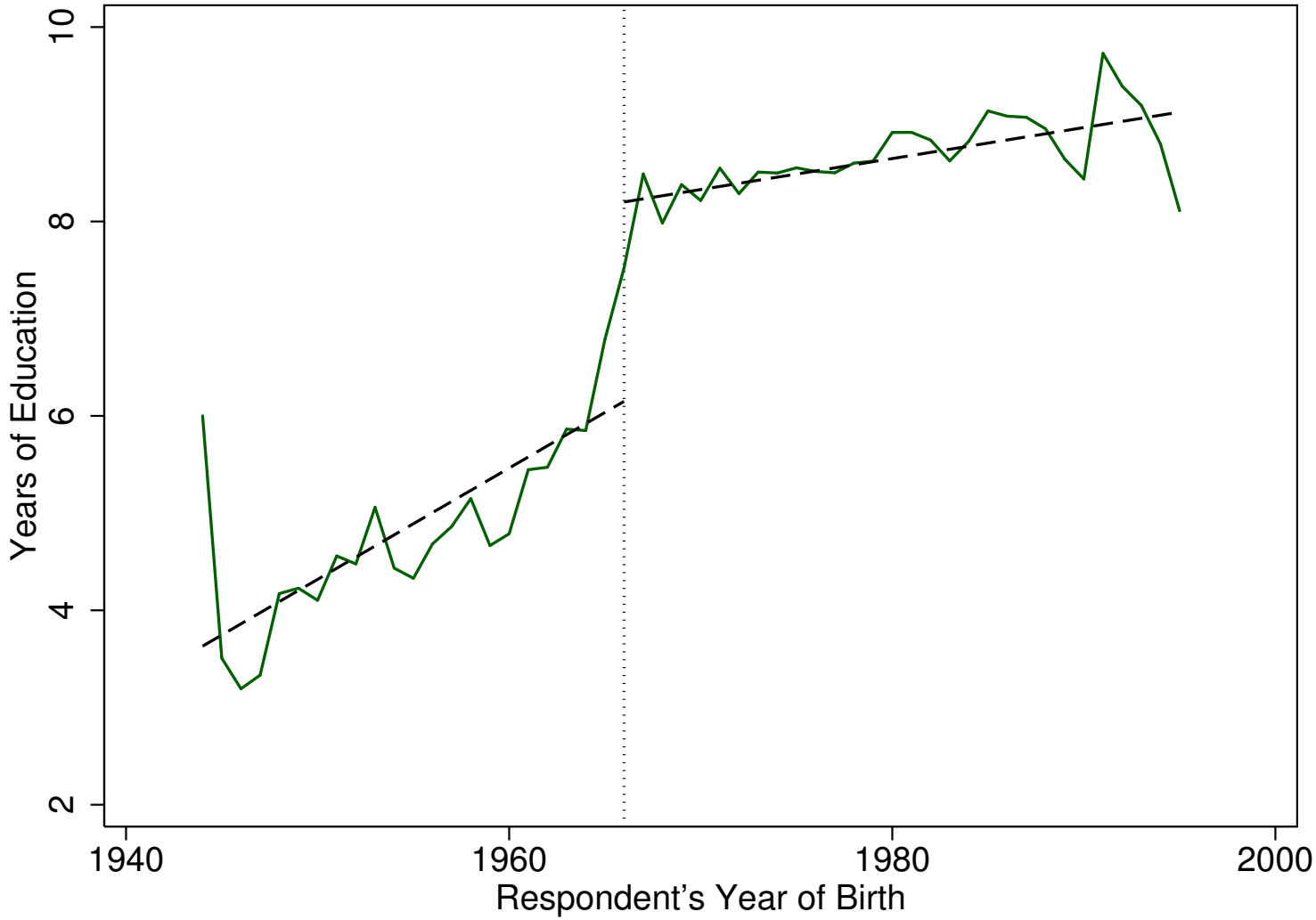


Figure 3: Educational Attainment by Cohort: Zimbabwe

Educational Reforms

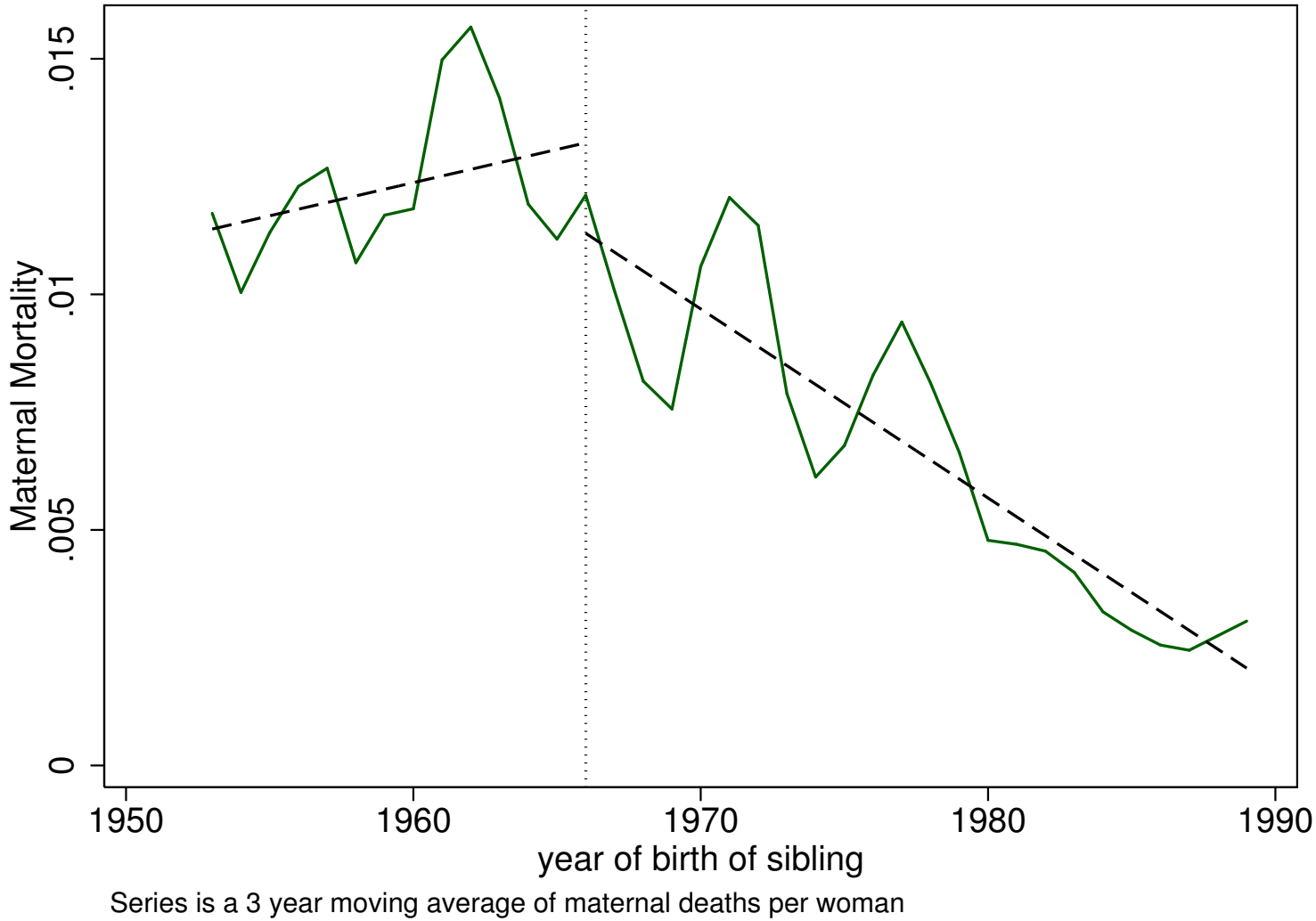


Figure 4: Maternal Mortality by Cohort: Zimbabwe

Educational Reforms

	(1) Nigeria	(2) Zimbabwe	(3) Kenya
Panel A: Education			
Treatment 1	2.179***	1.148***	0.953***
	(0.806)	(0.167)	(0.265)
Treatment 2	1.059**		
	(0.455)		
Observations	12,735	10,195	13,703
Panel B: Maternal Mortality			
Treatment 1	-0.0192**	-0.00413**	0.00689
	(0.00951)	(0.00143)	(0.00553)
Treatment 2	-0.0118**		
	(0.00518)		
Observations	28,694	28,631	25,602

*** p<0.01, ** p<0.05, * p<0.1

Notes: Panel A is the first stage equation, panel B is reduced form. Full specifications and treatment variables are described in section 5. Standard errors are clustered by state and birth cohort. 'Treatment 2' refers to pre-treatment cohorts who are partially affected due to over-age enrolments. 'Treatment 1' refers to affected cohorts.

Country-Specific Results

- Effects are significant in Nigeria, Zimbabwe
  - These are reforms which largely affect *primary* or lower secondary enrolment
  - No effect found in Kenya (reform affects 7^{th} year of education)
- By using data on fertility per woman (DHS), we can convert deaths per woman into deaths per birth to compare with our cross-country estimates (next slide)
- In each case, placebo tests are run using false (lagged) reforms

Interpreting Effect Sizes

- Preferred estimates from panel data suggest moving all uneducated women from 0-1 (5-6) years of education will reduce MMR by 166 (56) deaths per 100,000 live births
- Interpreting MMR reductions from policy experiments in terms of years of education gives:
  - an effect size of $\frac{-0.0192/2.179}{5.38} = -0.00164$ or 164 per 100,000 in Nigeria
  - or of $\frac{-0.00413/1.148}{3.61} = -0.00010$ or 10 per 100,000 in Zimbabwe
- Given that Nigeria was a primary reform, and Zimbabwe was a lower-secondary reform, these effect sizes match up surprisingly well

Mechanisms: Women's Bargaining Power and Fertility Choices

Table 3: Mechanisms: Female Bargaining Power and Fertility Preferences

	Husband Desires Higher Fertility			Maternal Mortality Ratio		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Male/Female Education	0.0407**	0.0414**	0.0347**	431.2***	398.3***	383.5***
	(0.0171)	(0.0166)	(0.0165)	(72.25)	(69.67)	(66.55)
Female Education (years)	-0.00405*	-0.00218	-0.00296	-11.34	-33.30**	-16.46
	(0.00354)	(0.00346)	(0.00340)	(13.78)	(13.34)	(13.39)
Observations	207	207	207	207	207	207
R-squared	0.253	0.294	0.334	0.625	0.625	0.647
Number of Countries	48	48	48	48	48	48

NOTES: Dependent variable in columns 1-3 is measured as the proportion of women aged 25-40 who report at their husband wants higher fertility than they do. Dependent variable in columns 4-6 is the number of maternal deaths per 100,000 live births. The estimation sample consists of all DHS countries in which women respond to desired fertility questions. Column 1 and 4 includes country fixed effects, columns 2 and 5 include country and year fixed effects, and columns 3 and 6 include fixed effects and full time varying controls with the exception of fertility (see column 6 of table 1. Male to female education is measured as the ratio in years. Heteroscedasticity-robust standard errors are reported. *p<0.1; **p<0.05; ***p<0.01

Summary

Conclusion

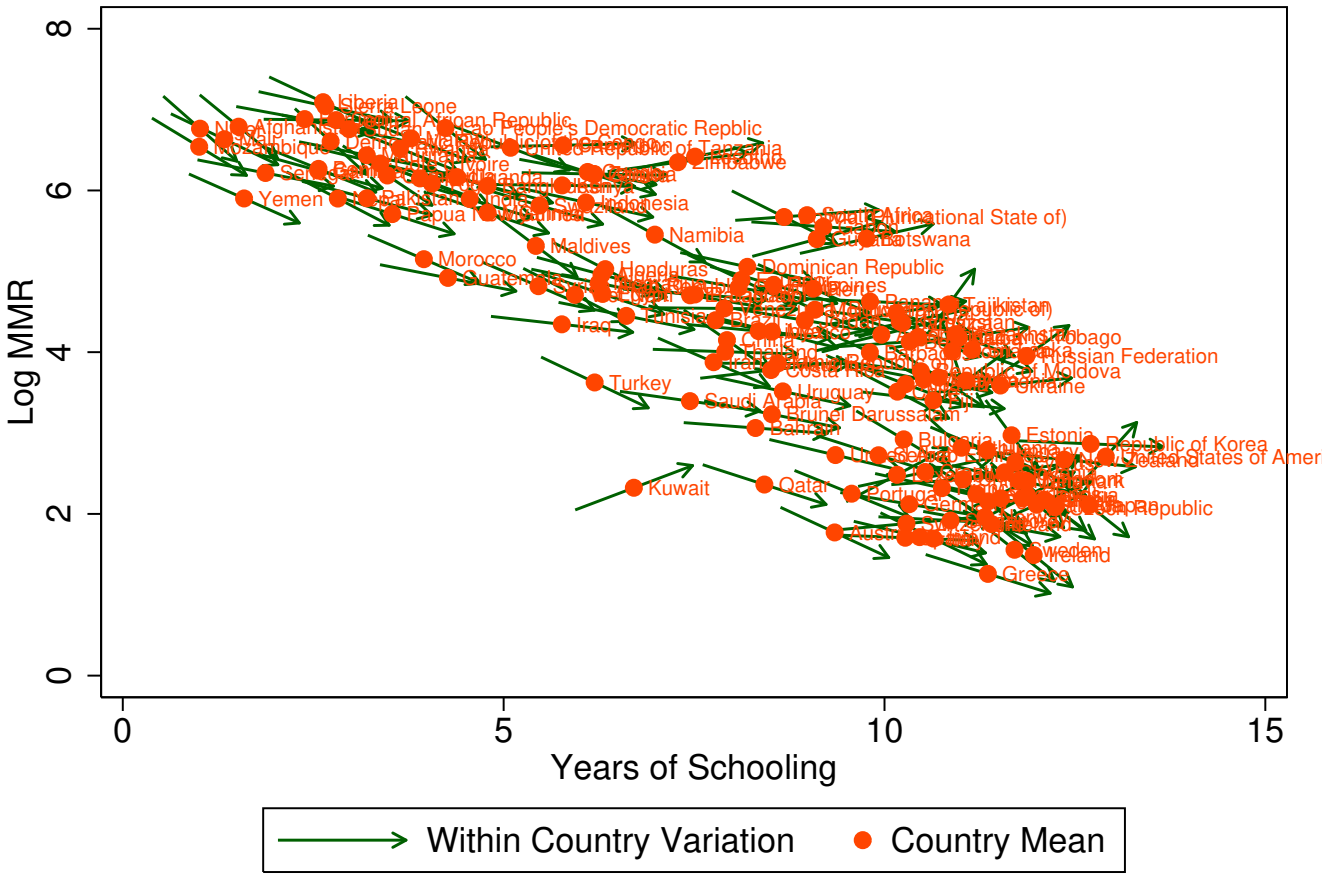
In the last two-decades maternal mortality has declined by ∼50%

- Our analysis suggets that gains in female education can explain an important (and largely unrecognised) proportion of this result
- Effects are largely due to initial (primary) years of education
- There is potential for important further gains:
  - 14.5% of women 15 or older still have no education (Barro-Lee 2013)
  - The probability that a 15 year old woman will die in child birth is 1 in 150 in developing countries (WHO, 2012)
- Important implications for post-MDG policy. The SDGs require a reduction from 210 (now) to 70 deaths per 100,000 live births by 2030.

Thank You

Additional Details...

Education and MMR: Cross- and Within-Country Relationship



116 countries have a negative trend, 30 have a positive trend.

Figure 5: Between and Within Country Correlations: Education and MMR

$$MMR = \frac{\text{deaths relating to pregnancy}}{100,000 \text{ live births}} \tag{3}$$

$$MMRate = \frac{\text{deaths relating to pregnancy}}{\text{Women of Fertile Age}} \tag{4}$$

So...

$$MMR = \frac{MMRate}{\text{Fertility per woman}} = \frac{\text{maternal deaths/woman}}{\text{live births/woman}} \tag{5}$$

Back

Table 4: Summary Statistics - Cross Country

Variable	Obs	Mean	Std. Dev.	Min	Max
Maternal Mortality	710.0	220.6	300.9	2.0	1900.0
ln(Maternal Mortality)	710.0	4.302	1.649	0.6931	7.55
GDP per capita	642.0	10540.0	15110.0	69.58	82400.0
ln(GDP per capita)	642.0	8.11	1.652	4.242	11.32
Immunization	690.0	84.75	15.9	18.0	99.0
Fertility	718.0	3.163	1.676	0.887	8.659
Percent Attended Births	450.0	77.29	27.59	-2.6e-06	100.0
Population (Millions)	670.0	40.49	144.0	0.09515	1338.0
Teen Births	670.0	55.68	46.12	2.796	220.6
Husband wants more kids than wife	290.0	0.2107	0.07437	0.05331	0.3843
Husband wants less kids than wife	290.0	0.07031	0.03495	0.01606	0.1858
Education - Female					
Total Years of Education	730.0	8.07	3.319	0.4692	13.99
Years of Primary Education	730.0	4.714	1.693	0.3421	8.907
Years of Secondary Education	730.0	2.963	1.754	0.04875	7.459
Years of Tertiary Education	730.0	0.3932	0.3744	7.15e-08	2.048
Percent Primary	730.0	23.83	17.44	0.02	77.85
Percent Secondary	730.0	45.97	23.88	1.203	95.65
Percent Tertiary	730.0	12.58	12.05	0.0	62.86
Percent No Education	730.0	17.61	23.4	0.0	93.59
Male/Female Education (years)	730.0	1.16	0.4165	0.7114	4.499

Back

Table 5: Summary Statistics – Natural Experiments

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A – Nigeria					
Years of Education	13221	4.822	5.349	0	22
Investment per Capita	12748	0.881	0.545	0.014	2.195
Non-West State	13235	0.828	0.377	0	1
Year of Birth (education)	13235	1968.329	5.119	1956	1975
Maternal Mortality	25354	0.019	0.137	0	1
Under 25 Maternal Mortality	29676	0.006	0.074	0	1
Year of Birth (MM)	29967	1968.472	5.381	1956	1975
Panel B – Zimbabwe					
Years of Education	10195	7.023	3.788	0	21
High School Enrollment	10195	0.439	0.496	0	1
Treated	10201	0.622	0.485	0	1
Year of Birth (education)	10201	1966.128	4.786	1956	1974
Maternal Mortality	23699	0.013	0.115	0	1
Under 25 Maternal Mortality	28631	0.003	0.055	0	1
Year of Birth (MM)	28842	1966.023	4.736	1957	1974
Panel C – Kenya					
Years of Education	13712	7.168	4.149	0	23
Treated	13712	0.575	0.443	0	1
Year of Birth (education)	13712	1968.389	8.147	1950	1980
Maternal Mortality	22738	0.014	0.116	0	1
Under 25 Maternal Mortality	25616	0.006	0.076	0	1
Year of Birth (MM)	25686	1967.686	7.770	1950	1980

Back

VARIABLES	(1) MMR	(2) MMR	(3) MMR	(4) MMR	(5) MMR	(6) MMR	(7) MMR	(8) MMR
Years of Education	-233.0***	-236.5***	-207.1***	-206.3***	-191.5***	-185.4***	-191.9***	-184.4***
	(23.83)	(26.67)	(24.03)	(23.55)	(26.85)	(29.12)	(37.32)	(36.65)
Years of Education Squared	12.34***	12.51***	12.53***	12.49***	11.68***	11.44***	11.73***	11.31***
	(1.347)	(1.567)	(1.522)	(1.490)	(1.581)	(1.672)	(2.040)	(2.026)
year==1995			-8.620	-9.644	-4.161	-4.580	-6.012	-8.210
			(10.81)	(12.35)	(12.01)	(11.68)	(13.14)	(13.64)
year==2000			-25.12*	-26.49	-17.91	-17.58	-20.62	-21.82
			(14.71)	(16.99)	(15.91)	(16.01)	(18.89)	(19.10)
year==2005			-50.16***	-54.36**	-37.12*	-38.49*	-42.52*	-40.69
			(17.23)	(24.80)	(22.21)	(21.47)	(25.56)	(25.21)
year==2010			-75.56***	-82.38**	-64.34**	-65.31**	-69.95**	-63.63*
			(21.61)	(34.77)	(30.85)	(30.36)	(34.74)	(34.07)
log GDP per capita				6.023	3.976	6.519	7.607	6.602
				(17.30)	(16.38)	(15.60)	(15.89)	(16.02)
Immunization (DPT)					-1.843*	-1.765**	-1.818**	-1.812**
					(0.934)	(0.885)	(0.867)	(0.873)
Attended Births						-0.636	-0.740	-0.870
						(0.841)	(0.827)	(0.833)
Fertility							-9.667	-15.13
							(22.73)	(23.58)
Teen births								0.793
								(0.895)
Constant	1,163***	1,183***	981.7***	933.1***	1,038***	1,030***	1,097***	1,057***
	(95.07)	(105.2)	(99.20)	(156.1)	(147.2)	(145.3)	(212.5)	(226.8)
Observations	710	428	428	428	428	428	428	428
R^2	0.425	0.538	0.580	0.580	0.601	0.604	0.604	0.606
Number of Countries	142	108	108	108	108	108	108	108

*** p<0.01, ** p<0.05, * p<0.1

NOTES: All regressions include fixed-effects by country. Results are for average years of education of females between the ages of 15 and 39 in each country. A full description of control variables is available in section 6.

Back

Follow Agüero and Bharawadj (2011) in estimating around the discontinuity in educational attainment between 14 and 15 year old cohorts in 1980:

$$\begin{aligned} y_{ij} &= \beta_1 \text{DumAge}_{ij} + \beta_2 \text{DumAge}_{ij} \times (\text{Age80}_{ij} - 14) + \\ &\quad \beta_3 (1 - \text{DumAge}_{ij}) \times (\text{Age80}_{ij} - 14) + \mathbf{X}'_{ij}\theta + \varepsilon_{ij}. \end{aligned} \tag{6}$$

Back

As per Chicoine (2011) define treatment based on probability of being in an affected cohort, and fit flexible quarter-of-birth trends:

$$y_{ijq} = \alpha + \beta \text{Treat}_{jk} + \mathbf{age}'_{ijq}\gamma + \mathbf{qob\ trend}'_{jq}\delta + \mathbf{X}'_{ijq}\theta + \varepsilon_{ijq}, \quad (7)$$

Back

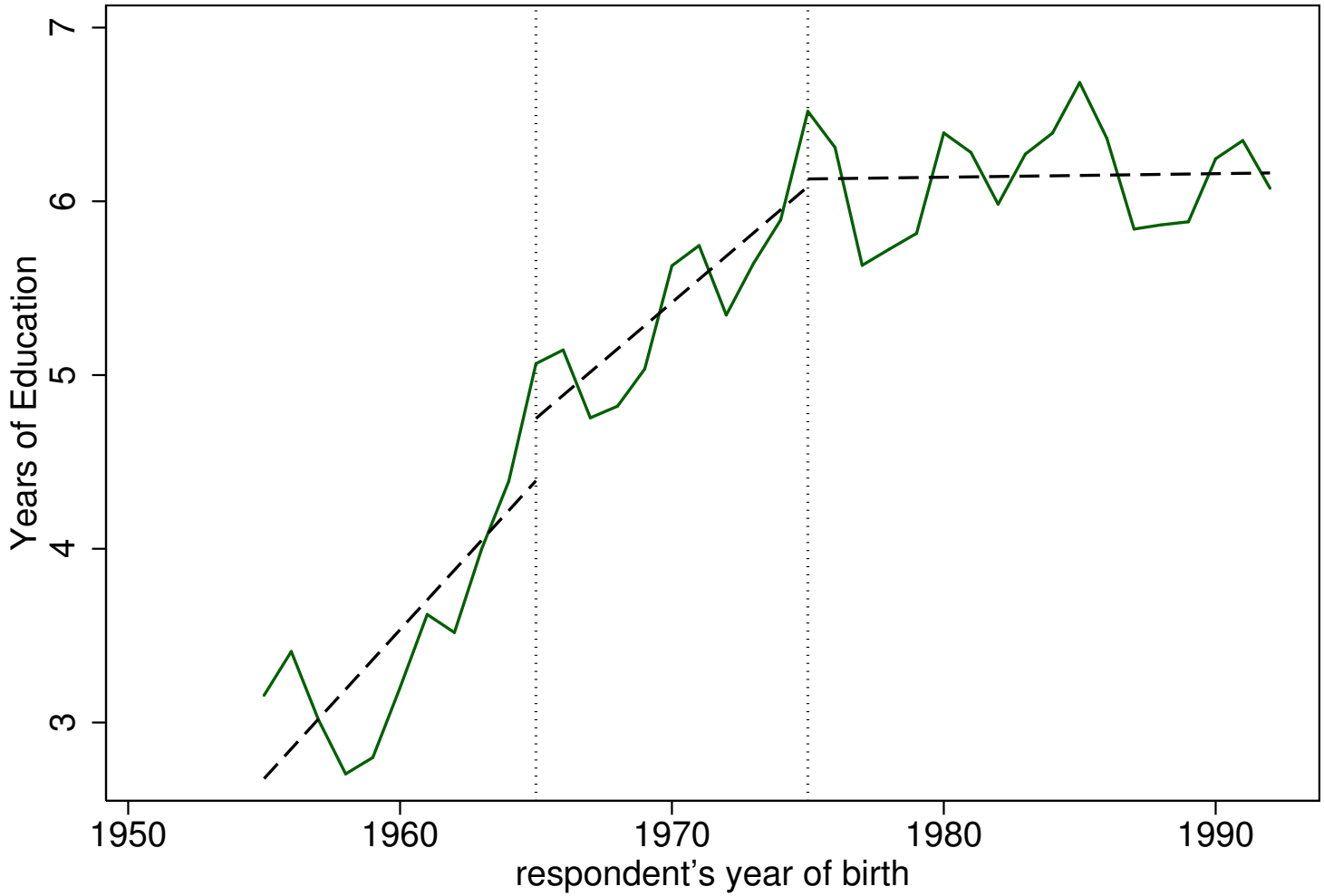


Figure 6: Educational Attainment by Cohort: Nigeria

Back

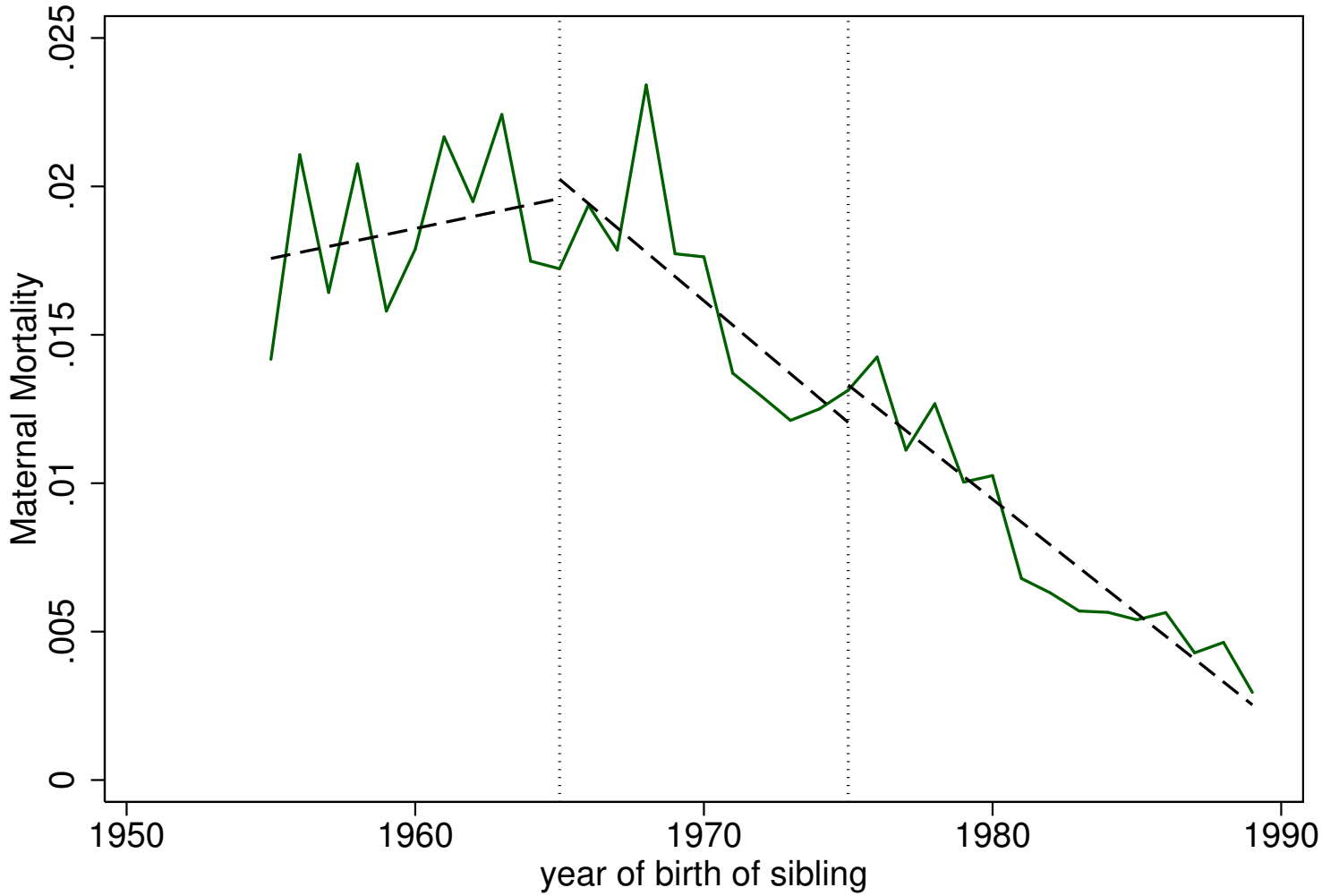


Figure 7: Maternal Mortality by Cohort: Nigeria

Back