Empirical Essays in Development Microeconomics

Gabriel Amobila Aboyadana

A thesis presented in partial fulfilment of the requirements for the award of Doctor of Philosophy Degree in Economics

Department of Economics

University of Strathclyde

United Kingdom

February 2022

DECLARATION

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree. The copyright of this thesis belongs to the author under the terms of the United Kingdom Copyright Acts as qualified by University of Strathclyde Regulation 3.50. Due acknowledgement must always be made of the use of any material contained in, or derived from, this thesis.

Wednesday,30th March 2022

DEDICATION

To the Glory of Yahweh, my God

To my parents, my wife and my children

and

To everyone who will not give up

I know thy works: behold, I have set before thee an open door, and no man can shut it: for thou hast a little strength, and hast kept my word, and hast not denied my name

Then he answered and spake unto me, saying, This is the word of the LORD unto Gabriel, saying, Not by might, nor by power, but by my spirit, saith the LORD of hosts.

ACKNOWLEDGEMENTS

First of all, I acknowledge my star supervisory team, Marco Alfano and Alex Dickson. They helped me have a smooth start to my PhD studies, having bi-weekly and later monthly meetings to check my progress. I am grateful for their recommending me for funding and for accepting me as their supervisee. Studying under their supervision has helped me develop both as a scholar and as a project manager. The journey to a successful career has now started and I hope to continue to benefit from their guidance.

I thank Markus Gehrsitz and Otto Lenhart for their invaluable advice on aspects of earlier versions of this thesis and for sending me useful resources. Their comments helped shape my research and for this I am grateful. And to Mrs Fiona McIntosh for helping me settle in at the beginning of my studies at Strathclyde.

I thank Professor James Abugre and Mrs Justina Abugre, Professor Anthony Aboagye, Professor Godfred Bokpin, Dr Henry Telli, Dr Patrick Assuming and Professor Lord Mensah for their invaluable mentorship and support throughout my academic journey. I thank my parents-in-law, Mr Soter Boachie-Mensah and Cecilia Boachie-Mensah for their support. My friends, Joachim Nyame, Alberta Cudjoe, Richard Akomatey, Irene Bossman, Shadrach Dare, Kwaku Adu-Amankwah, Nana Akua Adu-Amankwah, Agartha Boachie Mensah, members of the Church of Pentecost in Glasgow, members of the Strathclyde Catholic Society, Rev Fr William Apprey and my colleagues at the Economics Department here at Strathclyde for the diverse support to my family throughout the time of my PhD studies.

This journey began as a child when my mother said, "my children will attend all the schools we (my father and her) could not attend". As fate will have it, her prayer has been answered. My father was my personal academic tutor as a child. He taught me how to read and write. I asked more than 10 million questions as a child about almost anything, but he did not stop me from asking. Because of him, I am not afraid to ask questions. I thank my parents for the many diverse sacrifices they have made to see me through school and university. I thank my elder brother, Julius for all the help he gave me during my foundation years. He taught me how to write 8. I have now set the academic bar much higher than anyone before me and I hope Jeff, my younger brother will dare to surpass it before my children beat him to it.

They say that behind every successful man, there is a woman. I can say that

for my wife. Her encouragement and her own academic success inspired me to keep moving on. She accompanied me to the UK for my PhD and has been my most reliable sounding board. For these and more, I thank my wife, Lucy Gabrielle for standing by me this past decade and always saying “I believe in you”. I also acknowledge myself for pressing on and for not giving up halfway when I really felt like giving up. My friends have always said that I had a good measure of determination but the PhD stretched this to new boundaries.

I believe in God and he gave me a vision. He did not tell me how difficult it was going to be but I could see his guiding hand along the way. The rest of the vision is set for an appointed time. I thank God for bringing me this far and for sending amazing people to help me along the way.

ABSTRACT

This thesis includes three essays on issues that impact development in Africa.

There is an active debate in the literature on whether there is a causal relationship between education and health. The existing evidence is mainly from America and Europe and is mixed. The first study in this thesis contributes new evidence to this conversation using data from a natural experiment in a developing country. To credibly identify a causal effect, I explore Ghana's 1996 universal fee waiver policy within a framework of fuzzy Regression Discontinuity Design. The findings show a plausible causal effect of schooling on health outcomes such as smoking, healthy eating habits, the risk of obesity and hypertension. In terms of methodology, the study uses a more accurate definition of school cohorts that have not been used previously.

The second study reconciles findings from psychology experiments and econometric analysis on the relationship between climate variability and violence. The experiments, which have mostly been in America, have suggested that when the temperature is extremely high or low, violence was more likely. The recent econometric analysis, on the other hand, mostly using data from Africa, has suggested a link between Africa's hot climate and recent violent conflicts; and has explained that this is due to climate-induced economic shocks. This study argues that while an economic channel is plausible, it is not universal and suggests instead that *trust* is.

The third study examines the relationship between religion and fertility in Africa. Building on evidence from Nunn(2010), I instrument religion using Roome(1925)'s data on Christian missionary stations. This approach which has not been previously used allows for a credible identification of the effects of religion on fertility. The study examines the relationship between religion and fertility intentions and outcomes, son preference and use of contraception. The findings show that these relationships vary significantly between Christians and Muslims.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

OVERVIEW OF ESSAYS

The continent of Africa is composed mainly of developing countries and like most developing countries, countries in Africa face many challenges. Among these challenges are, poverty, political instability and poorer health outcomes. In this thesis, I make contributions to knowledge on these related themes by examining three distinct issues: (1)the relationship between education and health outcomes and whether causality is plausible, (2) the relationship between climate variability and violence and the role of trust in that relationship, and (3) examine the relationship between religion and fertility outcomes, exploring the possibility of a causal link. The findings in each case have implications for policy that are discussed: the first, for education and public health policies; the second, for institutional reforms, crime/security, and climate change; and the third, for social and demographic policy. Improvements in these areas are important for the socio-economic development of countries on the continent.

The first essay contributes to an emerging debate about whether more schooling causes better health. Much of the broader human capital theory has included a discussion on education and health. However, until about the last decade, most studies were correlational. Recent evidence, however, points to a potential causal relation, but also some recent evidence suggests otherwise, generating a heated debate. Grossman's theory of health capital makes a compelling case but while a correlation is not in doubt (by all sides of the debate), new evidence is required to support a case for causality. For the most part, disentangling several econometric concerns is challenging. Fortunately however, a policy reform in Ghana's school system makes it possible to use credible methods to explore a plausible causal relationship in a regression discontinuity framework. As far as I am aware, this approach has not been applied in the context of Africa and rarely in the context of any other developing region. The studies that are close to the spirit of this essay have almost exclusively examined fertility. I examine other health outcomes besides fertility.

In terms of contribution, the first essay contributes to the literature on education and health in developing countries. The existing literature has mainly focused on developed countries. In those contexts, there is a consensus on the fact that there is a correlation but causality is still debated. In developing countries, the few studies in this strand have focused on the relationship between education and fertility for

women. I extend this literature by looking at other outcome variables and include men in the analysis. I find plausible causal effects. The regression discontinuity design approach used in this essay has been applied to only a few other studies that examined compulsory schooling laws in Africa. However, the definition I use is different. While prior studies define cohorts by year of birth, I define cohorts by year of enrolment. This approach reflects what happens in fact. Additionally, within the context of non-fertility outcomes, the compulsory schooling laws examined have been in terms of the number of years spent in school rather than fee waivers, which is what this essay does.

The second essay reconciles findings from experiments with those from econometric analysis. The study reported in that essay is motivated by studies from psychology and economics. Psychologists have been studying whether temperature can increase the likelihood of aggressive *affect* and aggressive behaviour. Early studies were in laboratories where participants were observed in controlled environments. They found that when temperatures in the lab were identical to what was considered the normal temperature, participants did not show distinct attitudes but when temperatures were turned much higher or much lower, participants responded to questions in a way that reveals intention to engage in aggressive behaviour. These findings have been confirmed by observational studies as well. In the last decade, an emerging body of empirical research in economics and cognate social science disciplines has been exploring climate variability as a possible explainer of violent conflicts and crime around the world. An overwhelming majority of these studies find strong associations. Nonetheless, the authors cite different channels for each context. We take the view that if there exists a casual relationship, then the fact that conclusions are identical for different contexts implies there exists a channel that is not context-specific. We propose *Trust* as one such channel. The question of trust as a determinant of socio-economic behaviour has been of interest in a small part of the economics literature. It has however yet to be examined as a channel for violence. This is the focus of the second essay while also addressing several concerns raised by sceptics of the climate-violence connection.

The second essay's contribution is to the literature on crime, violent conflicts and the effects of climate change. We provide the first empirical evidence of a non-income channel. Most empirical studies in this literature have cited an agricultural income channel, for the effect of climate change on violence. Nonetheless, others have suggested

that significant effects still remain after accounting for income. It is clear that it is humans who engage in violence. Their decision to engage in violence is affected by their arousal, affect, and cognition, all of which are units of attitudes. We examine trust, as a unit of attitude within the context of political participation. We thus reconcile the findings of experiments in psychology with findings from econometric analysis in this new mechanism. Our results have implications for security and climate change policy.

Since Malthus, economists have sounded alarm bells on the potentially devastating consequences of high population growth. The key concern has been that if population growth is not controlled, there would come a time when people could starve to death due to the scarcity of food and other essential commodities. The fact that poor countries have traditionally had higher population growth rates has been cited in support of the Malthusian catastrophe. Consequently, population control has become part of the tool kit for development policymakers. The question of population control is however not complete without consideration of the role of religion. Artificial birth control methods are crucial in the tool kit of proponents of population control as a tool for economic development. The regions of the world which are considered the least developed tend to be the most religious. However, several of the world's major religious groups reject artificial birth control and so the uptake among their members is low. A handful of case studies have provided evidence of a strong correlation between affiliation to certain religious groups and fertility outcomes. Mainly, researchers have argued for a possible correlation citing doctrines and anecdotal evidence. Most of the few empirical studies have focused on the so-called developed countries, where fertility is generally lower. The third essay of this thesis focuses on Africa where fertility is high and religion is important to the people, but related studies are sparse. The finding is that fertility outcomes vary significantly between Christians and Muslims.

In terms of contributions, the third essay provides evidence that religious doctrines potentially influence the formation of fertility intentions which translates into outcomes. Hitherto, much of what we know about religion and fertility in Africa has been based on anecdotal evidence and descriptive statistics. However, there exist several correlates of fertility in Africa that make it challenging to disentangle the effects of religion. Moreover, only a few empirical studies have attempted any examination of religion as a determinant of fertility. Nunn (2010) introduced an old dataset from Roome (1925) of Christian missionary stations in Africa into the economics literature.

The dataset has geographic coordinates of the location of Christian missionaries who evangelised Africa. I argue that people who live close to a historical mission station were more likely to be Christians today. This is supported by the first stage of an instrumental variable estimation which shows that proximity to a mission station was a good predictor of current religious affiliation. I instrument religion with this predictor in a second stage to identify the relationship between religion and fertility outcomes. To the best of my knowledge, this is the first time this approach has been used. While clearly an important demographic issue, the role of religion has been largely neglected. This study thus brings this issue to the fore.

In each essay, theories and empirical issues are discussed briefly at an appropriate depth to situate the essay within the wider literature. This introduction has given an overview of the main purpose of each essay and highlighted the methods, findings and contributions. A conclusion at the end of the thesis also gives a summary of the key findings and conclusions.

Chapter 1 EDUCATION AND HEALTH IN DEVELOPING COUNTRIES: EVIDENCE FROM GHANA'S FCUBE

Abstract

Does education cause health? There is a strong correlation between education and health and a sound theoretical basis. For policy to be effective, however, there is the need to establish causality. Existing evidence of causality has come from developed countries and the conclusions are mixed. In developing countries, recent efforts have focused on fertility and child health. This paper contributes to this discussion by examining adult data for Ghana, a developing country. The implementation of the 1996 universal school fees waiver policy (FCUBE) in Ghana was such that primary school children received different treatments based on their age, conditional on enrolment. This presents a source of exogeneity that I exploit within a regression discontinuity framework. The findings show that the school fees waiver increased the total years of completed schooling by about 1.5 years. This increase in schooling led to a decrease in the probability of smoking and fertility intention and they were more likely to include vegetables in their meals. Females were more likely to attend antenatal visits and had an increased risk of obesity. These findings imply a potential causal effect of schooling on health in developing countries.

1.1 Introduction

For a long time, it has been observed that people who have more education tend to be healthier (Albarran et al., 2020; Amin et al., 2015; Arcaya and Saiz, 2020; Davies et al., 2018). Some suggest that the reason for this is because better-educated people have better labour market outcomes which provide them with higher income with which they are able to access quality healthcare (Albarran et al., 2020; Hamad et al., 2018). Others have also suggested that schooling develops cognitive skills which enhance health decision-making and engenders the adoption of positive health behaviour (Lleras-Muney, 2005; Odunowo, 2020). At the national level, the UNDP health index (UNDP, 2020) and national literacy rates (Burton, 2020) reveal that on average, the more literate countries also have higher health indices. There is, however,

no conclusive evidence that suggests that this relationship is causal in nature (Hamad et al., 2018; Xue et al., 2020). While a few studies have pursued the path of finding causal relationships in developed countries, particularly in the US and UK in the last decade, the same cannot be said for developing countries (Dilmaghani, 2020; Fletcher, 2015; Fonseca et al., 2019; Hamad et al., 2018). This paper extends the frontiers of this strand of research by examining data from a natural experiment originating from an early childhood policy in Ghana, a developing country.

This study makes at least four contributions to our understanding of the education-health nexus. First, it examines the causal relationship between education and health. There are relatively more studies that have shown that there is a correlation between education and health (Janke et al., 2020). Studies concerned with the causality of this relationship are however limited. The small (but fast-growing) literature in this area, however, presents mixed results (Albarran et al., 2020; Hamad et al., 2018). For instance, Clark and Royer (2013) and Janke et al. (2020) exploited compulsory schooling laws, as a source of exogeneity in Britain and concluded that while those policies increased average years of schooling, there was no causal effect on health outcomes. Albarran et al. (2020) obtain a similar conclusion using cross-country data for Europe. One explanation suggested for those results is that the general quality of, and access to healthcare in those countries are high so that there is little variation based on educational attainment. Other studies such as Davies et al. (2018) however, using data for Britain and exploiting the same compulsory schooling laws, find very strong causal effects of education on health. This paper contributes to this discussion by providing new evidence.

Second, this paper provides evidence in a developing country context. The evidence supporting both sides of the discussion above has mostly been from European countries and the US. The evidence from developing countries is limited. This is noted in recent reviews of the literature by Hamad et al. (2018) and Arcaya and Saiz (2020). A search of the literature shows that the few studies on developing country contexts mostly examine the fertility effects of education. The review by Hamad et al. (2018) for instance found only one published in Africa (from Kenya) which examined sexual health. In addition, I find Osili and Long (2008), for Nigeria, Boahen and Yamauchi (2018) for Ghana and Keats (2018) for Uganda, all of which examined female fertility effects of schooling. This study examines other outcomes in addition to fertility. I am

not aware of any other study on Africa that examines other outcomes besides fertility. As previous studies examine female data, the third contribution of this paper is that it includes males for some variables.

The fourth contribution of this paper is that it examines the effect of a universal school fee waiver at the basic education level. Universal primary education (UPE) has been implemented in other African countries. This included 6years of free primary education. However, Ghana's version of the policy included 3 years of junior secondary school; a total of 9 years. Only Uganda's UPE has been exploited using a similar methodology by Keats (2018). The policies examined in developed countries have been at the secondary school level. It has however been shown that early education interventions are important for long-term outcomes. This paper examines the long-term health effect of an early childhood education policy. The fact that school fee policies have not been previously studied makes the findings of this paper relevant for poor countries and for developed countries that experience health inequalities resulting from inter-generational poverty.

This paper exploits the discontinuity in school attainment as a result of the FCUBE[1] policy in 1996. The data is taken from the DHS[2], Round 7. The unit of analysis in this study is the residents of Ghana, a small emerging economy in West Africa. Ghana's ethnic diversity is like most other African countries. Its political stability over several decades and the ECOWAS policy of free movement within the sub-region have made it home to millions of people from other West African countries. Official records put the legally registered immigrants at about 15% of the total population with a substantial number of undocumented migrants. This regional character means the study findings are relevant for other west-African countries as many of these countries plan to implement similar policies (Nishimura and Byamugisha, 2011).

The classical problems of causality arise in this study. Omitted variables such as innate ability may be co-determined with health. For example, people born with certain disabilities may also suffer health challenges as a result. The omitted variable problem may, however, be less severe than is suggested by previous studies (Ashenfelter and Krueger, 1992) because instances of people being born with disabilities that also affect health are rare. Nonetheless, it is important to account for this in empirical

[1]Free Compulsory Universal Basic Education
[2]Demographic and Health Surveys

analysis. Also, because schooling is a choice variable, it is likely that healthy people may self-select into higher attainment. Measurement errors in schooling data on the other hand have been shown to be small and potentially not significant (Card, 2001). Another concern is reverse causality. This concern arises from the fact that sick children are likely to miss more school days, and may drop out of school due to ill health (Miguel and Kremer, 2004). While this concern is valid, it is unlikely to be severe. Instances of ill health that bar people from attending school are extremely rare events that are unlikely to have a severe effect on this study. Nonetheless, I take steps to address these issues in this paper.

The findings of the study show that the fee waiver was effective in increasing school attainment. Cohorts assigned to receive an additional year of fee waivers were more likely to have ever enrolled in school, completed basic education, and completed more schooling on average. Individuals in this cohort completed an average of 1.5 years of additional schooling. This translated into significant benefits for their health as adults. The probability of being a smoker, and fertility intention were lower for the assignment cohorts. Healthy eating, antenatal visits and risk of obesity were higher. Except for the risk of obesity finding, all findings can be considered desirable outcomes. The higher risk of obesity confirms an increasing trend of obesity in developing countries identified in the health literature. Policy implications are discussed.

I give an overview of the study context in section 1.2 and review prior studies in section 1.3. I describe the data and methods in section 1.4. The results are discussed in section 1.5 and evaluated for robustness in section 1.6. Section 1.7 concludes.

1.2 The Study Context

1.2.1 The Country

Ghana is a lower middle-income country in West Africa with an estimated population of over 30 million (as of 2020) and a GDP of about USD70billion. The country has made significant economic progress in the last 30 years, currently with a human development index of 0.6 (medium) and a Gini of 42. Until 2018, there were 10 administrative regions, 275 parliamentary constituencies, and 216 districts. These have since been reorganised into 16 regions and 260 districts. Compared to its neighbours, it is widely considered stable both politically and economically. Together with its rich history, it

is an attractive destination for migrants, investors and tourists.

After gaining independence from Britain in 1957, the new country's economy grew rapidly until political instability in the late 1960s led to a long period of economic decline. For instance, the index of real monthly income fell from 315 in the 1970s to 62 in the 1980s (Akyeampong, 2009; Nudzor, 2013a). From 1979 to 1983 alone, the economy contracted by about 14% and real per capita income fell by about 23% (Akyeampong, 2009; World Bank, 2004). These economic circumstances led to more than 60% of the population living below the poverty line. At the peak of the economic decline, in 1983, the onset of drought led to a mass exodus, mostly of teachers and other skilled workers, to neighbouring countries.

1.2.2 The Education System

Ghana's current education system, introduced in 1987, includes 2 years of non-compulsory kindergarten from age 4 to 6; 6 years of primary school from ages 6 to 12; 3 years of junior secondary school from ages 12 to 15; 3 years of senior secondary school (or vocational/technical school) from ages 15 to 18; qualifying students can then enrol for tertiary education.

Basic education in Ghana includes a primary school and junior secondary school and pupils are required to take a school-leaving exam called the Basic Education Certificate Exam (BECE) in the final year of junior secondary school. The BECE examines the syllabus of the junior secondary school only, which comprises 8 compulsory subjects and 2 optional subjects (a Ghanaian language and French). Pupils must obtain at least 6 passes, which must include English, Maths, and Integrated Science, to be able to progress to senior secondary school. They take 8 subjects in secondary school and must pass at least 6 of them (including English, Maths, and General Science) in the West Africa Secondary School Certificate Exam (WASSCE) to qualify for admission into the university and other post-secondary educational institutions. Both the BECE and WASSCE are graded on a 9-point scale and students require at least 50% to pass a subject (World Education Service, 2019).

Until 1987, the educational system consisted of 6 years of primary school, 4 years of middle school, 5 years of secondary school, and 2 years of the sixth form; a total of 17 years. The political and economic events prior, together with deteriorating educational infrastructure led to a decrease in school enrolment by more than 100,000

and stagnated until 1986/1987. Government spending on education also reduced from 6.4% to 1.5% of a much lower GDP by 1984 (Nudzor, 2013b). Consequently, school fees were reintroduced at all levels. These events led to the deepening of inequality in school enrolment (Akyeampong, 2009). By reducing the years of pre-tertiary school to 12 years, the savings were channelled to expand the infrastructure and reverse the decline in enrolment. These interventions, however, did not lead to a rapid increase in enrolment until after the implementation of FCUBE in 1996.

1.2.3 The Policy

The 1992 constitution included a clause that mandated the government to make basic education fee-free and compulsory, hence the FCUBE policy was implemented in the school year starting in August 1996 (Akyeampong, 2009). In principle, tuition has always been free at all levels because the government pays the salaries of teachers and provides basic infrastructure. However, there were additional non-tuition costs that were charged to pupils (World Education Service, 2019). These costs were charged at the local level. The government approved some fees, but each school could charge additional fees and levies as required to meet operational costs that are not funded by the government. These fees were called *school fees*. Besides eliminating fees and levies, the policy required the government to provide books and other learning materials. In the years following, the government introduced free school meals and free school uniforms (Salifu et al., 2018). Thus, the FCUBE policy sought to eliminate all forms of direct money costs. To improve quality, the government also embarked on a large-scale expansion of education infrastructure across the country and trained more teachers to teach at the basic school level and reduced the number of untrained teachers it employed.

Unlike other universal primary education policies that have been implemented in other African countries, Ghana's FCUBE eliminated fees for all pupils at the basic level, not just for those who entered primary school after the implementation of the policy. This means that all children enrolled in primary and junior secondary school from 1996 benefited from the policy regardless of the grade they were at; but those already enrolled before August 1996 benefited from fewer years, the higher their grade. For instance, pupils who entered in 1995 received 8 years of fee-free schooling, whereas those who entered in 1996 received 9 years of fee-free schooling. Thus, exposure to the

policy changes in 1-year increments.

1.3 Prior Literature

1.3.1 The Theoretical Literature

Grossman (1972, 1973)'s work on health capital and health consumption are the most cited on the relationship between education and health. In this theory, education enters either as a determinant of demand or as technology. He characterises health as a durable commodity that individuals produce and consume and education enters the production function. The theory argues that in the health production function, education enhances productive and allocative efficiency. The main arguments of Grossman (1972) are summarised in Appendix A.

The theory argues that individuals inherit an autonomous stock of health at birth *(initial health endowment)* that depreciates with age (Kaestner et al., 2020). That is, people are born with a predetermined quantity of health but the amount available at any point in their lifetime will vary from their initial stock of health. To maintain or increase the stock of health at any point in time, the individual must invest in their own health. This could be in the form of better nutrition, exercise, and medical care. As a commodity, the shadow price of health depends on factors beyond the price of medical care. Shifts in these other factors alter the stock of health and the derived demand for gross investment in health, measured by, say, medical expenditures. For example, if the rate of depreciation increases with age, the price of health will increase with age.

Grossman argues that better-educated individuals are more efficient producers of health because they have access to more information (for example) and are capable of critical evaluation of health information, and so choose an optimal mix of inputs. Thus, the price of health will be lower for better-educated people if they are efficient producers of health. Consequently, the stock of health of educated people will be higher at any point. This argument makes a strong case for countries with lower health outcomes to invest more in education as a form of indirect investment in public health (Jones et al., 2014). Wagstaff (1986) suggested that the rate of return to health from more schooling is greater by far than the returns from medical care intervention.

Consumers demand health for two reasons. First, as a consumption good which

enters directly into their utility functions. Illness is a source of disutility. Its absence, therefore, generates positive utility or as implied by Kahneman (2012) the disutility resulting from ill health is about twice the utility of good health. Secondly, health is an investment good because illness reduces the hours available for work. Investing in health ensures that no productive time is lost and so the money return to health investment is the money return from the reduction in lost productive hours. Where the definition of productive hours is not limited to paid work. Just as individuals (and other agents) invest in education to increase their human capital, they also invest in health capital via schooling. As human capital improves labour productivity, so does health capital contribute to health production which also feeds into the productivity of labour. In other words, investment in health capital generates returns via the labour market by creating healthy time for market (and non-market) activities that generate money earnings (and other positive-utility consumption goods). Health capital also enhances the efficiency of human capital.

Grossman's health capital theory was developed following work by Becker (1964) and others on the nature and causes of human capital. Grossman identifies that health is an important component of human capital; a complement to education. Investments in both education (skill) and health enhance human capital. However, these theories ignored an important distinction between education (skill capital) and health capital. Becker (1964) suggests that investment in human capital should decline with age because the time to realise the returns gets shorter. Nonetheless, if we consider skill capital as distinct from health capital, it is straightforward to see that large investment in skill capital typically occurs early in life and the returns are realised over the future life course (consistent with Becker) whereas, more investment in health capital is required in later life, as the rate of depreciation of health increases (Kaestner et al., 2020).

Four channels are cited in the theoretical literature as pathways from education to health (Becker and Mulligan, 1997; Fuchs, 1982). The first, it is argued, is that education improves health (productive) efficiency (Lochner, 2011). The second channel is via changes in inputs into the health production function (allocative efficiency) because of superior information resulting from higher education (Heckman, 2007). The third channel is via time preference (Fuchs, 1982; Dickson, 2013). Education changes time preference (and thus inputs into health production) because schooling

focuses students' attention on the future. The fourth channel is the indirect effects of education mediated through higher income, occupational status, access to better housing, environmental conditions, et cetera.

The theoretical literature also discusses alternative sources of health capital. Lleras-Muney (2005) argues that early childhood interventions affect health in adulthood through cognitive and non-cognitive skills, and so investments in early childhood have the most return to health. Future health investments would yield low returns if the earlier investment in education is low. Thus, she suggests that early childhood education is key to overall population health in the long term as does Aslam and Kingdon (2012) and Odunowo (2020). This paper contributes to the literature in this area by examining the long-term health effects of an early childhood education intervention.

1.3.2 Overview of the Empirical Literature

Since Grossman, there has been a large body of literature seeking evidence of a relationship between education and health. This is because the arguments suggesting a potential link are both compelling and apparent. For instance, being educated equips individuals with literacy skills which allows them to be able to access and understand health information. Additionally, because educated people have higher wages (Buscha and Dickson, 2018), their opportunity cost of ill health is higher and so they will make healthier choices. Moreover, their higher income makes healthcare more accessible. While these arguments are compelling, the evidence of causality is mixed. There is, however, a near-universal consensus on the existence of a strong correlation between education and health (Hamad et al., 2018; Albarran et al., 2020).

Towards finding a causal effect

Investment in education and health is important for human capital development. For policy interventions to be effective, a causal link is desirable. Finding a causal relationship is important for understanding the determinants of (demand for) health(care) and the role of education. It also gives an assurance that spending is targeted in a way that is certain to yield the expected outcomes. There is a growing literature that seeks to find a causal link between education and health (Ayyagari et al., 2011). These efforts are faced with estimation challenges such as reverse causality

(Harrison et al., 2020; Hughes et al., 2021). While some authors have argued that theoretically, reverse causality is possible, little evidence supports this (Angrist and Pischke, 2008; Hughes et al., 2021; Jurges et al., 2013).

The argument for reverse causality has been that ill health affects the ability to attend school, but the size of the effect implied by this argument in empirical studies is likely to be small. Moreover, the available evidence shows that the educational attainment required to generate health benefits need not be super high (Bijwaard et al., 2015; Delprato et al., 2017; Johnson, 2010). For instance, it has been shown that completing primary school was sufficient to generate positive health returns to education (Belfield and Kelly, 2013). If an individual's health was so poor as to prevent them from completing primary school, chances are that they inherited a low stock of health, which is autonomous. For instance, a recent study by Hughes et al. (2021) examined this concern by using genetic data to examine how childhood health conditions affected schooling attainment. They concluded that an association may exist but this was not causal. Moreover, the conditions that they examined were either learning disabilities or hereditary in nature. This supports the argument put forward here that any poor health in children that has the potential to severely impair schooling must have been inherited at birth and there is little to do about this in empirical studies. A systematic review by Zinyemba et al. (2020) finds that children born with HIV missed school because of illness and hospital appointments. If we consider that children have limited control over decisions that affect their health, it makes sense to think that the health returns to education in childhood must flow from parental education (Odunowo, 2020). This has been shown in several studies (Aslam and Kingdon, 2012; Baltagi et al., 2019). Thus, returns to own education accrues in adulthood (Arendt et al., 2021) while parental education generates health returns in childhood (Kaestner et al., 2020).

Others have argued that the correlation could be because of third variables that drive both education and health. Recent studies have sought to establish that causality runs from education to health but isolating the effects of third variables has been a challenge (Heckman, 2007; Lochner, 2011; Albarran et al., 2020). Omitted variables include genetic factors, native ability, time preference and poor health in childhood (Miguel and Kremer, 2004). The presence of third variables raises concerns about endogeneity. It would have been straightforward if third variables could be controlled for. However, these variables are latent and difficult to measure. Rather than

attempt to measure these variables, recent studies have treated education as endogenous and then used instrumental variable methods to isolate health returns attributable to education. Finding good instruments can however be difficult in instrumental variables estimation. The present study uses an educational policy as a source of exogeneity to instrument for education in a fuzzy regression discontinuity framework.

The evidence so far

The evidence of a causal link is mixed. Ma et al. (2018) examined the causal relationship in Ireland using the 1960 abolition of tuition fees as a source of exogeneity. They find that one additional year of schooling led to a lower prevalence of hypertension and diabetes by 3 percentage points and 1 percentage point, respectively. In the US, Lleras-Muney (2005) finds that educational attainment has a causal effect on mortality.

Using the compulsory schooling laws in Britain in 1947 and 1972 as a source of exogeneity, Jurges et al. (2013) and Clark and Royer (2013) find that while schooling increased by 1 year, there was no causal effect on health. Baltagi et al. (2019) reached the same conclusion when examining compulsory schooling laws in Turkey. Jurges et al. (2011) find a mixed effect on health outcomes such as obesity and overweight in western Germany. They find that the effect of education on women's health is larger and more robust than for men.

Potential Mechanisms

Different mechanisms are suggested. These include, first, that better-educated people will find good employment. Good employment means more satisfaction, higher lifetime earnings and the ability to afford quality healthcare (Hoenig and Wenz, 2021). Education also affects health through relative social status, acquisition of knowledge, better or improved processing of health information, and decision making and changes the perception of health risks, making individuals more future-oriented. Knowledge or access to information is usually cited as the main mechanism.

The theory of demand for health (Grossman, 1972) suggests that education has a causal effect on health because schooling increases the efficiency of health production. Thus, being more educated means having more knowledge about the health production function because of access to information. Boahen and Yamauchi (2018) find that the mechanism by which education affects adolescent fertility was through a knowledge

effect. That is, if women are educated, they will be aware of health issues and so would seek healthcare and take preventive measures. However, Kenkel (1991) examines the relationship between education and health behaviour and finds a negative relationship between education and cigarette and alcohol consumption and a positive relationship with exercise. He examines the hypothesis that the mechanism is via health knowledge and finds that even after controlling for health knowledge, substantial effects of education remain and concludes that there are other important channels beyond knowledge. He also concludes that the highly educated were much more likely to choose healthy behaviour than those who were highly knowledgeable about the consequences of the behaviour. This suggests that there are other mechanisms by which education affects health besides knowledge. These other mechanisms could include the time preference effect suggested by Fuchs (1982).

The effect of education on health varies for children and adults. It has been shown that education has an impact on child health via parental education (Lleras-Muney, 2005). For instance, Aslam and Kingdon (2012) find that in Pakistan, parental education is associated with child health outcomes (e.g., stuntedness, obesity) and parental health-seeking behaviour (e.g., the immunisation status of a child). Baltagi et al. (2019) finds that in Turkey, a mother's health had beneficial impacts on infant health (e.g., low birth weight), child health (e.g., obesity, stuntedness) and preventive care initiation. Thus, own education matters most for own health in adulthood (Arendt et al., 2021) and has spill-over effects for own children(Kaestner et al., 2020).

Another issue raised in the literature is whether school quality matters (Jones et al., 2012). All schools are not created equal. There are differences in the quality of education received at different schools at similar levels of attainment (Jones et al., 2011). This means that the quality of school attended could be an important mediator of health outcomes. The fact that findings from different countries point to similar conclusions suggests otherwise. Regardless of school quality, the conclusions do not change except that they are higher if the school quality is high. For instance, Sansani (2011) and Fletcher and Frisvold (2011) find that difference in school quality is correlated with lower mortality and overweight in the US.

The need for more evidence

Both the studies showing a causal effect and those showing no effect are mostly from Europe (Courtin et al., 2019; Janke et al., 2020). New evidence is required from other contexts. Studies on the relationship between education and health in Africa have mainly focused on fertility. Johnson-Hanks (2002) finds from her studies that Cameroonian women with more schooling had higher pre-marital fertility. This finding contradicts both theory and empirical findings. She conducts further anthropological analysis and concludes that rather than obeying any regularity of causal models, female fertility was affected most by cultural values and dominant practices within each society. This conclusion is supported in part by Osili and Long (2008)'s findings which show that it is not only own education that determined fertility, but communal education was an important determinant in Nigeria. More recent studies such as Boahen and Yamauchi (2018), Masuda and Yamauchi (2018) and Keats (2018), have continued to focus on fertility. Their findings have overwhelmingly yielded support for the hypothesis that more schooling leads to fertility decline. Oreopoulos (2006) and Psaki et al. (2019) however, concluded based on a systematic review and meta-analysis that although these effects may be positive it is not large nor consistent. They suggested that the balance may be tipped by context.

This paper contributes to the literature by extending the analysis beyond fertility. There is no study that I have seen that has analysed the relationship between education and health behaviour, health knowledge, and other health outcomes in the context of sub-Saharan Africa. Moreover, only a few studies have done this at all even for other developing countries. This could be because of data constraints and partially due to methodological challenges. For instance, the widely available data on health in Africa from the Demographic and Health Surveys(DHS) samples more women than men and collects data on more variables for women than men. Recent developments in methods and data availability have increasingly made research in this area viable. I contribute to the literature by examining a causal link between education and these three domains in the context of a sub-Saharan African country in a fuzzy regression discontinuity framework.

1.4 Empirical Strategy

1.4.1 Study design

Children in Ghana are required to enrol in primary school in the academic year starting after their 6th birthday. The policy implementation date was the academic year starting in August 1996. Thus, children born after August 1989 up to August 1990 were the first cohort the policy targeted for full treatment. As a result, August 1989 is chosen as the cut-off for eligibility. This allows for analysing the implementation of the FCUBE within the framework of a regression discontinuity design (RDD). The FCUBE policy was however not implemented strictly. That is, children who were past the official starting age or younger were admitted to primary school. An example is a 7-year-old child who missed starting at age 6. Such children were not denied the right to get an education. It is also possible that some children who were a few months away from their 6th birthday would enrol. This generates non-compliance on either side of the cut-off point. This noncompliance implies a fuzzy RDD.

The only other study to have examined the Ghana FCUBE in a similar way is Boahen and Yamauchi (2018). They pool different waves of the survey, use the year of birth as cohorts, and select 1989 as the cut-off year. This approach assumes that all children born in a given year start school in the same year. However, because the school year starts in August or early September, children born in the last quarter are required to enrol in the following school year. This also means that children are exposed to the FCUBE policy in one-year increments. The approach I take in this paper is to define an annual cohort as children born in or after August up to July of the following year. That is, I define a cohort as people starting school in the same academic year instead of people born in the same calendar year. This approach allows the cut-off point to be precisely determined. This reflects the fact that children born in January will start school 8 months older and children born in December will start 9 months older (the following year). That is, all things being equal, though they are born in the same year, they would start school in different years and receive different treatments. Thus the cohorts to the right of the cutoff serve as placebo checks. Being born closer to the official school start month (mostly late August up to mid-September) increases the probability of receiving the full treatment. Using the year of birth masks this. Nonetheless, I check for the existence of discontinuity using a definition similar to Boahen and Yamauchi

(2018) and an alternative dataset to verify that the approach used here is robust (see figure A.3).

The analysis proceeds as follows. First, I select an optimal bandwidth (Imbens and Lemieux, 2008; Imbens and Kalyanaraman, 2011; McCrary, 2008; Calonico et al., 2014; Hahn et al., 2001) from the full sample of adults from the DHS dataset and I estimate the impact of the policy on attainment. Secondly, I estimate the effects of schooling on various health variables. Thirdly, I estimate these effects using an alternative measure of schooling and undertake other robustness checks. The optimal bandwidth ensures a comparison of pupils who were assigned to receive 9 years and those who were assigned to receive 8 years of fee waivers under the FCUBE policy (Hahn et al., 2001). Finally, I test for the knowledge hypothesis (Kenkel, 1991) and employment as potential mechanisms.

This study seeks to isolate the causal effect of schooling on health. I compare the average health outcomes for the birth cohorts who were exposed to full treatment and those who were not. That is:

$$E[H_{1c}|D_i = 1] - E[H_{0c}|D_i = 0] = E[H_{1c} - H_{0c}|D_i = 1] \tag{1.1}$$

1.4.2 The Impact of FCUBE on Schooling

I estimate the effect of assignment to full treatment at the time of enrolment on schooling using specification 1.2:

$$S_{ic} = \Upsilon_0 + \Upsilon_1 D_{ic} + f(R_{ic}) + \mathbb{X}'_{ic}\Upsilon_2 + \varepsilon_{ic} \tag{1.2}$$

Where S is the years of schooling completed, D is the dummy for whether an individual(i) was assigned to receive 9 years of fee waiver. R is the centred running variable (measures age), centred at 0, around the eligibility cut-off point. Thus, months prior to August 1989 take negative values, and those born after August 1989 take positive values, in each case, at increments of 1. August 1989 takes a value of 0. $\mathbb{X}$ is a vector of controls. Its inclusion in the first stage reduces the variation in the residual and so improves the efficiency of the estimates. The function $f(\cdot)$ estimates the relationship between the outcome and birth cohort. The error term, ε captures other factors that may affect schooling besides the controls. The parameter of interest is Υ_1. It captures the effect of FCUBE on schooling. The subscripts i and c are individual

and cohort(i), respectively. An interaction term is included to capture the effect of differences in slope on either side of the cut-off.

1.4.3 Impact of Education on Health

I estimate equation 1.3 in the second stage of two stage least square (2SLS) with equation 1.2 as instrument.

$$H_{ic} = \beta_0 + \beta_1 S_{ic} + h(R_{ic}) + X'_{ic}\beta_2 + \upsilon_{ic} \tag{1.3}$$

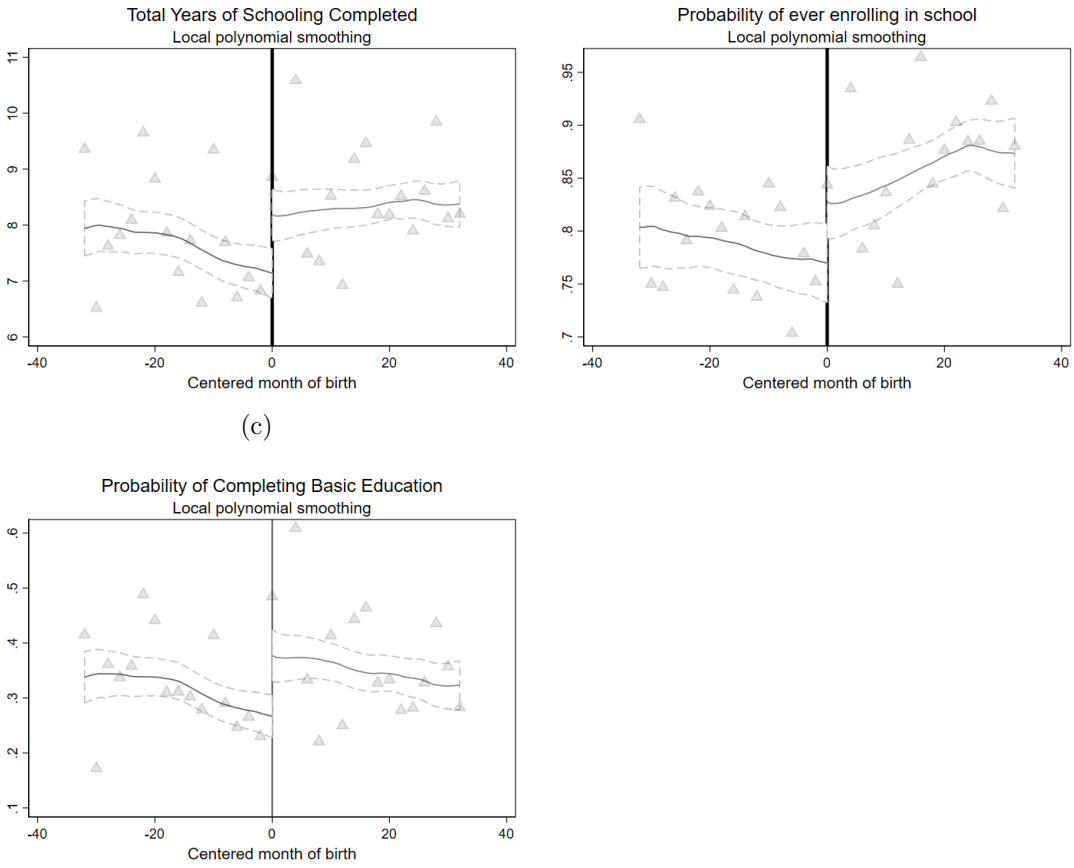
Where H_{ic} is health for individual i in cohort c. Other variables have the same description as before. The function $h(\cdot)$ captures the relationship between birth cohort and health. β_1 captures the effect of an additional year of fee waiver and X' is a vector of other controls and an interaction to capture differences in slope on either side of the cut-off. I estimate β_1 via 2-stage least square using D_{ic} as the excluded instrument to derive an estimate of the health return to additional schooling induced by assignment to an extra year of fee waiver.

1.4.4 Identification,internal and external validity

The literature suggests two ways to implement regression discontinuity analysis (Imbens and Kalyanaraman, 2011; Imbens and Lemieux, 2008; Jacob et al., 2012). The parametric estimation characterises the treatment as a discontinuity at the cut-off and finds an optimal specification (functional form) to fit the data. The nonparametric approach, on the other hand, characterises the treatment effect as local randomisation and finds the minimum data that fits a linear specification. While the parametric approach produces more efficient estimates, bias is more likely. The reverse is true for the nonparametric approach. However, a trade-off in favour of less bias is preferred (see Imbens and Lemieux (2008) for detailed discussion). Consequently, I follow the nonparametric approach which is also the most preferred in the literature. This approach is underpinned by the assumption that the conditional expectation of outcomes by birth cohorts is smooth through the cut-off point (R=0). Hence, any discontinuity can be attributed to the causal impacts of the policy. The optimal bandwidth allows for a comparison of those who were born late enough to be exposed to 9 years of fee-free schooling and those born early enough to receive 8 years of fee-free schooling (Hahn et al., 2001). Hence the estimated effects will be the Local Average

(a) (b)

Figure 1.1: Discontinuity in Schooling



Notes: The graphs presented in this figure use data from the Demographic and Health Survey to show that school attainment increased sharply for cohorts that were assigned to full FCUBE treatment. Different measures of schooling are used. Total Years of Schooling is measured in single years. All measures of schooling are indicator variables.

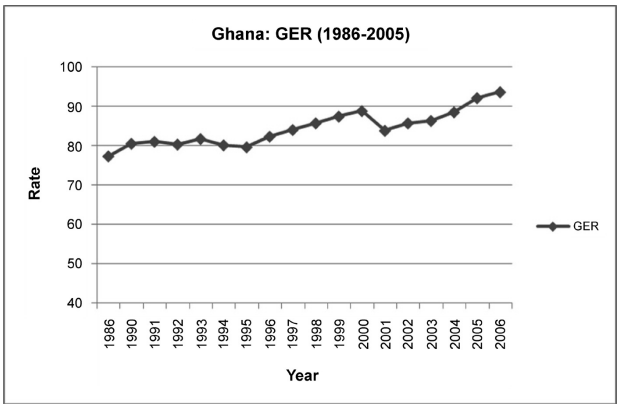
Treatment Effect(LATE)

Figure 1.1 plots the running variable and alternative measures of schooling. All plots show a discontinuity at the cut-off *(R=0)*. I interpret β_1 as the health return accruing from one extra year of a fee waiver for those who will otherwise not have enrolled in school. These effects may, however, vary for individuals who would have enrolled in school even if the policy were not introduced. A closer look at the data suggests that school dropout before completion of primary school was higher in the pre-August-1989 cohorts, suggesting that tuition cost was a reason for non-enrolment and dropout.

Internal validity

Three important concerns may be raised regarding the ability of the FCUBE as a natural experiment to recover the policy effect (Lee and Lemieux, 2010). The first is that parents of children from poor households are likely to delay enrolling their children if they know the policy implementation date to benefit from the policy. This is however

Figure 1.2: Gross Enrolment Rate



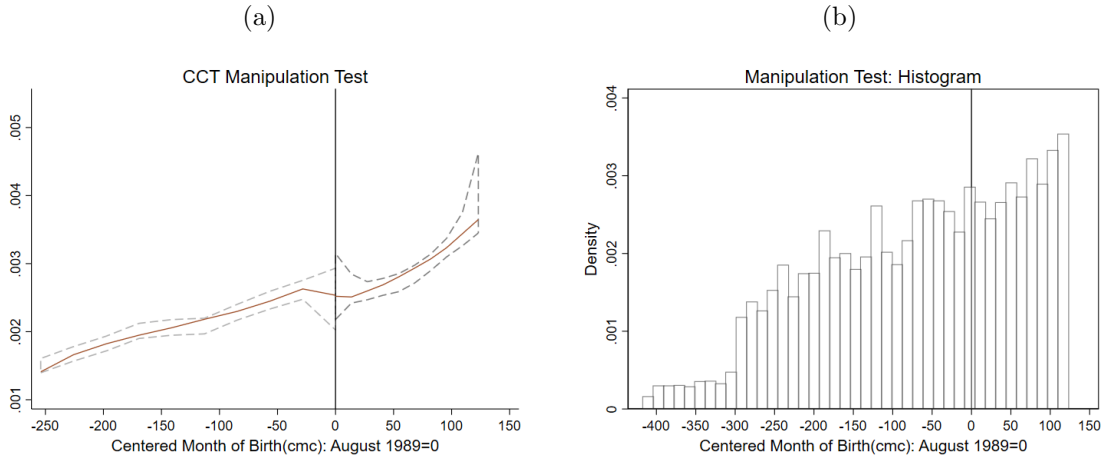
Notes: This graph is from Akyeampong (2009). It shows gross annual primary school enrolment for Ghana. The gross enrolment rate was stable at about 80% and with a downward trend up to 1995 but rises continually from 1996, the year the FCUBE was implemented.

not likely to have happened because all children in school were going to benefit from the policy regardless of the grade they were in as of August 1996. Since the policy was announced in 1995, if this concern was valid, there would have been a significant decline in gross enrolment in 1995. Data presented by Akyeampong (2009) however shows that gross enrolment in 1994 was comparable to 1995. They observe a sharp increase only from 1996 (see figure 1.2). Moreover, the announcement was made when the school year had already started. The implication is that the estimates recover the effect of the policy on children who would otherwise not enrol in school, that is the local average treatment effect.

Another concern is the effect of dropout and re-enrolment. By design, children who were 6 years and younger are in the treatment group and those older are in the control group. However, children who had dropped out prior to the policy implementation could re-enrol at an older age to benefit from the policy. Similarly, those who would otherwise not have enrolled might have enrolled at an older age. There is also the likelihood of early entry. If late entry and re-enrolment were more likely, the policy effects would be underestimated and if early entry was more likely, it would be overestimated. I check for this using round 7 of the Living Standards Survey (GLSS7)- which is nationally representative- which includes data on the age of enrolment. The mean age of entry in the survey is 6.8years with 73% of children enrolling at the expected age and 90% enrolling by age 8.

A third concern is whether the exclusion restriction is likely to hold. A potential problem is that other government policies are likely to have occurred at the same cut-off. To the best of my knowledge, no other policy was implemented whose eligibility

Figure 1.3: Manipulation



Notes: Calonico et al. (2014) method is used. The running variable is the centred month of birth using the century month code. Centred at zero, months increase(decrease) at intervals of one. Months to the left(right) are those before(after) August 1989. August 1989 is zero, the cut-off point. This definition of a cohort is more representative of the actual definition of a school cohort but has not been used in previous studies. For robustness, I use the common measure and a previously used dataset in figure A.3 to confirm that there is no manipulation (McCrary, 2008).

criteria for treatment is similar to the FCUBE or which only affected a portion of the observations in the optimal bandwidth. Furthermore, if any private educational investment created a discontinuity at the cut-off, this would affect the internal validity of the results. It will imply that the estimates are a combined effect of both the private investments and the policy; hence the effects will be overestimated. Moreover, receiving fee-free education could mean more family real income as resources are freed up. These resources can be invested in other areas of child development. In that case, private investments for children who were fully treated are expected to be higher. The exclusion criterion is tested by examining pretreatment variables (Jacob et al., 2012; Imbens and Lemieux, 2008). The best pretreatment variables in the data are ethnicity and religion. I conduct a two-sample t-test to check for this. The result is as shown in table 1.1. Together with other formal tests in figure 1.3, there is no evidence of manipulation (McCrary, 2008).

External validity

The weakness of the findings of this study lies in the fact that they are applicable only to the individuals in the optimal bandwidth which is about 3 years on either side of the cut-off. This is, however, a general limitation in the regression discontinuity design (Lee and Lemieux, 2010). The findings are nonetheless useful for policy in related contexts such as other African countries that are actively looking to implement UPE or FCUBE-type policies (Nishimura and Byamugisha, 2011; Bonney, 2021). In Ghana,

Table 1.1: Two sample test of differences in pre-assignment variables

	Ethnicity	Religion
t	0.9971	-0.8360
$Pr(\|T\| > \|t\|)$	0.3188	0.4033

Notes: This table tests the hypothesis that pretreatment variables do not differ for respondents on either side of the cut-off. It is generally difficult to get suitable variables in survey data for this type of hypothesis test. Ethnicity and Religion are the best two variables available in the dataset that can be used to test this. Ethnicity is fixed and religion is usually sticky; that is, it does not change often and most people tend to follow the religion of their families. The assumption here is that if treatment was randomly assigned, then respondents should not differ on pretreatment variables. The results presented in this table suggest this to be the case. Indeed, in Ghana, several social and economic factors differ systematically across ethnicities and religions and so we can be confident that this result is indicative that indeed the sample selection and treatment assignment are not biased.

a new policy was introduced in 2017 extending fee-free education to cover the 3 years of senior secondary school. The results of this study provide insights into what might the effects of the new policy.

Also, there is a scarcity of evaluation of the health benefits of fee-free education in the countries that have implemented policies similar to the FCUBE such as Kenya. Findings from this study will prove useful for these countries. The result will also provide a counterfactual for countries that have never implemented fee-free policies. Such cross-national comparison will be conditional on the differences in healthcare policies across such countries.

Finally, because survey data was used, concerns may be raised regarding social desirability bias and recall bias, particularly for self-reported variables. In the case of the latter, people may answer questions in a way that they consider to cast them in a good light in the eye of society. For instance, if smoking carries a social stigma, a person who smokes may fail to disclose the truth about their smoking status or the substance they smoke. While this is likely, it is not avoidable in surveys. However, its effects are not likely to be significant. In any case, the summary statistics for the variables that could possibly carry a stigma (example: Smoking) are consistent with official estimates in other datasets. In addition, because respondents are interviewed individually, and by a stranger who visits in an official capacity, respondents are likely to feel more confident to disclose accurate information. Recall bias, on the other hand, is likely to be minimal since information on the variables used in this study is usually about recent events. In the case of other events that may have occurred in the distant past, these are often major events that are unlikely to be forgotten. For instance, a person is unlikely to forget that they ended their schooling at the secondary school level.

1.4.5 Other Estimation issues

It is well established in the economics literature that education is endogenous partly because schooling is a choice variable. This endogeneity has been shown theoretically to arise from omitted ability which correlates with the choice of years of schooling and health outcomes. That said, Fujiwara and Kawachi (2009) and Lundborg (2012) found from using twins' data that unobserved ability might be uncorrelated with schooling level. Measurement errors in years of schooling could also account for endogeneity. Measurement errors are likely to be small because the schooling data is reliable. I confirm that years of schooling is endogenous in the data using Wooldridge's test.

The endogeneity problem is addressed by using assignment-to-full-treatment status as an instrument in the second stage estimates. I confirm the validity and strength of the instrument using the Kleibergen-Paap Rank LM (F) test, Cragg-Donald Wald test, Stock-Yogo, and Hansen's J-test in all specifications. Using a large sample provides additional efficiency gains, which is important in a nonparametric estimation (Gehrsitz, 2017). Reverse causality is also a concern in empirical studies. For instance, pupils may drop out of school due to ill health (Dickson, 2013; Miguel and Kremer, 2004; Hughes et al., 2021). Using comparable data from the Living Standards survey (GLSS7), ill health accounted for a small part of the reasons for not attending school. The most important reason was financial and this is addressed by the policy. Besides, this concern is mitigated by the research design.

Following the recommendations by Abadie et al. (2017) and Nunn (2010) standard errors are clustered at the level of survey clusters. This approach to clustering yields standard errors that are robust against arbitrary patterns of within-cluster variation and covariation (Cameron and Miller, 2015). Clustering at survey clusters is useful because while respondents are identical across cohorts, their characteristics may differ by location; in the context of this study, social and economic status can vary much within and between clusters. A section of the literature also clusters at the level of running variables. The point estimates remain robust to clustering at the level of the running variable. The strength of the instrument, however, becomes sensitive to alternative bandwidths in this approach. I report results for the former only. As expected, the point estimates and conclusions remain robust to not clustering. For brevity, only the relevant main results are reported.

Finally, the main results are presented using a bandwidth of 36months. This

Table 1.2: Summary statistics

Variable	Mean (SD)
Smokes	0.0172 (0.1512)
Antenatal Visits	6.1668 (2.75)
Fertility Intention	3.979(1.2121)
Healthy Eating-Vegetables	3.6156 (2.4127)
Weight for Height	0.0067 (0.1131)
Body Mass Index	23.9794 (4.0553)

Notes: Data is from the 2014 Ghana Demographic and Health Surveys. Means are presented for the optimal bandwidth. Standard deviations are in parentheses

is to reflect the fact that exposure to the policy changes at intervals of 12 months. Robustness checks are also done using the optimal bandwidth from the Calonico et al. (2014) approach.

1.4.6 Data

The Dataset: This study analyses data from round seven of the Ghana standard DHS conducted from September to December 2014 by the USAID[3] funded DHS[4] Program. The demographic and health surveys are nationally representative global surveys carried out by national statistics bureaus to collect information on specific demographic and health variables. Round seven of the Ghana DHS survey includes adult females in all sampled households between ages 15 and 49 years and males in selected households between ages 15 and 59 years. The optimal bandwidth for this study includes respondents who were between 22 and 28 years on the survey date. Summary statistics are presented in table 1.2 and discussed below for respondents in the optimal bandwidth. Data for some variables are available for only males or only females. Where this is the case, the discussion highlights it.

Health Insurance: Ghana has a National Health Insurance Scheme (NHIS) that is available to all people (Amo-Adjei et al., 2016). The annual premium is low (GHS7.2 -GHS48 or USD1.25 - USD8.35), not more than a week's wage, at the minimum daily wage rate. Individuals below 18 are exempt from paying premiums if either parent has active coverage. Pregnant women, differently-abled people, people older than 70, state pension recipients, active Social Security and National Insurance Trust fund (SSNIT) contributors, and people from households who are officially classified as poor (these households receive regular cash transfers from the government as an income

[3]United States Agency for International Development
[4]Demographic and Health Surveys

supplement) are exempt from paying a premium. Regardless of whether a person is exempt from premium, most people are required to pay a small amount each year to get a sticker on their card (or a new card) that shows that they have active coverage. About 61 per cent of the respondents reported that they have active insurance coverage. The coverage provided by the NHIS includes nearly all common health conditions (officially stated as 95%). The scheme covers care at all public health facilities and many accredited private service providers. Medicine, laboratory consultation, in-patient and out-patient care, etc are covered.

Smokes: Smoking has been shown to be a cause of several health problems. This dummy variable takes a value of 1 if the individual smokes. Individuals who smoke cigarettes, pipes or other substances are assigned a value of 1. Less than 2 per cent of the respondents in the optimal bandwidth are categorised as being smokers compared to 3.8 per cent in official population-wide estimates.

Fertility Intention: Fertility Intention is measured as the total number of children one wants to have or their ideal number of children. The mean for this variable in the optimal bandwidth is 4 children.

Healthy Eating: Respondents who included vegetables in their food often are considered to eat healthily. This is measured by the number of days in a week a respondent ate vegetables. Vegetables are staples in many parts of Ghana but are considered to be expensive in urban centres. Access to the specific vegetables that are stapled in one's ethnicity is limited if one does not live in their hometown. This may lead to the omission of the same from one's diet. Nonetheless, respondents ate vegetables for an average of 3.6 days per week- about half of the week instead of every day.

Antenatal Visits: Pregnant women who use antenatal care services are more likely to have safer pregnancies and healthier babies (Okedo-Alex et al., 2019; Abor et al., 2011). This has the benefit of reducing neonatal and maternal mortality (World Health Organization, 2019a). The neonatal mortality rate was 29 per 1,000 live births and maternal mortality was 319 per 100,000 births, both in the survey year. These are very high. At the clinic, they receive a clinical examination, counselling and teachings on nutrition and other health and pregnancy-related issues (Tadesse et al., 2020). Antenatal care in Ghana is free of charge and there are health facilities in most parts of the country, making it generally easy to access. In addition, pregnant

women are exempt from paying a premium for national health insurance which ensures that they can access postnatal care. Many health centres have dedicated staff and appointments each week where women can access antenatal care. On average, females in the optimal bandwidth who had been pregnant before attended antenatal care about 6 times during their last pregnancy. This is also consistent with estimates by Duodu et al. (2022) for Ghana. This compares to the 4 visits recommended by the WHO up to the time the data was collected. Since 2016 the recommendation is for at least 8 visits.

Risk of Obesity: Risk of Obesity is measured using Body Mass Index and Standard deviation of Weight for Height. The DHS survey measures respondents' height and weight and calculates body mass index (BMI) from it. Higher values signal a high risk of various diseases. High BMI is associated with health conditions including type 2 diabetes, high mortality, and obesity. The variable Obese[5], uses the WHO categorisation of BMI from 1 to 4 so that higher values indicate a higher risk of obesity. The mean BMI of 24 puts the average person in the overweight category.

Weight for height index measures the body mass of individuals relative to their height and is an indicator of current nutritional status (Ofori-Asenso et al., 2016). The index expressed as a standard deviation shows whether a person is malnourished (including being overweight). A standard deviation below -2 or above +2 indicates malnutrition. It is based on the notion that a healthy person should have a given weight for their height (Ofori-Asenso et al., 2016; Duda et al., 2006). It is a comparison of weights of individuals with identical heights globally using a WHO benchmark weight for their height. The positive sign of the mean of this variable suggests that the average respondent in the optimal bandwidth was at a higher risk of obesity than people of similar ages globally. The point estimate of the mean of 0.0067 and standard deviation of 0.1131 can be interpreted to imply that most people in the sample are within healthy weights relative to identical age cohorts around the world. However, recent studies have suggested a growing trend of obesity in Ghana (Addo et al., 2009).

[5]1 if BMI is between 16 and 18.5, 2 if BMI is between 18.5 and 25,3 if BMI is between 25 and 30, and 4 if it is over 30

Table 1.3: First stage estimates with different bandwidths

	32 months (Optimal bandwidth)		12 months		24 months		36 months	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable= Total number of years of education							
Assigned	1.4697***	1.2797***	2.4484***	2.2248***	1.8572***	1.7021***	1.3709	1.1717***
	(0.4064)	(0.3638)	(0.6334)	(0.5607)	(0.4533)	(0.3973)	(0.3807)	(0.3485)
Observations	2,333	2,332	959	959	1,774	1,773	2,626	
F-stat	13.08	12.37	14.94	15.74	16.78	18.35	6.79	41.65
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: This table shows the first stage results. Columns (1), (3), (5) and (7) do not include controls and columns (2), (4), (6) and (8) include controls for ethnicity and religion. It shows the average effect of the FCUBE policy on the total number of years in education. The policy was intended to get pupils into school and to keep them enrolled for at least 9 years. Using the optimal bandwidth, the results show that the additional year of fee waiver increased the total years of schooling completed by about 1.5years. This suggests that the policy was effective. Standard errors are clustered at the survey clusters and reported in parentheses $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

1.5 Results and Discussion

1.5.1 School fee waivers increased attainment

The FCUBE policy had as part of its objectives to increase enrolment, reduce dropout, and consequently increase the average total years of schooling completed. The first stage results suggest that the policy was effective in achieving these objectives. Figure 1.1 shows the local average effect of the FCUBE policy on the years of schooling completed using the cohorts closest to the assignment threshold. An optimal bandwidth of 32 months was selected using the Calonico et al. (2014) local polynomial bandwidth selection method. The corresponding regression in table 1.3 shows that the average effect of the policy was up to 1.5 years more for the cohorts who were assigned to 9 years of fee waiver compared to those who were assigned to receive fewer years of fee waivers. This size is close to 1.4years from Odunowo (2020)'s first stage; she used Nigeria's 1976 UPE.

The size of the effects gets larger with narrower bandwidths and smaller with wider bandwidths, as expected (see figure A.5). Back of the envelope estimates using all adults in the survey show a difference of 1.7 years, similar to what Odunowo (2020) finds for Nigeria. I check for the robustness of the policy effect estimates to functional forms. The results are summarised in figure A.4. It shows that the policy effects are well within identical ranges regardless of the functional form selected. Using the Information Criteria (BIC, AIC), the linear interaction form is implemented. This is also appropriate given the differences in slope on both sides of the cutoff (Jacob et al., 2012).

These estimates are higher than the 1-year effect that Boahen and Yamauchi

(2018) found for a number of reasons. While we define cohorts differently, our optimal bandwidths overlap. However, they pool earlier rounds of the survey similar to what Keats (2018) does for Uganda. For instance, in round 7, the youngest person is 22 years. In the previous round, this person was 16years. They would still be in secondary school at 16 but would have completed a degree by 22, hence the attainment will be lower when earlier rounds are used. Their approach was however consistent with their research question which examined teenage pregnancy.

The effects are also larger than Keats (2018) for Uganda. In the case of Keats (2018), he defines a cohort similar to Boahen and Yamauchi (2018) but unlike Boahen and Yamauchi (2018) and I, he was interested in the treatment effect for all children who should have received at least one year of fee waiver versus those who should not have received any treatment and had a bandwidth that was twice as wide. This means his treatment effect of 0.72years was the average effect for children who received at least one year of fee waiver whereas Boahen and Yamauchi (2018) and I estimate the effect of an additional year of treatment by comparing those who were assigned to receive 9 years versus 8years of fee waivers. However, to account for the fact that the degree of exposure to the policy changes at intervals of 12 months, the main results use a bandwidth of 36 months.

Finally, I carry out an F-test to determine the viability of the treatment effect as an instrument in the second stage (Sanderson and Windmeijer, 2016). Conventional wisdom in econometrics is that an F-stat of 10 suggests a strong instrument (Stock and Yogo, 2005). Weak instruments are undesirable. While the basis of this wisdom has been challenged, I follow it for completeness. Across bandwidths in table 1.3, the F-stat is greater than 10, suggesting that the instrument is strong. Additionally, the standard diagnostics of overidentification and underidentification[6] is carried out for each specification in the second stage results. In each case, the models are exactly identified.

1.5.2 Education improves health

Having established that the FCUBE policy has a positive impact on years of schooling completed, I now discuss its impact on health. The health outcome variables included in this study also reflect health behaviours. The expectation is that people who have

[6]Kleibergen– Paap rk, Hansen J

Table 1.4: Fee Waiver, Schooling and Health

	OLS	IV	RF	OLS	IV	RF
			Panel A			
		Smokes			Healthy Eating	
Schooling	-0.001**	-0.023*	-0.026**	0.005	0.311*	0.359**
	(0.001)	(0.012)	(0.012)	(0.012)	(0.177)	(0.176)
Observations		2,625			2,624	
			Panel B			
		Body Mass Index			Weight for Height	
Schooling	0.064**	0.852	0.826*	0.002***	0.049*	0.048***
	(0.028)	(0.666)	(0.482)	(0.001)	(0.028)	(0.013)
Observations		992			990	
			Panel C			
		Antenatal Visits			Fertility Intention	
Schooling	0.115***	1.464	0.8280***	-0.072***	-0.289***	-0.333***
	(0.020)	(1.225)	(0.288)	(0.006)	(0.096)	(0.085)
Observations		1,161			2,626	

Notes: This table presents estimates of the average effect of an additional year of schooling on health outcomes and behaviours. Three estimates are presented for each variable, OLS, IV and Reduced Form. In the case of the RF results, the coefficient of *Schooling* is the difference between those assigned to receive full treatment vrs partial treatment. All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$.

higher educational attainment will have better health behaviour because they can access information on healthy living and are able to process such information better. Also, they have better labour market outcomes.

Two sets of results are presented. The first uses the Stata command, *rdrobust*, written by Calonico et al. (2014). It also includes controls for ethnicity and religion, both of which are credible pretreatment covariates. The first set of results is presented in table A.1in the Appendix. The second set of results is presented for OLS, IV and Reduced Form (RF) estimates in table 1.4. The main difference between the two sets is that the algorithm of the first selects a different optimal bandwidth for each outcome variable. These bandwidths are reported in the results table for information. On the other hand, the second set uses a single bandwidth, which was discussed earlier. The *rdrobust* command is new and was made with regression discontinuity in mind whereas the other results use established regression techniques. However, there is a school of thought that considers the *rdrobust* command to be more reliable and less manipulable. The two sets are thus presented both for completeness and as a form of robustness.

Although classical linear regression theory suggests that OLS is BLUE[7], its assumptions do not always apply. We have already established in earlier sections that endogeneity is possible and so OLS results are likely to be biased. OLS estimates

[7]Best Linear Unbiased Estimator

may be biased upwards due to unobserved factors such as innate ability or biased downwards due to measurement errors in educational levels. These are ameliorated by the instrument used in the IV estimates given that the eligibility criteria for assignment to full treatment for FCUBE are not manipulated and also given the placebo. The IV results are interpreted as the effect of 1 year of schooling completed. The reduced form (RF) results are interpreted as the effect of the fee waiver policy. The conclusions are stable across IV and RF estimates. Either of the two latter results is interesting but within a regression discontinuity framework, the RF estimates are more informative hence the discussion that follows is based on the reduced form estimates. Nonetheless, OLS, IV and RF estimates are all presented in all cases.

When comparing the IV and RF estimates, one must keep in mind that the policy effect is 1.5years whereas the IV results measure the effect of each year of schooling. Compared this way, the point estimates are intuitively identical. On the other hand, the results in table A.1 are interpreted as the effects of the policy on those who were sufficiently close to be treated or untreated. That is the local average treatment effect(LATE). In nearly all cases, the results show a positive impact of the fee waiver on health.

Education reduces the likelihood of smoking

Results in table 1.4 show that being in the cohorts assigned to an extra year of fee waiver reduces the likelihood that an individual will be a smoker by about 2.6%. The estimates in table A.1 are close. This effect is significant relative to the sample mean. That means that the cohorts who were assigned to receive the full treatment were twice as likely not to be smokers at the time of the survey compared to those who were assigned to receive one year less of treatment. Dickson (2013) makes a compelling case for why education and smoking habits may be associated citing arguments by Fuchs (1982). Back-of-the-envelope calculations show that within the optimal bandwidth, individuals who had never enrolled in school were 2.8 times more likely to be smokers. Similarly, individuals who enrolled but did not complete JSS were 3.2 times more likely to be smokers than those who completed JSS. This compares to 4 times in the full sample. This reveals a possible spillover effect on the larger community. That is, there is a positive peer effect. Smoking can be *fashionable* if one's peers smoke. The fewer peers who smoke one has, the less likely they are to be smokers.

The magnitude of effects I find for Ghana is smaller than de Walque (2007) finds for the US. He studied the effect of education in the US using the years of schooling above college as a measure of education. He finds that completing 1 year above college reduces the likelihood of smoking by about 5%. This is not surprising because smoking is more common in the US than in Ghana and the measure of schooling is set much higher. Thus, being educated in college (equivalent to a bachelor's degree) means a person in Ghana is going to be much less likely to smoke than one in the US. However, Heckman et al. (2018) finds effects to range for 2.6% to 3.3% and Dickson (2013) finds 2.7%, both for high school graduation in the US and UK respectively.

In an African context, Desai et al. (2019) find that in South Africa, people who had dropped out of school before turning 20 years were much more likely to be smokers. Currently, about 6 million deaths annually are attributable to smoking (Desai et al., 2019). This is expected to rise to 10 million in 2030 and it is projected that 70% of these deaths will occur in developing countries (Owusu-Dabo et al., 2009). Globally, smoking prevalence is about 21% for people 15+. The rate is even higher in some developing countries. For instance, Desai et al. (2019) reports a prevalence of 31% in South Africa. The dataset used in the present study places the prevalence rate at 3.7% for Ghana, similar to estimates by Owusu-Dabo et al. (2009) of 3.8%. This means that smoking is not a big problem in Ghana as in other developing countries. Nonetheless, Owusu-Dabo et al. (2009) finds, as in this study, that the few who smoke tend to be those with lower levels of education. There might be a reason why people smoke that is ameliorated by more schooling.

Education improves healthy eating

I define healthy eating as one that regularly includes vegetables. A healthier diet reduces the likelihood of illness and may accelerate the healing process if one is ill. Respondents provided information on how many days in the week they included vegetables in their diet. The results show that cohorts assigned to receive an extra year of fee waiver ate healthily more often. They ate healthily at least 0.36 days more per week than cohorts who received a year less of fee waiver. This is about 10% of the average days of healthy eating in the week.

The recommended healthy diet is one that has all nutrients available. Except for vegetables, most people ordinarily consume many of the other classes of food. The high

cost of vegetables, resulting from higher costs of production, is considered an obstacle to their inclusion in diets regularly (Ofori-Asenso et al., 2016). Better educated people are more likely to understand the importance of a balanced diet and so choose to eat them often. Having more schooling also improves earnings and makes healthy eating more affordable. There is generally a scarcity of studies that directly examine the effect of schooling on healthy eating, but many studies show that when people are *educated* on the benefits of healthy eating and how to achieve it, they are more likely to choose healthy eating.

The heterogeneity effect examined in table 1.8 suggests a possible interaction with wealth (van Kippersluis and Galama, 2014). That result shows that while the effect of healthy eating remains positive for both rich and poor households, it is both larger and statistically significant only for poor households thus supporting the explanation that cost is a barrier to healthy eating. Poor households' food budgets are expected to be more constrained, but the results show that because those with more schooling understand the benefits of a balanced diet better, they are more likely to include vegetables even if they are poor.

Educated women use antenatal services more

Maternal mortality is high in developing countries (World Health Organization, 2019b). Health personnel are able to detect any potential dangers to maternal health or dangers to the baby in the womb if the mother attends regular medical checkups (Abor et al., 2011). Thus, antenatal care is important for the health of the mother and for the baby. Modern antenatal care practices coexist with traditional practices in developing countries. I take the view that women who have attended more schooling are likely to have a more favourable disposition to modern practices and so would attend the clinic when pregnant (Duodu et al., 2022). This view is supported by the findings of this study.

The results show that the cohorts that were assigned an extra year of fee waiver attended antenatal care sessions about 0.8 more times than others. This represents about 13% more visits than the mean. Antenatal care is free in Ghana at all health facilities regardless of whether the mother-to-be has health insurance coverage. Coupled with the range of access options, attendance is not constrained by costs. A possible explanation is that better-educated women understand the benefits of antenatal care

and so choose to attend more of it (Abor et al., 2011). This is supported by findings in table 1.8 that show that among the poor, respondents who received an extra year of fee waiver attended antenatal care 0.8 times more just as in the combined sample in table 1.4.

This finding compares to an effect of 6 percentage points for Turkey following a change in the duration of compulsory schooling from 5 years to 8 years (Dinçer et al., 2014). Tann et al. (2007) reports that in Uganda, while attendance rates were high, women with lower levels of education received less attention. This can be interpreted to mean that in addition to the fact that being educated makes one more likely to seek antenatal care, health personnel are biased favourably towards better-educated mothers-to-be. There is a large body of literature that shows that socio-economic differences between healthcare professionals and patients affect the quality of care (Juergens et al., 2016). This effect may also be at work in Ghana and can be the focus of future studies.

Education reduces fertility intention

This finding is not surprising and in fact not new. Many studies document this across nearly all contexts. By design, respondents are younger than 30, so this variable sought to measure how many children they wanted in their ideal family. That is their desired number of children. The results in table 1.4 includes both males and females.

The results show that one more year of schooling reduces this appetite by about 0.33 children (8% of the mean). The mean appetite in the estimation data is 4 children compared to 4.8 for women over 40 in the DHS data. Women over 40 are usually considered to have completed childbearing or are very close to finishing. It also confirms a trend of declining fertility and ideals around the family size in Ghana which has been attributed in part to an increasing rate of higher education, changing labour markets for women and access to contraception options. This finding and interpretation are consistent with a previous study on Ghana's neighbour, Nigeria, where it was found that an additional year of schooling reduced fertility by 0.26 (Osili and Long, 2008). Both estimates also compare to Altindag et al. (2011) who examines several birth cohorts, found effects ranging from 0.09 and 0.36; and suggests that the effects of education on fertility vary by cohort.

Education increases the risk of obesity for women

A person whose body mass is too high for their height is considered to be overweight or obese. Obesity is a function of weight for height and has been linked to the causes of several life-threatening diseases. Unlike developed countries where obesity is common among the poor, obesity has been found to be a problem for the wealthy in developing countries (if we consider that education is correlated positively with wealth) (Templin et al., 2019). This study examined the effect of schooling on body mass index and weight for height using standard deviations. Different standards exist of what is considered to be too high. The weight for height standard deviations is constructed relative to standards recently determined by the WHO for different heights. Only females are included in this estimation due to data unavailability for men.

The results show that one extra year of schooling increases a female's weight for height by 0.05 of a standard deviation. Body mass index also increases by about 0.8 for the cohorts who were assigned to receive the full treatment. While these estimates suggest an increased risk of obesity, the results for Obese show that they fall just short of being obese. Indeed, the means of these measurements reported in table 1.2 is just under the threshold for obesity. This could be explained partially to be as a result of the sedentary nature of the employment that highly-educated people are involved in (Addo et al., 2009; Duda et al., 2006) and the fact that these people may also be able to afford more food. Secondly, there is a sub-culture where female obesity is associated with beauty and having a good life (Duda et al., 2006). Both explanations are consistent with results in tables 1.7 and 1.8 and discussed further in section 1.6.

1.6 Robustness

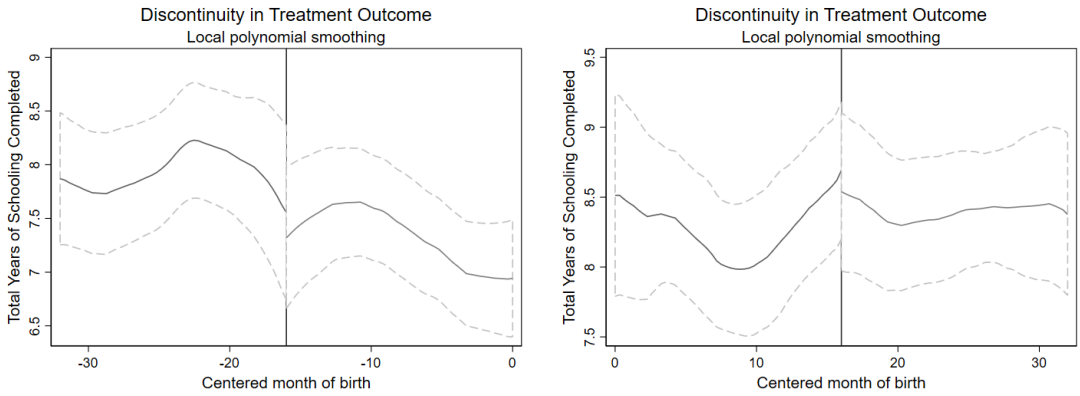
1.6.1 Econometric Tests

Up to this point, robustness checks have been highlighted throughout. A battery of robustness tests is carried out to ascertain the stability of the findings. Those already highlighted include tests of over- and under-identification, instrument strength and the use of alternative methods of estimation. In addition to these, I re-estimate the main findings using different functional forms in table 1.5. In most cases, both the statistical significance of the results and the conclusion remain.

Graphically too, figure 1.3 checks for the existence of manipulation (McCrary,

Figure 1.4: Discontinuity at non-discontinuity point 1

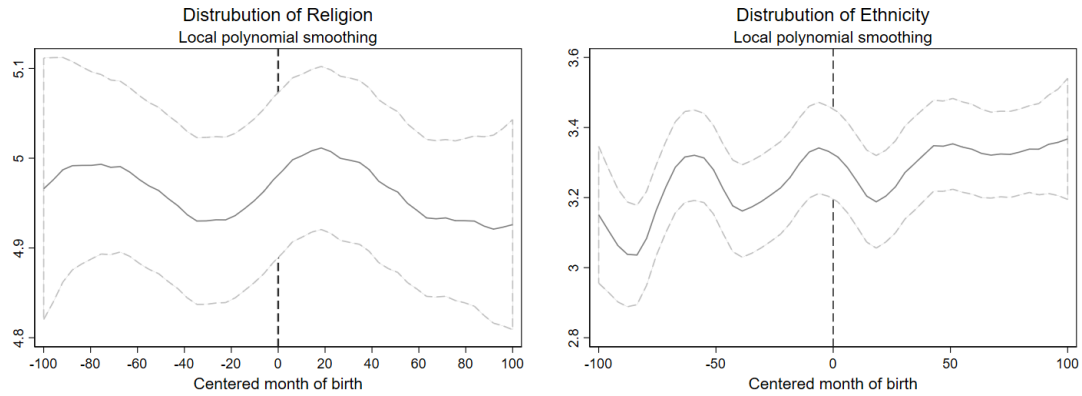
(a) Only assigned to partial treatment (b) Only assigned to full treatment



Notes: Figure tests for discontinuity at points other than the cut-off point for robustness. I take all respondents whose cohorts were assigned to receive at least one year of treatment. The data is split into two halves on either side of the cutoff. For those on the left, those further left of the fake cut-off were assigned to receive one year less of treatment but are also older. For those on the right, everyone was assigned to receive full treatment. As a consequence, some jump is expected on the left half but less significant than at the real cut-off whereas no significant jump is expected on the right half. This is as shown.

Figure 1.5: Distribution of Control Variable on either side of the Cut-off

(a) Religion (b) Ethnicity



Notes: For illustration, this figure shows the distribution of religion and ethnicity on both sides of the cut-off. Each variable is used in its original form as in the DHS survey. Ten religious and nine ethnic groups are included and each takes a unique value starting from 1.

2008), figure 1.5 shows the distribution of religion and ethnicity, figure 1.1 presents alternative plots for schooling attainment which are consistent with the main plot. Figures 1.4,A.1 and A.2 check for discontinuity at non-discontinuity points. These plots show results that confirm the research design. These graphs have already been discussed in some detail in earlier sections. I use the Ghana Living Standards survey to check for consistency of the assumptions, as shown in figure A.3. The wave used, round 7, is more recent and includes a more even distribution of men and women. I check for manipulation (McCrary, 2008) using the standard definitions of variables in this paper and the presence of a jump using the definition used by Boahen and Yamauchi (2018). The size of the jump with controls is 0.61years compared to 0.72years in Boahen and Yamauchi (2018). Without controls, the size is 0.55years.

There is a section of the literature that finds that the quarter of the year in which a person is born determines how many years of schooling they complete, their performance in school and some life outcomes (Robertson, 2011; Angrist and Krueger, 1990). The identification strategy defined in this study relies on the month of birth which in some ways is a proxy for the quarter of birth given the study design. If the quarter of birth effects found in prior literature exists in the data, then the effects already discussed could be overestimated because then it would include the quarter of birth effects. To rule out this possibility, I split the data into two: people who are partially treated versus those who are fully treated. I use August as the cut-off point. The result is shown in figure A.2. By not showing a jump at August, figure A.2 suggests that being born between August and December does not determine how many years of total schooling is completed. It is still important to acknowledge the observation that the total years of schooling increase towards the end of the year and say that some quarter of birth effects may exist but it is just not significant as was found by Angrist and Krueger (1990).

Putting the above discussions together, there is little reason to be concerned about the robustness of the study findings. In the next section, additional robustness checks are done in the form of heterogeneity analysis to determine how the results change with different sub-sample selections.

Table 1.5: Main results with different functional forms

	Linear	Linear Interaction	Quadratic	Quadratic Interaction	Cube	Cubic interaction
Smokes	-0.0346***	-0.0309*	-0.0326**	-0.0347	-0.0359*	-0.0138
	(0.0133)	(0.0126)	(0.0129)	(0.0211)	(0.0187)	(0.0234)
Antenatal Visits	0.7171**	0.7738**	0.7514**	0.7249*	0.7389*	1.0202*
	(0.2981)	(0.3074)	(0.3044)	(0.4295)	(0.3818)	(0.6118)
Fertility Intention	-0.3315***	-0.3334***	-0.3334***	-0.2452*	-0.2335*	-0.5293**
	(0.0916)	(0.0932)	(0.0923)	(0.1376)	(0.1221)	(0.2092)
Healthy Eating	0.3738**	0.3875**	0.3785**	0.0619	0.1703	-0.1379
	(0.1841)	(0.1841)	(0.1836)	(0.2737)	(0.2439)	(0.3766)
Weight for Height	0.0466***	0.0467***	0.0467***	0.0409**	0.0439**	0.0219
	(0.0138)	(0.0140)	(0.0139)	(0.0204)	(0.0184)	(0.0273)
Body Mass Index	0.8395	0.8819*	0.8547*	0.7846	0.9427	0.9772
	(0.5107)	(0.5224)	(0.5151)	(0.6029)	(0.7666)	(0.6911)

Notes: The results in this table reestimate the main results using alternative functional forms. Reduced form estimates were reported. All estimates include controls for ethnicity and religion. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

1.6.2 Heterogeneity

The plurality of findings in the literature suggests that the relationship between education and health may be mediated by socio-economic characteristics (Zhang et al., 2020). I reestimate outcomes using sub-samples selected according to given characteristics.

Men and Women

Much of the literature on the relationship between education and health has focused on women and fertility (Zhang et al., 2020). This is mainly due to data availability. Where data is available, I reestimate the results separately for men and women. These are presented in table 1.6. Variables that have data for only women are not included.

The effect of education on the probability of smoking is higher for men than for women. While the probability of smoking reduces by 9% for men, it reduces by 0.9% for women. This is not surprising given that it is more common to observe men to be smokers compared to women (Desai et al., 2019; Nketiah-Amponsah et al., 2018). The results also show that education reduces fertility intention equally for both men and women. The point estimates for both men and women are identical but have stronger statistical significance for women than men. This could be because women do more work in childbearing than men in a way that they are unable to always combine with schooling. It is common for women to postpone childbearing till after a certain level of school attainment (Keats, 2018). Thus higher overall attainment for women will mean delayed childbearing which will inevitably translate to fewer. Moreover, a higher level of

Table 1.6: Heterogeneity: Gender

	Female			Male		
	Smokes					
	OLS	IV	RF	OLS	IV	RF
Schooling	-0.0001	-0.0086	-0.0090*	-0.0092***	-0.0495*	-0.0912**
	(0.0003)	(0.0059)	(0.0048)	(0.0033)	(0.0268)	(0.0438)
Observations		1,726			605	
	Fertility Intention					
	OLS	IV	RF	OLS	IV	RF
Schooling	-0.0792***	-0.3164**	-0.3282***	-0.0621***	-0.1829*	-0.3368*
	(0.0062)	(0.1350)	(0.1044)	(0.0125)	(0.1064)	(0.1826)
Observations		1,727			605	

Notes: The results in this table splits the data into men and women to understand the gender heterogeneity. All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

school attainment opens up diverse career paths for women, hence a higher opportunity cost- career-wise. The point estimate for women is also larger and comparable to Osili and Long (2008) for Nigeria.

These estimates show that the results for smoking are driven by the effects on men while the fertility intention is marginally driven by women. It is worth emphasising here also that the results for antenatal visits and weight for height discussed earlier included only women. Policy implications of these results are highlighted in a separate section.

North and South

Ghana is divided into 16 regions. The 5 northern-most regions are culturally and economically different from the 11 southern regions in important ways. In terms of land size, both the north and south are approximately equal. However, due to poorer living conditions in the north, migration to the south is common, making cities in the south have higher population densities. Access to advanced healthcare infrastructure is lacking in the north relative to the south. For instance, there are four better-equipped teaching hospitals in the south versus one in the north. Medical personnel sometimes refuse to be posted to the north due to the harder conditions they have to work under. These factors are among others that make it interesting to see how the results change for the north versus the south. The results is presented in table 1.7

Smoking status is impacted more in the south than in the north. This difference could be driven by differences in wealth (van Kippersluis and Galama, 2014). For instance, the results in table 1.8 show that for poor people, education does not matter. It is not immediately obvious why people choose to smoke, but if people choose to smoke as a way to feel good about themselves, it might be the case that poor people smoke as

a temporary escape from life's problems that are due to poverty. It would be interesting to explore these reasons in a future study. A related study by Nketiah-Amponsah et al. (2018) found that respondents in the northernmost part of Ghana had a higher daily smoking intensity than respondents in the southernmost regions. They suggested also that this could be because educational attainment and household wealth are both lower in the north than in the south. Their study included only men.

The effect of education on fertility is strongest in the north. The point estimates for fertility intention in the north are larger than the combined sample effect and about twice as large as in the south. The sign, however, remains stable across all samples. This is not so surprising given the higher fertility rates in the north. Here too, a few factors might account for these differences. The north has a larger Muslim population and Catholics in the north form the majority of Christians. As shown in the study in chapter 3, religion appears to be a key driver of fertility (via pronatalist doctrines) (Abor et al., 2011). Moreover, these higher fertility rates may be driven by lower education attainment and higher poverty rates in the north. In the presence of these factors, it is expected that the fertility differential due to higher education would be higher for women in the north than in the south. Antenatal Visits show an identical point estimate and statistical effect for both north and south and suggest that the benefits of education on antenatal visits were not affected by location (Duodu et al., 2022; Abor et al., 2011). This could possibly be due to equity in access options across the country.

Healthy eating varies both in magnitude and statistical significance from north to south. The effects are stronger in the north but neither is statistically significant. Clearly, there might be a wealth effect here as well when we consider the results in table 1.8. As already highlighted, vegetables are scarce and expensive everywhere making them less accessible to the poor.

In the case of the risk of obesity, the effects captured in the full sample appear to be driven mainly by the south than the north. The point estimates for body mass index are both larger and statistically significant for the south but not for the north. The point estimate in the former is also larger than in the full sample suggesting that the full sample estimates are driven more by the south. Similar patterns can be seen for weight for height. The lower risk of obesity in the north may be driven mainly by wealth differences between the south and north and by the fact that sedentary work is

Table 1.7: Heterogeneity Location: South Vs North

	South			North		
	OLS	IV	RF	OLS	IV	RF
			Smokes			
Schooling	-0.0010	-0.0461	-0.0378**	-0.0014**	-0.0090	-0.0162
	(0.0010)	(0.0291)	(0.0159)	(0.0007)	(0.0125)	(0.0209)
Observations		1,655			676	
			Fertility Intention			
Schooling	-0.0633***	-0.3034*	-0.2484**	-0.0761***	-0.2530**	-0.4562***
	(0.0071)	(0.1735)	(0.1064)	(0.0085)	(0.1164)	(0.1701)
Observations		1,656			676	
			Antenatal Visits			
Schooling	0.1523***	3.2788	0.7462*	0.0732**	0.6308	0.7370*
	(0.0260)	(7.7012)	(0.4244)	(0.0316)	(0.5502)	(0.4038)
Observations		674			374	
			Healthy Eating			
Schooling	0.0244	0.4671	0.3846	-0.0249	0.2254	0.4064
	(0.0168)	(0.3375)	(0.2382)	(0.0182)	(0.2016)	(0.2740)
Observations		1,654			676	
			Body Mass Index			
Schooling	0.0462	-87.8567	1.0465*	0.0967**	0.1580	0.4814
	(0.0414)	(4,357.8129)	(0.6206)	(0.0446)	(0.2988)	(0.9167)
Observations		625			266	
			Weight for Height SD			
Schooling	0.0018	13.7378	0.0523***	0.0034***	0.0108	0.0328
	(0.0012)	(2,141.5543)	(0.0157)	(0.0012)	(0.0091)	(0.0265)
Observations		623			266	

Notes: The results presented here repeat the estimates using a sub-sample of respondents from the 5 northern regions and 11 southern regions. These north and south are culturally and economically distinct. All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

less prevalent in the north. Poor transport networks in the north and longer distances to access social and economic infrastructure also mean that people in the north are likely to be physically active, hence a lower risk of obesity.

Household wealth

A variable rich is defined for household wealth such that respondents in the bottom 40% of households are classified as poor and those above are classified as rich. The results are reestimated for the poor and rich. The results presented in table 1.8 show that the effect of education on the rich is different than for the poor. Some of these have been highlighted in prior discussions.

The results show that education reduces the probability of smoking for people from rich households by 3.4%, higher than the combined effects, but not for poor households. As suggested earlier, if people smoke as a way of escape from challenges associated with poverty, then it is likely that regardless of educational attainment, poor people will smoke. This might be a complementary channel to the effect of education (Nketiah-Amponsah et al., 2018). There could also be an earnings effect inherent in the education effect but this may also suggest that the earning effect is strongest among the very highly educated; assuming that the rich are also the most highly educated.

Table 1.8: Heterogeneity: Wealth

	Rich			Poor		
	OLS	IV	RF	OLS	IV	RF
			Smokes			
Schooling	-0.0007	-0.0256*	-0.0341**	-0.0019	-0.0668	-0.0243
	(0.0008)	(0.0143)	(0.0154)	(0.0012)	(0.1202)	(0.0219)
Observations		1,468			863	
			Fertility Intention			
Schooling	-0.0507***	-0.1941**	-0.2588**	-0.0600***	-0.9233	-0.3506**
	(0.0075)	(0.0967)	(0.1122)	(0.0085)	(1.2730)	(0.1468)
Observations		1,468			864	
			Antenatal Visits			
Schooling	0.1174***	0.5889	0.5956	0.0701**	-3.7082	0.7729*
	(0.0270)	(0.5470)	(0.4502)	(0.0347)	(11.1734)	(0.4662)
Observations		523			525	
			Healthy Eating			
Schooling	0.0361**	0.1580	0.2121	-0.0083	1.9040	0.7231**
	(0.0174)	(0.1781)	(0.2377)	(0.0202)	(2.8317)	(0.2869)
Observations		1,466			864	
			Body Mass Index			
Schooling	-0.0377	1.3051	0.9223	0.0088	0.5941	0.8975
	(0.0461)	(1.5807)	(0.6976)	(0.0454)	(0.5823)	(0.7268)
Observations		559			332	
			Weight for Height SD			
Schooling	-0.0008	0.0599	0.0431**	0.0011	0.0366	0.0558**
	(0.0013)	(0.0610)	(0.0179)	(0.0013)	(0.0241)	(0.0219)
Observations		558			331	

Notes: Results in this table include a sub-sample of individuals in the middle and two upper household wealth quintiles (Rich) and the two lower quintiles (poor). All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

The effect of FCUBE on reducing fertility intention is stronger for poor households than for the rich. This can be explained by the fact that compared to less educated poor households, the opportunity cost of having more children is higher for rich households. For example, in Ghana children from farming communities, who are also among the poorest, are valuable farm hands (Janssens et al., 2019). Therefore more children mean cheap labour and higher household income. On the other hand, because educated people in Ghana are also less likely to choose farming (Jolliffe, 2004), their children are not potential farm hands. Thus, the net cost of having children may be higher. This is one possible explanation for the observed difference.

The point estimate for antenatal visits is larger and statistically significant for women in poor households but not for women from rich households (Duodu et al., 2022). This is most likely because antenatal care is free. The fact that it is statistically significant could also be interpreted to mean that it is not only the cost that motivates people to choose or not choose but that being educated in and of itself affects the decision to attend. This explanation can be applied to healthy eating in the same table. The findings on healthy eating show that educated people from poor households

eat healthier but healthy eating is not affected for the rich. Thus, for the rich, they may be eating healthily because they can afford to, but for poor households, the inherent benefits of education-possibly due to better knowledge- might be stronger than the wealth effect. Similarly, the effect of the policy on the risk of obesity differs only marginally between rich and poor households. Thus regardless of wealth status, educated people are at greater risk of obesity, measured as the standard deviation of weight for height.

On heterogeneity: finally...

Altogether these heterogeneous effects make much sense and are consistent with expectations. For instance, if we assume that healthy eating depends on being able to afford it, then it should not have a significant effect on rich households. In addition, if access to care is easier in the south than in the north, then educated people in the north are more likely to be motivated to get care than the less educated in the north. Finally, women's fertility window tends to be shorter than men's; this is during their youth. The longer they stay in school and delay birth, the reduce the window even further and so on.

1.6.3 Mechanisms

The findings so far show clearly that respondents who received an extra year of fee waivers or an extra year of schooling had better health behaviour and outcomes. One possible explanation for this is that educated people have better access to health information and so are more knowledgeable about health. This is a common explanation in the literature. The theoretical argument presented earlier hinges on this explanation by suggesting a productive efficiency channel. I test this mechanism by examining access to a possible knowledge channel (Kenkel, 1991). Respondents were asked questions about the causes and prevention of common illnesses. I measured knowledge here as a sum of the number of responses that indicated that a respondent had the correct knowledge in a given question up to a maximum of 13.

Other perspectives discussed earlier hold that education impacts health via employment. I also test for a possible employment channel. Employment is measured as a dummy for whether a person was currently in employment. This measure is not ideal given that education is not necessary to get one into employment; instead, it is

Table 1.9: Potential Mechanism- Knowledge

	Smokes	Fertility Intention	Antenatal Visits
Schooling	-0.0298**	-0.2502***	0.6608**
	(0.0124)	(0.0895)	(0.2982)
× Health Knowledge	-0.0002**	-0.0098***	0.0133***
	(0.0001)	(0.0008)	(0.0028)
Health Knowledge	0.0087**	0.0707***	0.2323***
	(0.0041)	(0.0182)	(0.0821)
Observations	2331	2332	1048

	Healthy Eating	Weight for Height	Body Mass Index
Schooling	0.3883**	0.0437***	0.8041
	(0.1829)	(0.0140)	(0.5253)
× Health Knowledge	-0.0012	0.0002**	0.0066
	(0.0018)	(0.0001)	(0.0045)
Health Knowledge	0.0747*	0.0068**	0.2217**
	(0.0414)	(0.0034)	(0.1082)
Observations	2330	889	891

Notes: This table shows results for knowledge as a mechanism. Only reduced form results are presented. All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

the type and status of the employment that is determined by differences in educational attainment. Nonetheless, given the constraints of the data available, employment is used here loosely to indicate the probability that a person earns an income, which makes health affordable. The results for both mechanisms are presented in tables 1.9 and 1.10. Taken as a whole, it is not far-fetched to conclude that a knowledge and employment channel is plausible.

1.6.4 Further discussions

Although methodical issues are stated variously in earlier discussions, some are worth highlighting here. First, the regression discontinuity method, while powerful for causal analysis is limited in the generalisability of results. By its design, findings are true for observations in the optimal bandwidth (McCrary, 2008; Imbens and Lemieux, 2008; Calonico et al., 2014). In a policy context such as the one examined in this essay, government policies over time may have impacts on future cohorts such that the effects of past policies may not be as relevant presently given the passage of time and changes in demography. For instance, after more than two decades, it is now normal for pupils to have access to free schooling at public basic schools. That is, full treatment is now common and there is no differential treatment. Thus, going forward any benefits from the extra year of treatment will become normalised.

Table 1.10: Potential Mechanism -Employment

	Smokes	Fertility Intention	Antenatal Visits
Schooling	-0.0298**	-0.2696***	0.7329**
	(0.0125)	(0.0894)	(0.3051)
× Employment	-0.0014*	-0.0743***	0.1170***
	(0.0008)	(0.0063)	(0.0240)
Employment	0.0200**	0.6811***	-0.2396
	(0.0090)	(.0790)	(0.2492)
Observations	2331	2332	1048

	Healthy Eating	Weight for Height SD	Body Mass Index
Schooling	0.3909**	0.0452***	0.8489*
	(0.1825)	(0.0139)	(0.5231)
× Employment	-0.0114	0.0023**	0.0600*
	(0.0129)	(0.0009)	(0.0334)
Employment	0.3327*	-0.0157	-0.5174
	((0.1720	(0.0117)	(0.4112)
Observations	2330	889	891

Notes: This table shows results for employment as a mechanism. Only reduced form results are presented. All estimates include controls for ethnicity and religion and the functional form used is linear interaction. Errors are clustered at the survey cluster level and presented in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

That said, the findings of this study have at least two important benefits for policy. The first is that it serves as a form of policy evaluation and the second is that, it provides a reference for future policies on tuition fee waivers, of potential long-term benefits. As a form of policy evaluation, it is informative and possibly confirmatory of benefits that were anticipated at the inception of the policy. If policymakers at the time based their decision on scholarly literature, these findings advance that knowledge. As a reference for future policy, the findings show that fee waivers have causal benefits for health in the long term. In 2017, Ghana's fee waiver policy was extended to include senior secondary school. That is, three additional years. While data is not yet available for evaluating its impact, the sharp increases in the enrolment numbers suggest that identical benefits are to be expected. Moreover, the idea of free, compulsory and universal basic education is being mulled over by other African countries. These countries, many of whom have identical characteristics to Ghana, will benefit from these lessons from Ghana's experiment.

The second issue, which is more specific to this essay is the choice of bandwidth. An important decision that is made in this paper is to maintain a single bandwidth, the optimal bandwidth (Imbens and Lemieux, 2008), for all outcome variables. This was to allow for comparison. The consequence of this decision is that some outcomes do not consistently show strong statistical significance in heterogeneity analysis. The

alternative is to allow for bandwidths to vary for each outcome variable (Calonico et al., 2014). This approach is also acceptable and used in the literature. I present the main results using this method in the appendix. Although this approach provided stronger evidence, it compares observations from distant cohorts. The approach taken in this paper has strengths that can be considered to be superior (Imbens and Lemieux, 2008) but it is worth acknowledging the merits of the alternative.

1.7 Conclusion

This paper examined whether a causal link exists between education and health by exploiting the FCUBE policy in Ghana as a source of exogeneity in a Fuzzy RDD. The paper makes important contributions to the literature as being one of scarcely any studies on the causal effect of education on health in Africa, and to have examined other variables besides fertility and one of scarcely any to have included men. Beyond Africa, existing evidence in Europe is mixed and split almost evenly on either side. Studies on the US mostly show findings consistent with the findings in this paper. This study also includes variables such as antenatal visits and fertility intention, which, to the best of my knowledge have not been previously examined. On the whole, the question of causality has only begun to be addressed in empirical studies in the last decade. The contributions of this paper are thus important both for the developing country context and the worldwide literature.

The findings of this study have economic significance. Consistent with global trends, life expectancy and overall well-being are increasing in Ghana as a result of medical advances. The results presented here show that the increases in educational outcomes are partly responsible for these positive health outcomes. By design, the findings of this study apply specifically to the respondents in the optimal bandwidth. Nonetheless, the results can be extrapolated to the whole population especially because the under-30s constitute the larger share of the Ghanaian population. Ghana extended the tuition fee waiver to senior secondary schools in 2017. The effect of the fee waivers induced by the FCUBE is estimated to be at least 1.5 years. The mean years of schooling of the sample in the optimal bandwidth were 8 years. This means that the individuals included in this study did not complete junior secondary school, on average. The duration of senior secondary school is 3 years. This means that the fee waiver for senior secondary school can adduce more than twice the health benefits estimated in

this study. This is not a small effect. With the exception of the risk of obesity (and arguably fertility), these effects can generally be regarded as positive. The heterogeneity analysis also suggests that one cap does not fit all people all the time, but it certainly fits all people sometimes. Thus, the benefits of education are wide-reaching.

Outside of Ghana's context, the results provide useful lessons for countries whose tuition fee waiver policies have not been extensively evaluated. It also provides lessons for those countries that have plans to adopt a similar policy. It may also be informative in that it provides a counterfactual for countries that have not implemented tuition fee waiver policies. Although such a comparison must consider any differences in national health policies.

Considering that the health variables examined here are mostly behaviour, increasing educational attainment could mean lower public health expenditure in the long run. The results also suggest that health knowledge and employment are plausible channels for at least some health outcomes. In terms of the practical impact of the findings of this study. It is noteworthy that obesity is on its way to being endemic globally, malnutrition and smoking are already global crises. The findings of this paper contribute to efforts to understand the social and economic factors that cause or mitigate these health challenges. Thus a contribution to the solution.

Chapter 2 HOT IN THE HEAT: CLIMATE VARIABILITY, MISTRUST AND VIOLENCE

Co-authored with Marco Alfano

Abstract

For a long time, experiments in psychology have associated extreme temperature fluctuations with aggression. This has also been found in recent econometric analyses. We extend this literature by examining trust as a potential mechanism linking temperature fluctuations to aggression. We construct an index of human perception of ambient temperature and combine it with attitude surveys. We find that respondents were more likely to report that they mistrust the government and be willing to join a protest against the government on warmer days. They were also more likely to vote against the incumbent president if elections were held on warmer days. These effects are magnified for the poor and marginalised groups. Our proposed mechanism is complementary to an agricultural income channel.

2.1 Introduction

The idea that climate change has significant effects on economic outcomes is intuitive and not new (Nordhaus, 1993; Collier et al., 2008; Chhibber and Laajaj, 2008; Burke et al., 2010). Extant literature has examined links between climate variables (such as temperature, wind and rainfall) and public health, energy demand, labour productivity and agricultural output (Dell et al., 2014; Hsiang et al., 2011); usually seeking to highlight the adverse impacts of climate change on livelihoods. However, while violence clearly affects livelihoods, there is no consensus in the literature about the effects of climate change on the initiation of violent conflicts.

While many studies have found a positive and significant relationship between precipitation and temperature anomalies and violent behaviour, armed conflicts and aggression, a few others have suspected that these may be spurious, citing spatial aggregation and the omission of socio-politico-economic factors which they consider to be more plausible explanations of violence. An important contributor to the latter side

of the debate is Buhaug (2010) who challenged findings by Burke et al. (2009), arguing that rather than climate variability, institutional factors and political marginalisation are the factors that explain civil violence. He, however, suggests that the conclusions of contributors on both sides of the conversation have been based on aggregated climate and conflict measures and that disaggregated measures are likely to be more informative of any possible relationship between climate variations and violence or civil conflicts. In response to Buhaug (2010)'s recommendation on research design, several studies have since used disaggregated high-frequency high-resolution spatial data to identify conflict incidence and have established that there is indeed a positive and significant relationship between the two. Nonetheless, little attention has been paid to a possible pass-through of the political and social factors that Buhaug (2010) argued for. We address these by examining the relationship between the climate-violence nexus and attitudes towards political institutions using disaggregated high-frequency high-resolution spatial data.

This paper contributes to the literature in three ways. First, we provide new evidence of the existence of a direct effect of climate change on the initiation of conflict using data for the whole of Africa. Most existing studies use data for single countries or regions within a country. Secondly, we use spatial data from geographic coordinates to precisely match climate variables to the location of violent conflicts instead of aggregated data. Thirdly, we show that climate variables affect the initiation of violence by weakening trust in elected leadership. We do this by matching data from an attitude survey to the exact location and date of the occurrence of climate variability. We are not aware of any paper that has examined trust as a mechanism by which climate change can contribute to aggression.

As a first step, our study replicates findings from Hsiang et al. (2011), Burke et al. (2009) and Harari and La Ferrara (2018) who also find that violence was more likely when temperatures are higher than long-term means. We compute cell level temperature anomalies- deviations from long-term means, using the exact cells used by Harari and La Ferrara (2018). The data from Harari and La Ferrara (2018) divides the continent into 2,757 cells of size 1×1 degree latitude and longitude (approximately 110km at the equator). Next, we create a monthly panel for the years 2009 to 2018. Our results show that a positive temperature anomaly of 1°C increases the within-cell monthly incidence of riots and protests by 0.135. That is, riots and protests were more likely when temperatures were higher than usual. These findings are consistent with

much of the literature in this area.

For our second set of findings, we examine the mechanisms by which violence is begotten by temperature anomalies. Herein lies the novelty of our paper. There is a dominant view in the literature that climate change causes violence by negatively affecting agricultural production. Thus, as drought sets in and crop yields fall, and grazing fields become depleted, individuals who rely on crops and livestock lose their livelihoods and fight over scarce resources (Dickson et al., 2022). This explanation has been cited for studies both in Africa and Asia (Gangopadhyay and Nilakantan, 2017). However, evidence from non-agricultural contexts such as America has also linked temperature anomalies to increases in violence (Schinasi and Hamra, 2017). We explore trust as an alternative mechanism but first, we establish that an agriculture channel exists by replicating known results (Harari and La Ferrara, 2018).

We argue that violence cannot be explained by temperature except by how the human body perceives it. Thus, we employ components of Steadman (1979a,b)'s Heat Index using a standard algorithm that combines air temperature, humidity, wind speed and solar radiation to measure ambient temperature. Where ambient temperature is temperature as perceived by the human body (real feel). We compute the index using data on daily temperature, humidity, wind speed and solar radiation and match it to round six of the Afrobarometer survey to identify the effect of ambient temperature on self-reported mistrust in government and on intention to protest, riot and voting intentions. Our data includes geographic coordinates of the location of respondents at the time of the interview. Combining this with ambient temperature at that location on the day of the interview, we are able to identify the effect of ambient temperature on mistrust and intention to vote.

Our findings show that respondents were more likely to report mistrust of the government during positive ambient temperature anomalies. Using ambient temperature for one day and two days before or after the interview, by contrast, gives precisely estimated effects of zero. When we disaggregate the index's four components, humidity shows the strongest effect, thus confirming the view that it is not temperature but how it is felt that matters. We also find that temperature anomalies affect self-reported intentions to act. That is, people were more likely to declare the intention to vote against the party of the current president or prime minister or engage in protest (if one were to arise). These intentions are particularly heightened by poverty and

existing grievances such as by marginalised ethnic groups.

Our study is among a growing body of literature on the determinants of trust. In the case of Africa, Rohner et al. (2013) show that inter-ethnic trust reduces the incidence of conflict. Depetris-Chauvin et al. (2020) find that respondents interviewed the day after an important football match involving the national team were more likely to self-identify with their nation (rather than ethnic groups/tribes) if the national team won and were more likely to say they trusted other ethnic groups/tribes. Nunn and Wantchekon (2011) also show that historical factors such as the slave trade were a determinant of mistrust among ethnic groups. They find that people from ethnic groups that experienced greater intensities of the slave trade were less trusting. Besides conflict and political stability, trust is important for trade and contract enforcement, which are necessary for economic development (Robinson, 2016b; Nunn et al., 2018).

The rest of the paper is structured as follows. In section 2.2 we present a summary of prior literature. In section 2.3 we describe our data and define the measurement of key variables. We describe our estimation approach and results for our first set of findings in section 2.4 and for our second set of findings in section 2.5. Conclusions are presented in section 2.6.

2.2 Prior Literature

The interest in the relationship between climate change and violence is not new. For decades, psychologists and neuroscientists have been interested in the relationship between temperature and aggressive behaviour (Kenrick and MacFarlane, 1986). For example, Anderson et al. (1996) exposed participants to photos of guns and varying degrees of heat in an experiment and found that extreme heat and cold increased state hostility and hostile attitudes of participants but viewing guns did not. On the other hand, viewing guns increased hostile cognition but the extreme temperature did not. Their finding implies that while exposing people to weapons could make them think of violence by stimulating imagination they are more likely to take action in the presence of extreme temperature anomalies. Larrick et al. (2011) observed baseball matches and found a correlation between hot weather days and the number of times pitchers hit batters with a ball if the former's teammates were hit by the pitcher in the latter's team. In order words, they were more likely to retaliate in hot weather. Similarly, Haertzen et al. (1993) found that inmates were more likely to commit infractions in

summer months than at other times of the year. Thus, experimental and observational evidence clearly demonstrates the existence of a relationship between heat and violence.

Nonetheless, the economics literature on this topic is scant. For decades, conflict researchers have suggested that competition over scarce natural resources has contributed to wars in parts of the developing world (Dickson et al., 2022; Collier and Hoeffler, 1998; Maystadt and Ecker, 2014). This subsequently led to a focus on the effects of climate change on the availability of natural resources such as sources of water and arable land (Linke et al., 2015; Theisen, 2012). Recent interests in the economics literature have been on the effects of resource scarcity on migration, health (Dell et al., 2014; Cervallati et al., 2017), economic growth (Dell et al., 2012) and political stability (Hsiang and Burke, 2013). Ours is an interest in political stability but without emphasising the role of natural resources. We explore mistrust as an explanatory factor in civil unrest by characterising mistrust as a manifestation of psychological processes. While extant studies in the social science literature have discounted a psychological channel and emphasised economic factors, we take the view that regardless of external factors, internal factors are a necessary condition for violence to occur (Selby and Hoffmann, 2014).

This section presents an overview of the literature on the link between climate change and violence. The issues presented in this overview reflect diverse disciplinary perspectives. The terms Climate Change and Climate Variability are used interchangeably. Some authors stress that climate change is more appropriate when referring to the long term and climate variability is appropriate for referring to the short term. However, what constitutes long-term and short-term is not strictly defined hence we avoid making this distinction here. Moreover, this is not of material significance to the present discussion.

2.2.1 Theories connecting climate variability to violence

There are relatively more empirical studies that show that there is a relationship between heat or climate change and violence. Only a few theoretical papers have, however, modelled this relationship. The most widely cited theories in the empirical economics literature are those that emphasise an income channel to explain the climate-violence relationship. One of these theories is by Coccia (2017) who argues in his theory of General Causes of Violent Crimes (GCVC) that income inequality is

the most plausible universal explanation of violent crime. Another is the theory of relative deprivation (Walker and Pettigrew, 1984). The main argument of this strand of the literature is that climate change has an adverse effect on livelihoods so that the opportunity cost of violence is low (Harari and La Ferrara, 2018; Collier and Hoeffler, 1998). That said, new empirical evidence shows that after accounting for income, significant effects remain unexplained (Gangopadhyay and Nilakantan, 2017; Baysan et al., 2019). This suggests that an income channel is not universal.

However, a new body of theoretical literature is emerging that highlight psychological channels in the climate-violence relationship. For instance, in their General Aggression Model (GAM), Allen et al. (2018) argued that aggressive behaviour is determined by proximate factors (such as temperature) and distal factors [1] that interact to affect a person's cognition, mood and arousal. Also, Tiihonen et al. (2017) citing that low serotonin contributes to higher impulsivity and novelty-seeking behaviour conclude that high temperature reduces serotonin and makes people want to go out and explore more hence a higher chance of violence. This supports the distal factors of the model by Allen et al. (2018). This is however only plausible in an environment where such temperature is rare or when temperature deviates from long-term mean. Moreover, it is difficult to test these theories empirically.

Similarly, Van Lange et al. (2017) and Rinderu et al. (2018) state in their CLASH[2] model that it is short-term variations in climatic conditions that affect aggressive behaviour. They argued that long-term variations do not affect aggressive behaviour and the risk of violence because society tends to adapt its cultural norms over time to suit long-term climatic conditions. Thus, it is fluctuations in average seasonal temperature that influence aggression (Schinasi and Hamra, 2017). We agree with this part of their theory but disagree with another assertion that cultural traits such as self-control are less likely in hot climates hence a greater risk of aggressive behaviour. Culture is shaped by the community and what might be considered a manifestation of self-control may not be the same for every community.

The CLASH model and GCVC theory can easily be tested using aggregate social and climate data but because social data and climates vary across countries, conclusions may not be generalisable. On the other hand, GAM can provide more

[1] Including biological modifiers-eg. testosterone, low serotonin and hormonal imbalances and environmental modifiers such as cultural norms and deprivation

[2] CLimate, Aggression, and Self-control in Humans

objective conclusions but can be expensive to carry out. Moreover, ethical concerns may arise. Our hypothesis that trust is an explainer of the climate-violence relationship sits well within the CLASH model. Indeed, several pieces of empirical evidence within the economics literature have shown that trust is a social construct (Robinson, 2016a; Fafchamps, 2006; Algan and Cahuc, 2010). In Africa, it has been shown that low levels of trust were more common among certain ethnic groups (Robinson, 2016b; Moscona et al., 2017) and was related to historical experiences (Nunn and Wantchekon, 2011). However, trust has mostly been explored within the context of market transactions (Tabellini, 2010) and local economic development (Knack and Keefer, 1997). Our study is related to another strand that notes the implications of trust for institutional effectiveness (Robinson, 2014; Blanco and Ruiz, 2013) and political stability (Nunn et al., 2018).

This paper takes the view that the level of trust within a community and towards elected officials explains the climate-violence relationship. This view also reflects a recent trend in the economics literature where authors suggest that psychological channels complement income channels (Gangopadhyay and Nilakantan, 2017). For instance, Baysan et al. (2019) concedes that economic factors may not be the immediate factors but only serve to either mitigate or amplify the climate-violence nexus and goes on to suggest that temperature causes conflicts through psychological and physiological factors. We contribute to this emergent strand by showing that deviations from mean temperatures are associated with both outbreaks of riots and aggressive affect(intentions) toward government institutions.

2.2.2 Conversations in the Empirical Literature

Until the last decade, only a few studies in experimental psychology had suggested that extreme heat and extreme cold were associated with the intention to engage in violence and aggressive behaviour (Hsiang and Burke, 2013; Vrij et al., 1994; Anderson et al., 2000). However, widespread armed conflicts in Africa and Asia in the 1990s and the rising global temperatures led social science researchers to ask whether this could explain conflicts in these parts of the world (Burke et al., 2009; Hsiang and Burke, 2013). The earliest of such studies found a strong connection between temperature and the incidence of conflicts (Burke et al., 2009). This finding has not been received well by a section of the literature that appears to take the view that such findings could

suggest that residents in warm climates are inherently violent (Buhaug, 2010). A major concern is that if such a conclusion is reached, policy and related efforts at world peace would be hopeless.

In the years following, new evidence using historical data has also revealed that periods of violence in European history such as the persecution of Jews occurred at a time when temperatures were extremely cold (Anderson et al., 2017). These new findings, also consistent with earlier laboratory experiments (Anderson et al., 2000), suggest that it is not simply temperature, but how the human body perceives it, that affects behaviour (Prudkov and Rodina, 2019). Thus, when the temperature is extremely low or high compared to the long-term mean the resulting discomfort adversely affects social interactions (Schinasi and Hamra, 2017; van Weezel, 2014).

The dominant explanation in the social science literature has been one of the economic consequences of such extreme climate variation (Mekonnen, 2014; Bollfrass and Shaver, 2015). Most authors suggest that extreme variations in rainfall, wind and temperature make grazing fields and water for livestock scarce so that competition between herdsmen makes violent conflicts likely (Maystadt and Ecker, 2014). Others also argue that lower incomes due to lower crop production makes agrarian communities targets for recruitment by insurgent groups and religious extremists (Eastin, 2018; Fearon and Laitin, 2003). The view taken by this paper is that given the findings in non-agrarian contexts (Bollfrass and Shaver, 2015; Selby and Hoffmann, 2014), there must be other channels besides agriculture shocks (Gangopadhyay and Nilakantan, 2017). In the remainder of this section, we discuss some of the key themes in the literature on the relationship between climate variables and violence (see Hsiang and Burke (2013) for a more detailed overview of the empirical literature).

What form of Violence?

An important question that arises is: what type of violence is affected by climate variability? We find that in the literature, a correlation has been established between climate variables and most forms of violence including personal, interpersonal, and collective violence (Baysan et al., 2019). For instance, Ranson (2014) finds a link between daily maximum temperature and daily precipitation and violent crimes such as rape, murders and assaults and explains that this occurs because of increased interpersonal interaction on warm days. Similarly, Sekhri and Storeygard (2014)

examines the deviation of rainfall from long-run mean and dowry deaths and domestic violence. They find no significant relationship for aggregated crime data but find significant relationships for disaggregated crime data. Miguel (2005) also finds a relationship between rainfall shock and the number of witch murders. Thus, climate variability affects different forms of violence (Baysan et al., 2019).

It is not just Africa

While many recent studies have focused on Africa, the effect of weather and climate variability on violent behaviour is neither limited to Africa nor to developing countries (Hsiang and Burke, 2013). For example, Wetherley (2014) studied the relationship between extreme weather variables such as typhoons, high temperature and violent crimes in the Philippines. She found a positive and statistically significant relationship which showed that when weather conditions deviate from their long-term means, the likelihood of violence increases. Jia (2014) and Chen (2015) also found a significant relationship between droughts and the probability of civil conflicts and dynastic conquest in historic China using data spanning several centuries. Similarly, developed countries have also seen studies that have established strong and significant relationships between temperature anomalies and violence (Chen and Lee, 2017). For instance, Anderson et al. (2017) studied medieval Europe and found that Jewish persecutions were more likely if temperatures were extremely low. Moreover, the studies previously cited for violent crimes were mostly for America and Europe (Schinasi and Hamra, 2017; Chen and Lee, 2017). This also supports evidence from much of the literature that shows that it is not just high or low temperatures but deviations from long-term means that might be associated with violent behaviour.

Mechanisms

Within the various strands of the climate-violence literature, the issue of the causal mechanism remains unresolved (Hsiang and Burke, 2013; Helman and Zaitchik, 2020). As long as the discussion in the economics literature is centred on economic channels, it is unlikely that this would change given the sharp diversity in national economic structures in a way that is systematically correlated with the location of civil conflicts (Buhaug, 2010). However, if climate variables have a causal effect on violent conflicts, the channel must be such that identical climate conditions should result in the

same likelihood of violent incidence (Bollfrass and Shaver, 2015). One thing that is clear is that the causal mechanism cited by authors varies in a consistent way by context. For instance, studies on Africa that find a significant relationship between weather variability and violent events systematically suggest an economic factor, mostly agricultural income shocks, as the main causal channel (Mekonnen, 2014; Gong and Sullivan, 2017; Burke et al., 2009; Ambaw and Sim, 2019). Others tend to argue for increased social interaction in warmer months as a causal channel in developed countries and contexts where agriculture is not rain-fed (Chen and Lee, 2017).

The economics literature has examined the climate-violence nexus through two channels (McGuirk and Nunn, 2020; Dickson et al., 2022). The first channel is the opportunity cost channel (Grossman, 1991; Post et al., 2016; Harari and La Ferrara, 2018; Collier and Hoeffler, 1998). Proponents of this channel argue that violence is more likely if the benefits outweigh the cost of a rebellion. They argue further that climate variability alters the opportunity cost of joining a rebellion or a riot when agriculture output is adversely impacted (Post et al., 2016). That is, climate shocks generate negative economic shocks that lower the returns for engaging in the labour market and lower the opportunity cost of joining a rebellion. The second channel is via incentives (the rapacity effect) (Dickson et al., 2022). Negative shocks arising from climate variability shrink the economic pie hence reducing the incentive to join a rebellion. For instance, negative shocks would lower government revenue and so the rewards of a rebellion (eg. Coups, riots; that seek to take over government) are reduced (Fearon and Laitin, 2003). The latter channel is however ambiguous since it depends on whether the economy is labour or capital-intensive. If the incentive for conflict is low because of the negative economic shocks occasioned by weather variability, then the economic return to violence is also low and should demotivate violence. Following this argument, because the economic returns to violence are larger in a prosperous economy, violent conflict should be more prevalent in rich countries; this is however not the case. Hence an economic channel is not universal. Recent evidence has discounted the universality of an economic channel (Gangopadhyay and Nilakantan, 2017; Sarsons, 2015; Baysan et al., 2019).

Departing from the economic channel arguments but still citing opportunity cost, Cervallati et al. (2017) argue that a mechanism by which climate change impacts conflicts is via health shocks. They argue that climate variability allows disease-causing

pathogens to flourish, causing poor health; people with poor health are more likely to take risks associated with conflicts and are likely to discount the future more. The arguments of their paper are counterintuitive given that violence often requires significant energy; that people with poor health would be limited in their ability to fight, for instance. A few other mechanisms have been suggested, including: weak institutions (Buhaug, 2010), migration (Bosetti et al., 2020) and markets (Dickson et al., 2022). However, Bollfrass and Shaver (2015) find that there is a positive relationship between weather conditions and violence regardless of whether agriculture is an important economic activity. Examining the effects of rainfall shortages in India in agricultural contexts, Sarsons (2015) finds that in districts with dams, agricultural outputs are unaffected by rainfall shortages but the likelihood of violence is. These studies underscore the fact that the agricultural channel is neither robust nor universal. There is still the need to find a channel that relies less on individual and community characteristics; while admitting yet that these characteristics may amplify or diminish violent incidences.

The role of institutions, ethnic fragmentation, and social factors

Social structure, institutional quality and ethnic diversity have been cited as being associated with conflict incidence and intensity. Thus, the discussion of the factors that influence violence and conflicts is incomplete without considering the socio-political correlates of violence. Firstly, ethnic fragmentation has been shown to correlate positively with violent conflict. For instance, Schleussner et al. (2016) found that it is more likely that climate change is associated with conflict in ethnically fragmented countries. Esteban and Ray (2008) have also argued that the outbreak of conflicts and its intensity depends on the extent of polarisation and ethnic fractionalisation. Similarly, Collier and Hoeffler (2004) argue that lack of political rights, and ethnic and religious divisions in society breed grievances that degenerate into wars if it is feasible. This is supported by evidence from the Philippines (Eastin, 2018).

Additionally, political factors such as democracy determine the likelihood of violent conflicts. It can be argued that aggrieved parties in a democracy will choose dialogue over violence. However, Collier et al. (2008) offer an alternative view, suggesting that democracy may fuel violence in low-income settings because democracy constrains the measures that government can use to repress violence, versus in an

autocracy. Weather shocks that lead to economic shocks may further constrain the ability of the state to afford peace as its income is negatively affected. Weather shocks have been shown to precede democratic transitions. For instance, Brückner and Ciccone (2011) obtain this conclusion and explain that rainfall shocks occasion economic shocks which are blamed on the incompetence of the incumbent government even if these shocks are exogenous (Nunn et al., 2018). Moreover, the economic shock also results in a temporary fall in the opportunity cost of contesting power (Dickson et al., 2022). Hence democracy may increase or decrease the likelihood of conflicts. However, a democracy where trust is high is more likely to reduce rather than increase violent conflicts. Trust is essential for establishing the legitimacy of democratic leaders. Nonetheless, the way modern democracies are organised, and competing interest, makes it impossible to achieve complete trust (Abramson, 2015). Thus, the level of trust among citizens and between governments and citizens can determine the stability of democracies. We test the hypothesis that temperature anomaly affects conflicts by reducing trust in elected public officials.

Also, a growing literature is interested in finding the relationship between trust and economic development (Tabellini, 2010; Robinson, 2014; Moscona et al., 2017). Prominent in this strand of the literature is the question of the relationship between trust and political stability (Nunn et al., 2018). Rohner et al. (2013) examined the role of trust in the risk of instability and concluded that when people trust others less in a country, there was more likely to be civil conflict or some form of attempt to oust the government. This can happen even if the country has been stable in the past such as in democracies (Nunn et al., 2018). When democracies function properly, the tendency to use violence to achieve stated goals is reduced.

2.2.3 In sum...

1. The evidence suggesting a link between weather/climate variability and violence is significant. A few authors have found contrary evidence.

2. While much of the empirical literature has focused on violent civil conflicts/war in Africa, a good number of studies have examined violent crimes in America and Europe. Both strands reach the same conclusions.

3. While much of the literature examines heat, others have found the same effect for cold. It is not absolute values nor averages in temperature but temperature

anomalies that are associated with violence.

4. The literature has mostly relied on economic channels but new evidence suggests they are not universal. Psychologists have begun developing theories but economists are yet to catch up.

5. Our main contribution is to the strand of the literature that examines mechanisms. No previous study has shown that trust is a potential mechanism by which climate variability can affect violent conflicts. That is our main contribution in this paper.

2.3 Empirical Strategy

2.3.1 Data and Measurements

The analysis combines data on climate variability, self-reported attitudes, civil unrest, elections and topography. Each dataset includes geolocation data for each observation. In each case, we use the topography data from Harari and La Ferrara (2018) to match climate data to data on attitudes, elections and civil unrest. This allows for extracting the location of each event. The topography data from Harari and La Ferrara (2018) divides the continent into quadrangular cells of size 1×1 degree latitude and longitude. Conflict data is at the cell level. Climate data is at the level of the location of a conflict event and at the level of the respondent location. The rest of this section presents further details on the sources of the datasets used in the analysis and measurement of variables.

i) Climate variability: Climate data are taken from the ECMWF2[3]-ERA5 reanalysis database, which contains high-resolution climatic data generated from reanalyses of historic data using the Integrated Forecasting System (IFS) Cy41r2 model from 1950.[4] These data are an updated version of the ECMWF ERA-Interim data that was used by Harari and La Ferrara (2018). In the next sub-section, we describe the Heat Index- a measure of ambient temperature. To calculate the heat index, we use the following climate data: data on surface air temperature (in °C), surface net solar radiation (in J/m^2), wind speed at 10 metres above the surface (in m/s) and surface dewpoint temperature (in °C), which we use to proxy humidity. For the individual-level

[3]European Centre for Medium-Range Weather Forecasts 2

[4]The IFS Cy41r2 model has been shown to give the most precise estimates for a range of climate variables. The data is available at https://cds.climate.copernicus.eu.

and voting analysis, we use climate data measured on the day of the interview and election day, respectively. For the cell-level analysis, we use monthly means of daily observations. All climate variables used are recorded at noon, local time. These are described below:

- **Surface air temperature and surface dewpoint temperature:** Surface air temperature is the temperature of the air near the earth's surface[5]. Surface air dewpoint temperature is the temperature near the surface to which a given air parcel must be cooled at constant pressure and constant water vapour content in order for saturation to occur; it measures the amount of humidity in the air[6]. Both measures of temperature are calculated by interpolation between the lowest model level and the earth's surface after accounting for atmospheric conditions. Both are measured in kelvin at two metres from the surface of the earth at the weather station within the cell. Dew point and air temperature are used to calculate water vapour pressure (Pha) using the following formulae:

$$rh = 100 * (exp\frac{(17.625 * dewpoint)}{(243.04 + dewpoint)}/exp(\frac{(17.625 * temperature)}{(243.04 + temperature)}),$$

where rh is relative humidity and

$$Pha = \frac{rh}{100} * 6.105 * exp\frac{(17.27 * temperature)}{(237.7 + temperature)}.$$

- **Wind speed:** The ERA5 contains two different measures of wind. The ten-metre(10m) u-component of wind measures the eastward component of the 10m wind. The 10m u-component of wind is the horizontal speed of air moving towards the east, at a height of ten metres above the surface of the Earth, in metres per second. This variable is combined with the v-component of 10m wind to give the speed and direction of the horizontal 10m wind. The 10m v-component of wind on the other hand measures the northward component of the 10m wind. It is the horizontal speed of air moving towards the north, at a height of ten metres above the surface of the Earth, in metres per second. We combine the u-component (u) and v-component (v) of wind to calculate wind speed using the squared root of the sum of squares of each component as follows: $\sqrt{u^2 + v^2}$

[5]Copernicus Atmosphere Monitoring Service Information, Description of data, 2020
[6]Copernicus Atmosphere Monitoring Service Information, Description of data, 2020

- **Surface net solar radiation:** The ERA5 defines Surface net solar radiation as the "Amount of solar radiation (also known as shortwave radiation) reaching the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface. Radiation from the Sun (solar, or shortwave, radiation) is partly reflected back to space by clouds and particles in the atmosphere (aerosols) and some of it is absorbed. The rest is incident on the Earth's surface, where some of it is reflected. The difference between downward and reflected solar radiation is the surface net solar radiation". It is measured in joules per square metre (J/m^2). In order to calculate the solar radiation absorbed by the human body, one has to make several assumptions about the size, shape and position of the human body. We follow the methodology suggested by Kenny et al. (2008) and make the following assumptions/adjustments:

    1. **Body Position:** We multiply solar radiation by 0.7 to account for the human body being in a sitting position, which we assume is how the interview takes place. The two alternatives considered by the authors are 0.78 for standing and 0.6 for crouched.
    2. **Albedo:** We multiply solar radiation by 0.483 to account for the albedo of the human body, for a medium-sized man. The authors also give alternative values of 0.446 for a large man and 0.645 for a woman.
    3. **Clothing:** We multiply solar radiation by 0.21 to account for clothing. The authors provide 0.57 and 0.37 as alternative values (Kenny et al., 2008). We chose 0.21 to account for the fact that individuals in hot countries wear appropriate(lighter) clothing.

    In table 2.4 we show that our results are remarkably stable across different assumptions/combinations regarding the shape, size and position of the human body across all specifications.

ii) Trust, voting intentions and intentions to protest: Data on self-reported trust in government and intentions to vote and to protest is from round six of the Afrobarometer. This survey round was conducted in 36 countries throughout Africa from March 2014 to November 2015. The survey covers approximately 54,000 individuals and is nationally representative. The scope of the data covers approximately 76 per cent of the population across most of the north, south and west of the continent.

Figure 2.2 shows respondents location on a map. We exclude the three island states of Cape Verde, Mauritius and Sao Tome and Principe. Upon request, the Afrobarometer also provided the geolocation coordinates of respondents at the time of the interview. This allows us to match climate variables on the day of the interview to survey responses. We also use questions on intention to vote against the incumbent president and intention or willingness to engage in protest. For ethical reasons, the geolocation of respondents is displaced by a few metres from their exact spot but kept close enough to the original spot to allow for reliable identification. Figures 2.1(c) and 2.3(c) show a distribution of self reported trust across questions and relative intensity across locations on the map.

We use six questions to approximate trust in government. These inquire whether the respondent i) trusts the parliament, ii) trusts the president or equivalent highest office of state, iii) believes politicians are out for themselves, iv) believes that the president should decide everything, v) believes there should be more than one party, and vi) believes that the president should be bound by laws.

1. **Does not trust president** uses the question *How much do you trust each of the following, or haven't you heard enough about them to say: The President?* The dependent variable takes value 1 if the respondent answers either *Not at all* or *Just a little.*

2. **Does not trust Parliament** uses the question *How much do you trust each of the following, or haven't you heard enough about them to say: The Parliament?* The dependent variable takes value 1 if the respondent answers either *Not at all* or *Just a little.*

3. **Politicians are out for themselves** uses the question *Do you think that the leaders of political parties in this country are more concerned with serving the interests of the people, or more concerned with advancing their own political ambitions, or haven't you heard enough to say?* The dependent variable takes the value 1 if the respondent answers *More to serve their own political ambitions – strongly agree* or *More to serve their own political ambitions - agree* or *Neither agree nor disagree*

4. **Disapproves of one-party rule** uses the question *There are many ways to govern a country. Would you disapprove or approve of the following*

alternatives: Only one political party is allowed to stand for election and hold office? Dependent variable takes the value 1 if respondent answers *Strongly disapprove* and *Disapprove*.

5. **Disapproves of the president can do what want** uses the question *There are many ways to govern a country. Would you disapprove or approve of the following alternatives: Elections and Parliament are abolished so that the president can decide everything?* Dependent variable takes the value 1 if respondent answers *Strongly disapprove* and *Disapprove*.

6. **President must obey laws** uses the question *Which of the following statements is closest to your view? Choose Statement 1 or Statement 2. Statement 1: Since the President was elected to lead the country, he should not be bound by laws or court decisions that he thinks are wrong. Statement 2: The President must always obey the laws and the courts, even if he thinks they are wrong.* The dependent variable takes the value 1 if a respondent answers *Agree with Statement 2* or *Agree very strongly with Statement 2*

Variable used for voting intention

- **Would vote against president** uses the question *If a presidential election were held tomorrow, which party's candidate would you vote for?* The dependent variable takes the value 1 if a respondent's choice does not match the party of the current president.

Variable used for intention to protest

- **Intends to protest** uses the question *Here is a list of actions that people sometimes take as citizens when they are dissatisfied with government performance. For each of these, please tell me whether you, personally, have done any of these things during the past year. If not, would you do this if you had the chance: Participated in a demonstration or protest march.* Dependent variable takes the value 1 if a respondent answers *No, but would if had the chance.*

Average levels of trust are reported in figure 2.1(c). Overall, trust in government is relatively low. Just under half of respondents report not to trust the parliament or the president of their own country. Moreover, around three-quarters believe that politicians are out for themselves, that the president should not do as he or she pleases and that

the president should obey the laws. A similar proportion disapproves of one-party rule. To measure voting intentions, we use the hypothetical scenario in the Afrobarometer, which asks respondents which party they would vote for if elections were held the day after the interview. We define a dummy variable taking the value 1 if the party selected by the respondent does not match the party to which the current president is affiliated. Figure 2.1(c) shows that around 65 per cent would vote against the current president.

We measure intentions to protest via a hypothetical scenario inquiring whether the respondent ever participated or would participate in a demonstration or protest march if they were dissatisfied with the government. Only a relatively small percentage, 9 per cent, ever participated in a protest. We drop these individuals and define a dummy taking the value 1 if the respondent states that they would participate in a demonstration or protest march if they had the chance. As figure 2.1c shows, 37 percent would. In the results, we scale these dummies to 100 so that they can be interpreted as percentages.

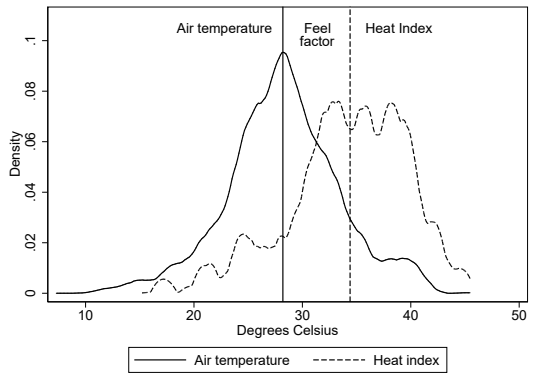
iii) Protests and riots: Data for protests and riots is drawn from the Armed Conflict Location and Event Data Project (ACLED).[7] For each event, ACLED reports the date, actors involved, fatalities and modalities along with the exact geographical coordinates. The ACLED categorises violent events into battles, violence against civilians, riots, protests and strategic developments. Our outcome variables are i) protests, defined as *a public demonstration in which the participants do not engage in violence, though violence may be used against them* and ii) riots, defined as *violent events where demonstrators or mobs engage in disruptive acts.* We focus on the years 2009 to 2018. Summary statistics for incidences of civil unrest, defined as either protests or riots, are reported in figure 2.1(d). For the whole of Africa in the years 2009 to 2018, ACLED report a total of 28,762 protests and 16,080 riots. This corresponds to around 0.087 protests and 0.049 riots per cell per month. In total, 47 per cent of cells experienced at least one protest or one riot during the sample period. On average, the proportion of cells experiencing either a protest or a riot in any given month is around 5 per cent. The distribution of protests and riots for each cell is shown in figure 2.4(c)

iv) Presidential election data: We used election results reported on the African Elections Database[8], which provides a comprehensive archive of elections in Africa up until the year 2010. These are complemented by a manual search of

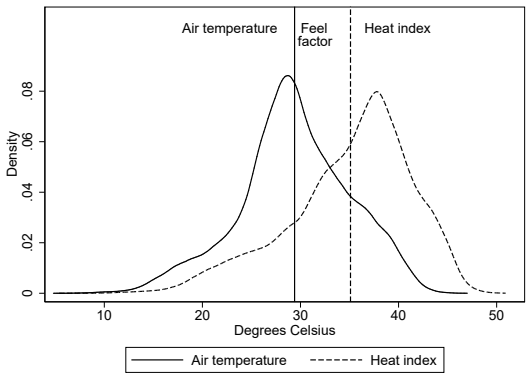
[7]The data are freely available under https://acleddata.com/.
[8]https://africanelections.tripod.com/

Figure 2.1: Air temperature, perceived temperature, attitudes and civil unrest

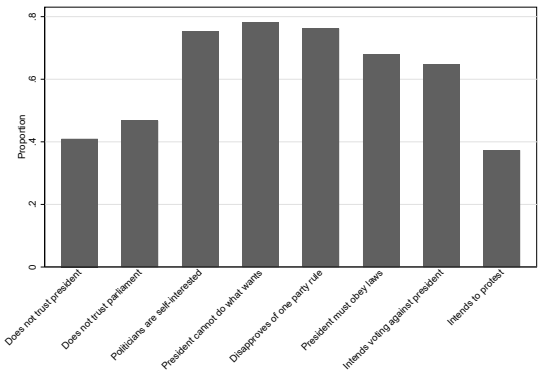
(a) Air temperature and heat index 2014-15



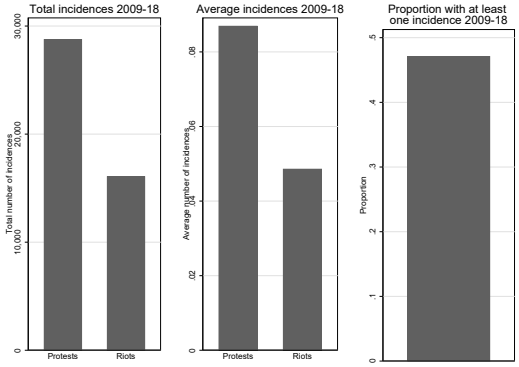
(b) Air temperature and heat index 2009-18



(c) Self-reported attitudes 2014-15



(d) Incidences of protests and riots 2009-18



Notes: These figures report summary statistics on perceived temperature, trust, intentions to vote and to protest, and civil unrest; *panel a* reports the air temperature and perceived temperature measured via the heat index in equation 2.1 in degree Celsius for the Afrobarometer sample for the years 2014 to 2015 *panel b* reports the air temperature and perceived temperature measured via the heat index in equation 2.1 in degree Celsius for the whole of Africa for the years 2009 to 2018; *panel c* reports the proportion of Afrobarometer respondents reporting mistrust in their government, voting intentions and intentions to protest; *panel d* provides summary statistics on protests and riots based on ACLED.

recent elections up to 2019. The data on the African Elections Database are obtained from a variety of sources, which include National Election Authorities (NEA), Official government documents, and Electoral Observer Mission reports. We complemented this database with data obtained from National Election Authorities' databases (preferred) or the news(if NEA database is not up to date) on recent elections. We identified the incumbent president by using the election results from the previous election.

The information we were interested in was the date of the election, the winner and their party and the ethnicities of the incumbent and winner. This allows us to match climate variables on election day to election outcomes and to examine the role of ethnic identity. Ethnic identity has been shown by a section of the economics literature to determine trust in Africa (Green, 2018; Fearon and Laitin, 2000; Depetris-Chauvin et al., 2020). These data were independently cross-checked from multiple sources by both authors. A list of elections included can be found in section B.

Inclusion criteria

- We choose presidential elections occurring in Africa between 1990 and 2019. We also include Botswana and South Africa. Although these countries do not hold presidential elections, the president is chosen by parliament. The parliamentarians in turn are chosen by popular votes and since the party with the most parliamentary seats gets to choose the president, voters are likely to vote for an incumbent party's parliamentary candidates if they are satisfied with the government.

- If a presidential election consists of more than one round we take the final round, i.e. the round that produces a president. We only include countries that were classified as either 'free' or 'partly free' by Freedom House in the year of the election[9].

- We only include elections for which we can identify the incumbent government. This *excludes* the first elections held after independence and any election following the collapse of democracy.

v) Topography, growing seasons and crops: We combine the geographical locations of climatic events, Afrobarometer respondents and incidences of civil unrest using the geographical grid provided by Harari and La Ferrara (2018), which divides the continent into 2,757 quadrangular cells of size 1×1 degree latitude and longitude (approximately 110km at the equator) map in figure 2.2(a). For each of the 2,757 cells, we also identify the major crop cultivated and calculate its growing season combining two data sources. We use data from the International Food Policy Research Institute (IFPRI) (Anderson et al., 2014) to identify each cell's major crop.[10]

- **Data on growing seasons:** was taken from the Nelson database which collects information on the planting and harvesting dates of 19 major crops across several countries from six sources [11] (FAO, USDA, USDA-FAS, USDA-NASS, IMD-AGRIMET, USDA-FAS) (Sacks et al., 2010).

- **Major crops for each cell:** We identify the major crop for each cell with data from IFPRI (figure 2.2(c)). The IFPRI data was generated using the Spatial

[9] https://freedomhouse.org/

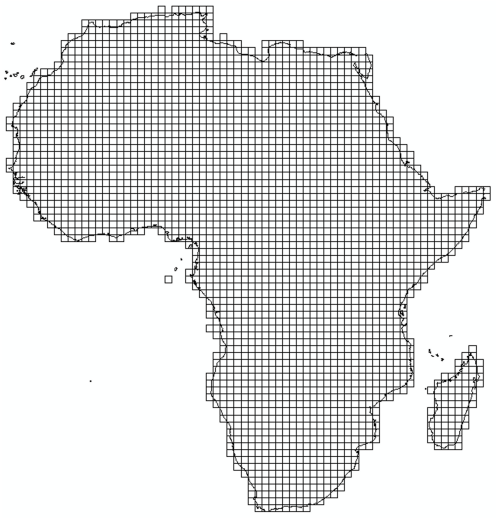
[10] The data are freely available at https://www.ifpri.org/.

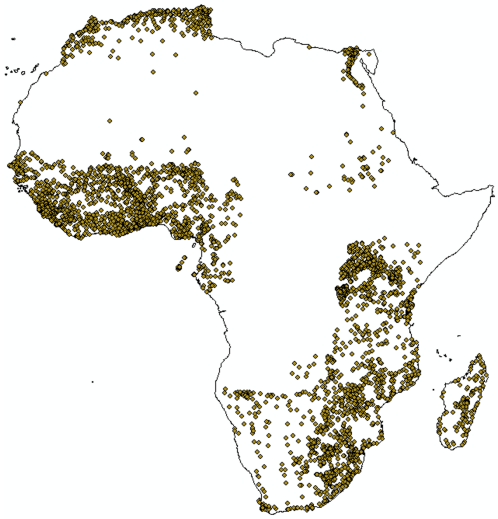
[11] The data are freely available at https://nelson.wisc.edu/sage/data-and-models/crop-calendar-dataset/index.php.

Figure 2.2: Cells, respondent locations, crops and slave trade maps

(a) 1×1 degree raster

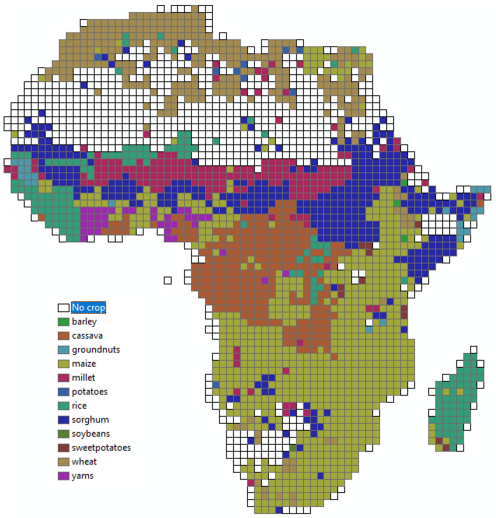
(b) Afrobarometer respondents

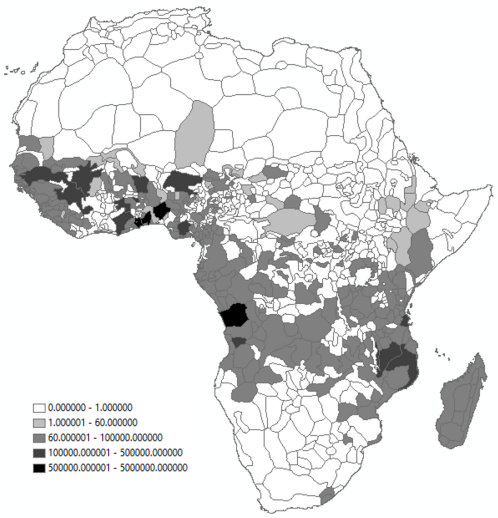




(c) Major cell-specific crops

(d) Historical slave trade





Notes: map a: shows the raster of the 2,757 1×1 degree latitude and longitude (approximately 110km at the equator) provided by Harari and La Ferrara (2018); *map b:* shows geographical coordinates of Afrobarometer respondents; *map c:* shows the major crop grown in each of the 2,757 cells; *map d:* shows ethnic homelands by total number of slave exports provided by Nunn and Wantchekon (2011).

Production Allocation Model (SPAM). The model disaggregates crop-specific production data by triangulating information from national and sub-national crop statistics, satellite data on land cover, maps of irrigated areas, biophysical crop suitability assessments, population density, secondary data on irrigation and rain-fed production systems, cropping intensity, and crop prices (Anderson et al., 2014).

2.3.2 Heat Index

We suggest in our context, that heat/climate is only relevant to the extent that it is perceived by the human body. The human body perceives a feeling of heat when its core temperature rises above 37°C. Temperature regulation occurs by a combination of perspiration and vasodilatation. The effectiveness of this process—and hence perceived temperature—depends on four environmental factors: air temperature, air humidity, sun exposure and wind (Tsutsumi et al., 2007). One of the most widely used measures for perceived temperature by Steadman (1994) combines these four meteorological variables into a single heat index, which denotes the equivalent temperature that the human body would perceive under a fixed set of climatic conditions (i.e. if the dew-point temperature were 14.0°C). In simple terms, the index denotes the temperature as one would feel it. Steadman's index is the basis for a variety of heat indices provided by reputable institutions, such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. National Weather Service[12] and the Australian Bureau of Meteorology.[13]

Steadman (1994) sets out the following algorithm, which maps temperature, humidity, solar radiation and wind to a single heat index

$$heat\ index = T + F \tag{2.1}$$

where T denotes air temperature (measured in °C). The variable F, which we call the *feel factor*, accounts for the fact that temperature as perceived by the human body also

[12]For instance https://www.weather.gov/oun/safety-summer-heatindex accessed May 2020.
[13]For instance https://www.wpc.ncep.noaa.gov/heat_index/details_hi.html and http://www.bom.gov.au/info/thermal_stress/ accessed May 2020.

depends on humidity, wind and solar radiation as follows

$$F = 3.48 \times P_a - 0.7 \times ws + 0.7\frac{Q}{ws + 10} - 4.25 \tag{2.2}$$

where P_a is water vapour pressure (a measure of humidity, measured in hPa), ws is wind speed (measured in m/s) and Q is net solar radiation absorbed per unit area of body surface (measured in $\frac{J}{m^2}$). Various studies have identified humidity as the most important determinant of the feel factor (Tsutsumi et al., 2007; Alahmer et al., 2012). We include both temperature (T) and the feel factor (F) as separate covariates in our main regressions. As a more parsimonious version, we also include all four meteorological variables (air temperature, humidity, wind and solar radiation) as separate regressors.

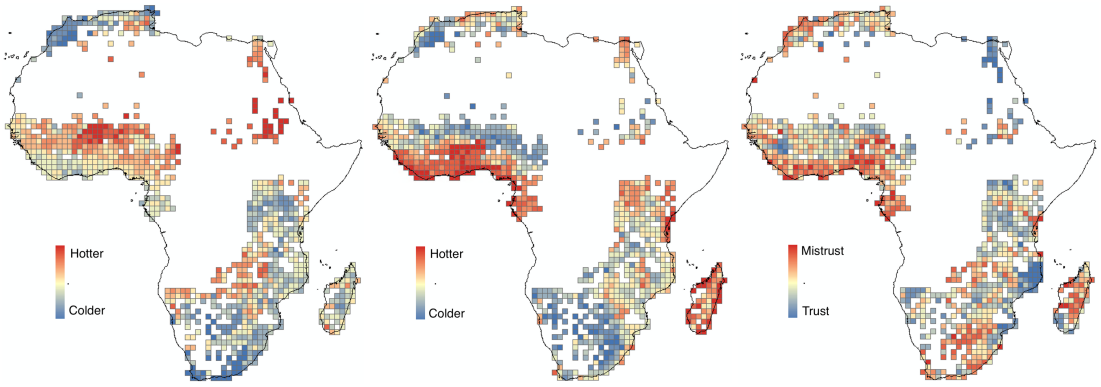
The distributions of air temperature and the heat index in equation 2.1 are reported in figures 2.1(a) and 2.1(b). The combination of humidity, wind and solar radiation captured by the feel factor leads the perceived temperature to exceed air temperature by around 5°C. This holds for both the Afrobarometer sample (from 2014 to 2015 in panel a) and the ACLED sample (from 2009 to 2018 in panel b). A possible reason for the heat index exceeding air temperature is that we measure all climatic events at 12noon when solar radiation is the strongest. This is exacerbated by the fact that much of Africa lies relatively close to the equator and that the effect of humidity on perceived temperature is particularly strong at high temperatures. This can be seen from figure 2.3 which shows the distribution of air temperature (a) and feel factor(b) on the map. It can be seen that countries closest to the equator have higher values for the feel factor than the air temperature. Similarly, the maps in figure 2.4 show warmer cells closer to the equator. Figure 2.3 was constructed using data for cells where the afrobarometer survey was conducted while 2.4 was constructed using cells where protest and riots data was available from ACLED. Additionally, when compared, figure 2.4 shows that air temperature was higher in the Sahara region, as expected but the feel factor was higher close to the equator.

2.4 Monthly climate variability and violence

The first part of the analysis in this paper replicates existing conclusions by examining the effect of perceived temperature (measured via the components T and F of the heat

Figure 2.3: Air Temperature, Perceived Temperature and Trust in Africa

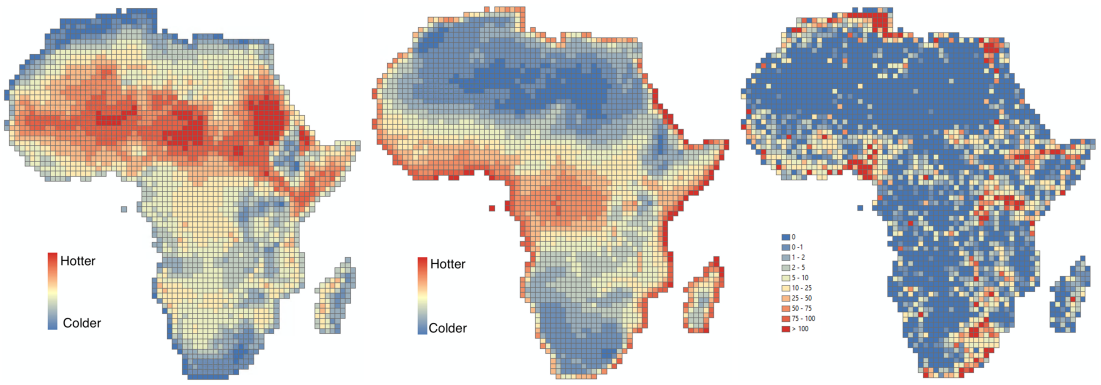
(a) Air Temperature (b) Feel Factor (c) Self-Reported Trust



Notes: These maps report air temperature, perceived temperature and trust for Afrobarometer respondents; *panel a* reports the mean air temperature on the day of interview for Afrobarometer respondents 2014-15, blue denotes lower and red higher values; *panel b* reports the mean feel factor (i.e. the perceived temperature resulting from humidity, wind and solar radiation outlined in equation 2.2) on the day of interview for Afrobarometer respondents 2014-15, blue denotes lower and red higher values; *panel c* reports the mean trust in government reported by Afrobarometer respondents 2014-15, values are based on the first principal component of the six questions used to measure trust in government, blue denotes higher trust and red lower trust in government.

Figure 2.4: Air temperature, perceived temperature and civil unrest in Africa

(a) Air Temperature (b) Feel Factor (c) Protests and Riots



Notes: These maps report air temperature, perceived temperature and incidences of protests and riots for the years 2009 to 2018; *panel a* reports the mean air temperature per cell for the years 2009 to 2018, blue denotes lower, and red higher values; *panel b* reports the mean feel factor (i.e. the perceived temperature resulting from humidity, wind and solar radiation outlined in equation 2.2) per cell for the years 2009 to 2018, blue denotes lower, and red higher values; *panel c* reports the total number of protests and riots occurring in each cell for the years 2009 to 2018, blue denotes lower and red higher values.

index in equation 2.1) on two types of actions: acts causing civil unrest and votes cast at presidential elections. First, we establish that there is a relationship between ambient temperature and violence. Previous studies use air temperature only for this analysis but for our purposes, we also use ambient temperature which accounts for the feel factor. This part of the analysis also tests the commonly cited agricultural income channel.

2.4.1 Estimation

We combine data from ACLED with the grid from Harari and La Ferrara (2018). We then construct a panel where each of these cells contributes one observation per month for the years 2009 to 2018. We define the dependent variable $unrest_{ctm} = 100$ if at least one protest or riot occurred in cell c in month m and year t, and estimate:

$$unrest_{ctm} = \beta_1 T_{ctm} + \beta_2 F_{ctm} + \beta_3 P_{ctm} + \overline{\boldsymbol{C}}_{\boldsymbol{cm}}{}'\boldsymbol{\delta} + \eta_c + \rho_t + \phi_m + \mu_c \times \tau + \epsilon_{ctm} \quad (2.3)$$

where T_{ctm} and F_{ctm} denote air temperature and the feel factor in equation 2.1 in cell c in month m and year t, respectively. Scaling the dependent variable to 100 allows coefficients to be directly interpreted as percentages. We also control for cell and month-specific precipitation, P_{ctm}. As before, we include a vector, $\overline{\boldsymbol{C}}_{\boldsymbol{cm}}{}'$, containing the long run means of the variables T_{ctm}, F_{ctm} and P_{ctm} for each month m in cell c.[14] This allows us to interpret T_{ctm}, F_{ctm} and P_{ctm} as anomalies, i.e. deviation from long run local means. We also include fixed effects for each cell (η_c), year (ρ_t) and month (ϕ_m) and country-specific time trends ($\mu_c \times \tau$) and also include the lagged dependent variable, $riot_{ctm-1}$. We estimate equation 2.3 by OLS.

To check whether the direct channel that we examine in the next section is compatible with the fact that climate affects conflict via income, we also include climatic events occurring during the growing season that finished before month m, C_{ct-1}. If the inclusion of C_{ct-1} changes the parameters β_1, β_2 and β_3, we know that the income channel is more important. However, if both the coefficient of C_{ct-1} and the β_1, β_2 and β_3 coefficients are large and significant, then we know that climate change can affect conflict via both channels at the same time. The results are presented in table 2.1

[14] We use the years 2008 to 2018 to construct these averages.

Table 2.1: Perceived temperature and incidences of protests and riots

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	= 100 if cell c in month m experiences at least one							Log agricultural GVA per worker
	Riot or protest	Riot or protest	Strategic violence	Riot or protest	Riot or protest	Riot or protest	Riot or protest	
Feel factor (F)	0.316***	0.322***	−0.026	0.361***	0.368***	0.499***		0.014
	(0.092)	(0.085)	(0.052)	(0.088)	(0.088)	(0.116)		(0.033)
Air temperature (T)	0.135***	0.087***	−0.024	0.085***	0.111***	0.139***		−0.039*
	(0.033)	(0.030)	(0.018)	(0.032)	(0.031)	(0.048)		(0.020)
Feel factor (F) × single ethnicity				−0.083*				
				(0.046)				
Feel factor (F) × rich country					−0.101**			
					(0.049)			
Average temperature inside previous growing season						0.373***		
						(0.098)		
Average temperature out of previous growing season						0.081		
						(0.107)		
Air temperature (zscore)							0.399**	
							(0.170)	
Humidity (zscore)							1.118***	
							(0.262)	
Wind speed (zscore)							0.084	
							(0.119)	
Solar radiation (zscore)							0.387**	
							(0.195)	
Rainfall (zscore)							−0.012	
							(0.120)	
Observations	330,840	330,840	330,840	330,840	330,840	242,403	330,840	404
Cell, Year & Month fixed effects	yes	yes	yes	yes	yes	yes	yes	no
Long term cell average climate	yes	yes	yes	yes	yes	yes	yes	no
Country specific time trend	no	yes	yes	yes	yes	yes	yes	no
Lagged dependent variable	no	yes	yes	yes	yes	yes	yes	yes
Country fixed effects	no	no	no	no	no	no	no	yes
Data source	ACLED	ACLED	ACLED	ACLED	ACLED	ACLED	ACLED	World Bank

Notes: This table shows results for the mediating role of ethnicity and poverty in the actual occurrence of riots and protests and riots in columns 1-7. Results in Column 3 are a robustness (falsification) check of effects. The results show that temperature anomalies are associated with actual outbreak of violence as they are with intentions to engage in violence. Column 8 shows the effect of temperature on agricultural Gross Value Added (GVA). It shows that an agriculture shock channel exists. Spatial HAC Conley standard errors with 180km radius and one month lag are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

2.4.2 Results 1: Perceived temperature anomalies and civil unrest

The three maps in figure 2.4 show the average air temperature (panel a), the average feel factor (panel b) and the total number of protests and riots (panel c) for all 2,757 cells in Africa for the years 2009 to 2018. The maps show a strong positive correlation between both climate variables and incidences of protests and riots. As shown in the figure, columns (1) and (2) of table 2.1 show that a 1°C positive monthly anomaly in the feel factor (F) increases the incidence of protests or riots by 0.3 percentage points per cell-month. The corresponding estimate for air temperature (T) is 0.1 per cell month. These remain stable after controlling for time trend, country fixed effects and including lag of the dependent variable. In column (3) we carry out a placebo check where we consider incidences of strategic violence defined as events that trigger the onset of violence. That is, strategic developments are not conflict events but events that have the potential to trigger a conflict. Contrary to protests and riots, this type of violence is likely to be determined by tactical, strategic and political factors rather than by attitudes (Passarelli and Tabellini, 2017). As expected, this outcome variable

is not affected by temperature.

As discussed in section 2.2, ethnicity and ethnic fragmentation have been shown to be important in the onset of violence. We test whether the effect of temperature on civil unrest varies by the ethnic composition of each cell. For this, we overlay our cells with the map of ethnic homelands provided by Murdock (1959, 1967) and define a dummy taking the value 1 if cell c contains only one ethnic homeland (the base are cells with more than one ethnic homeland). As column (4) shows, the effect of the feel factor is stronger in ethnically diverse cells. Ethnically homogeneous cells have a 0.8 percentage point lower probability of violence per cell month. As suggested by Coccia (2017) in the theory of General Causes of Violent Crimes we estimate whether the effect of temperature is stronger in poorer cells. That is cells with higher poverty rates. For this, we use World Bank data and define a dummy equal to 1 if the proportion of individuals living under USD1.90 (world bank poverty line) a day is below the median (the base consists of poorer cells). The estimates in column (5) that the effect of temperature is significantly stronger in poor countries. We note that across columns, the coefficient of air temperature remains more stable and the feel factor effect becomes stronger when social and economic factors are controlled for. This shows that social and economic factors are important in the onset of protests and riots as suggested by Buhaug (2010).

2.4.3 Mechanisms: An agricultural income channel exists

We show that the effect of temperature estimated in this paper complements the well-documented effect of temperature that operates through agricultural incomes. Our findings suggest that there is a strong effect of climate variability on incidences of protests and riots only in previous growing seasons.

First, we re-estimate equation 2.3 adding leads and lags of T and F for the three months before and three months after m. As figure 2.5a shows, anomalies in the three months before and after have a negligible effect on protests and riots. The effect of perceived temperature anomalies in the same month, by contrast, remains large. Since it is likely to take a whole agricultural season—almost a year-long—for weather fluctuations to affect incomes (Harari and La Ferrara, 2018), effects of perceived temperature within the same month are unlikely to be the result of income changes.

Second, we estimate the effect of temperature anomalies along the crop calendar.

The effect of the climate on agricultural productivity varies considerably by the crop calendar, which denotes the months during which a crop is in the ground. For each of the 2,757 cells, we define the growing season by combining the two independent data sources outlined in section 2.3.1. The map in figure 2.2 shows the major crops and is very similar to the one reported by Harari and La Ferrara (2018). Using the information on each growing season, we group the 12 months of the year into 6 groups always in relation to the harvesting month of the cell-specific major crop (6-11 months before, 3-5 months before, 0-2 months before the harvest and 1-3 months after, 4-6 months after and 6-11 months after the harvest). As figure 2.5b shows, the effect of temperature is remarkably stable along the crop calendar.

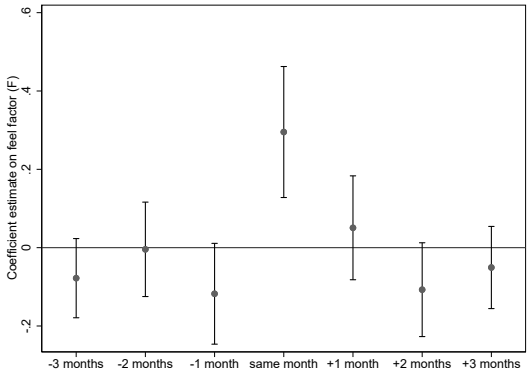
Third, in column (7) of table 2.1 we include all four parts of the heat index separately. As with the estimates on trust, humidity shows the strongest effect on protests and riots. Whilst the human perception of heat is very susceptible to humidity (Tsutsumi et al., 2007; Alahmer et al., 2012), Zhao et al. (2005) point out that short-term fluctuations in humidity have a negligible effect on agricultural output. Fourth, we analyse agricultural labour productivity directly by estimating the effect of yearly temperature anomalies on agricultural gross value added (GVA) data provided by the World Bank between 2009 and 2018.[15] As column (8) of table 2.1 shows, air temperature (T) decreases agricultural GVA by around 4 per cent, which agrees with the results found by Dell et al. (2012). By contrast, the coefficient on the feel factor (F) is close to zero, around 1 per cent. We test whether the effects of temperature documented in this paper complement or rival the well-documented effect of temperature that operates through agricultural incomes. For this, we follow the methodology proposed by Harari and La Ferrara (2018) and calculate, for each cell c in month m, two averages. The first is average air temperature during months falling *inside the growing season* prior to month m (T_g). Since T_g influences agricultural output, any effect on conflict is likely to operate through agricultural income.

We also carry out a placebo check where we calculate average air temperature during months falling *outside of the growing* season prior to month m (T_{ng}), which

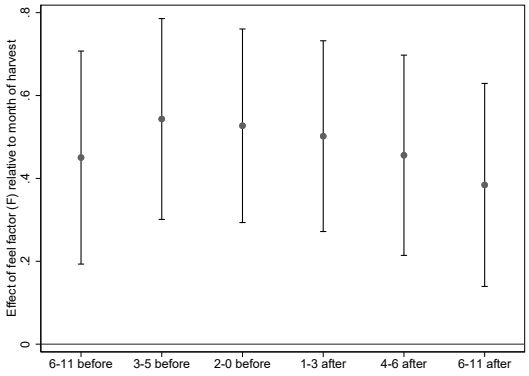
[15] Value added denotes the net output of the sectors agriculture, forestry and fishing after adding up all outputs and subtracting intermediate inputs. Data are in constant 2010 U.S. dollars. Agriculture corresponds to the International Standard Industrial Classification (ISIC) tabulation categories A and B (revision 3) or tabulation category A (revision 4), and includes forestry, hunting, and fishing as well as cultivation of crops and livestock production. Values are reported in constant 2010 US$. The data are freely available at https://data.worldbank.org/. Accessed July 2020.

Figure 2.5: Effect of perceived temperature on civil unrest by month and along crop calendar

(a) Effect on civil unrest by month



(b) Effect on civil unrest along crop calendar



Notes: These figures show how the effect of perceived temperature on protests and riots varies by month and along the crop calendar; dots report parameter point estimates from OLS regression for *Feel factor (F)* (i.e. perceived temperature resulting from humidity, wind and solar radiation outlined in equation 2.2); vertical lines denote 95% confidence intervals; dependent variable takes value 100 if cell c experienced at least one protest or riot in month m; *panel a* adds 3 months leads and lags for regressor *Feel factor (F)*; *panel b* interacts *Feel factor (F)* with six dummies indicating the position of month m relative to the cell-specific crop growing calendar; *6-11 before* =1 if month m falls 6 to 11 months before the harvest month of cell c's major crop; *3-5 before* =1 if month m falls 3 to 5 months before the harvest month of cell c's major crop; *0-2 before* =1 if month m falls 2 to 1 month before or on the same month as the harvest of cell c's major crop; *1-3 after* =1 if month m falls 1 to 3 months after the harvest month of cell c's major crop; *4-6 after* =1 if month m falls 4 to 6 months after the harvest month of cell c's major crop; *6-11 after* =1 if month m falls 6 to 11 months after the harvest month of cell c's major crop; spatial HAC Conley standard errors with 180km radius and one month lag.

should have no effect on agricultural productivity. Column (6) of table 2.1 shows that T_g increases incidences of riots and protests by around 0.4 percentage points whereas the coefficient on T_{ng} is very close to zero. Taken together with tables 2.2 and 2.3 these findings suggest that temperature affects protests and riots by changing agricultural incomes as well as via a more direct, short-term effect, operating through trust.

2.5 Temperature Anomalies and Attitudes

2.5.1 Estimation

We estimate the effect of perceived temperature (measured via the two components, T and F, of the heat index in equation 2.1) on self-reported attitudes and intentions as follows:

$$\begin{aligned} attitude_{ictmd} &= \alpha + \beta_1 T_{itmd} + \beta_2 F_{itmd} + \beta_3 P_{itmd} + \overline{\boldsymbol{C}}_{\boldsymbol{cm}}{}'\boldsymbol{\delta} \\ &\quad + \boldsymbol{X}'_{itmd}\boldsymbol{\gamma} + \eta_c + \psi_{tmd} + \epsilon_{ictmd} \end{aligned} \tag{2.4}$$

where $attitude_{ictmd}$ denotes mistrust in government (measured via the six questions outlined above), voting intentions and intentions to protest for respondent i living in

cell c interviewed in year t, month m and day d. The main regressors of interest are air temperature (T_{itmd}) and the *feel factor* (F_{itmd}) on the exact day of interview (i.e. day d in month m and year t) and at the precise location of the interview of respondent i. For completeness, we also control for precipitation (P_{itmd}). We estimate equation 2.4 by OLS.

We also include $\overline{\boldsymbol{C}}_{\boldsymbol{cm}}$, which consists of long term averages of T_{itmd}, F_{itmd} and P_{itmd} for month m in each cell c.[16] Because we include $\overline{\boldsymbol{C}}_{\boldsymbol{cm}}$, the variables T_{itmd} and F_{itmd} can be interpreted as daily deviations or anomalies on day d in month m from the long run average of month m and cell c. Whilst long-term climatic averages are likely to be associated with numerous underlying factors, such as, for instance, institutional quality (Rodrik et al., 2004; Acemoglu et al., 2002), daily deviations from these long-term means are plausibly exogenous. Finally, $\boldsymbol{X}'_{itmd}$ consists of characteristics[17] of respondent i; η_c and ψ_{tmd} are cell and date (i.e. for day d in month m and year t) fixed effects, respectively. We estimate Spatial HAC[18] (Conley, 1999) standard errors.[19]

We also re-estimate equation 2.4 including lags for T_{itmd} and F_{itmd} for the two days before (T_{itmd-1}, T_{itmd-2} and F_{itmd-1}, F_{itmd-2}) and leads for the two days after (T_{itmd+1}, T_{itmd+2} and F_{itmd+1}, F_{itmd+2}) the date of the interview. In addition, as a placebo check we estimate the effect of perceived temperature on (other unrelated) self-reported experiences that occurred before year t, month m and day d and should thus bear no relation to T_{itmd}, F_{itmd} and P_{itmd}.

2.5.2 Results 2: Temperature anomaly is associated with low trust

The dependent variables for mistrust in government are the six dummy variables described above. We also collapse these into a single index using principal component analysis and, to make the magnitudes meaningful, we create its z-score.[20] The maps reported in figure 2.3 plot averages for air temperature (panel a), the feel factor (panel b) and the first principal component derived from the six questions for trust in government

[16] We use the years 2009 to 2014 to construct $\overline{\boldsymbol{C}}_{\boldsymbol{cm}}$ for each month and each cell.

[17] As covariates we include dummy variables for the respondent living in a shack, or having no formal education, being employed, their religion being Christian, a female dummy, dummies for the respondent's race being black and one for mixed race. We also control for the respondent's age and for the latitude and longitude of the location of the respondent's residence.

[18] Heteroskedasticity- and autocorrelation-consistent

[19] Spatial HAC Conley standard errors use *reg2hdfespatial* programme by Fetzer (2020) based on Hsiang (2010) to account for heteroskedasticity and autocorrelations. We allow for 180km radius and one day lag.

[20] We use the first principal component.

(panel c) for each 1×1 degree latitude and longitude cells. Whilst average levels of mistrust show a correlation with both air temperature (T) and the feel factor (F), the mapping appears closer for the latter. This pattern is consistent with findings of prior studies highlighting the importance of humidity in determining perceived temperature (Alahmer et al., 2012; Vellei et al., 2017; Maley et al., 2018; Makowiec-Dabrowska et al., 2019).

The point estimates from the regressions of all seven dependent variables (six dummies and their principal component) on air temperature, T, and the feel factor, F, *on the exact day and at the precise location* of the interview are shown in panel A of table 2.3. We control for the local long-term means in T and F via $\overline{\boldsymbol{C}}_{\boldsymbol{cm}}{}'$, which allows for interpreting coefficients of both variables as the effects of deviations from long-term means, i.e. anomalies. Across six questions, a 1°C increase in the feel factor (F) increases self-reported mistrust by between 0.5 and 1 percentage point. This corresponds to 0.03 of a standard deviation in the principal component. When we consider voting intentions, we find that a 1°C positive anomaly in the feel factor (F) increases the probability of intending to vote for a party other than the current head of state by 0.8 percentage points (column 8).

As a robustness check, in panel B of table 2.3 we also control for air temperature and the feel factor on the location of interview two days before and two days after the interview (T_{itmd-1}, T_{itmd-2}, T_{itmd+1}, T_{itmd+2} and F_{itmd-1}, F_{itmd-2} and F_{itmd+1}). We do not expect an effect to exist for these. As expected, the parameter estimates for the two leads and two lags are small in size and not statistically significant. The magnitudes for the coefficient estimates on the actual day of the interview, by contrast, remain virtually unchanged in these specifications. That is, controlling for the effect of climate variability in the days before and after does not alter the conclusion.

2.5.3 Results 3: Temperature and voting

Finally, we test whether temperature's effect on voting intentions documented in section 2.5.2 reflects in election outcomes. That is, do people really vote against the government when they say they would? For this part of the analysis, we replicate our research design using data we digitised from all presidential elections held in Africa between 1990 and 2019. We only select countries that were classified as either *free* or *partly free* by Freedom House in the year the election was held. We also exclude the first elections

held after independence or after non-democratic regimes.

For each of the 98 elections in the sample, we construct a variable $votes_{ctmd}$ denoting the percentage of votes received by the incumbent president (or the party they are affiliated to) in country c in year t, month m and day d. We then regress $votes_{ctmd}$ on air temperature (T_{ctmd}), the feel factor (F_{ctmd}) and rainfall (P_{ctmd}) *on the exact day the election was held* whilst controlling for the long term averages of these three meteorological variables in country c for month m ($\overline{\boldsymbol{C}}_{\boldsymbol{cm}}$). Further controls include the number of registered voters, GDP per capita, foreign aid received and inflation (all measured in the year of the election) and year, month, and country fixed effects. The results are presented in table 2.6.

Table 2.2: Perceived temperature, trust in government and intentions to vote and protest

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variables:	1^{st} principal component for trust	1^{st} principal component for trust	1^{st} principal component for trust	1^{st} principal component for trust	1^{st} principal component for trust	=100 if resp. intends to vote against president	=100 if resp. intends to protest	1^{st} principal component for trust
Base category:		Different ethnicity to president	Ethnically heterogenous country	High slave trade	Poor country	Poor country	Poor country	
Feel factor (F)	0.031***	0.031***	0.044***	0.040***	0.041***	1.244***	0.798**	
on day of interview	(0.007)	(0.007)	(0.009)	(0.008)	(0.009)	(0.470)	(0.407)	
Feel factor (F)		−0.028***						
× same ethnicity		(0.008)						
Feel factor (F)			−0.024**					
× ethnically homogenous			(0.012)					
Feel factor (F)				−0.016*				
× low slave trade				(0.008)				
Feel factor (F)					−0.019	−0.688	−1.684***	
× rich country					(0.013)	(0.650)	(0.541)	
Air temperature (zscore)								0.004
								(0.021)
Humidity (zscore)								0.112***
								(0.026)
Wind speed (zscore)								0.014
								(0.010)
Solar radiation (zscore)								0.020*
								(0.011)
Rainfall (zscore)								−0.010
								(0.007)
Observations	49,968	49,968	45,185	49,968	49,484	49,968	48,828	45,349
Cell & Date fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Cell Climate average	yes	yes	yes	yes	yes	yes	yes	yes

Notes: This table shows results for the mediating role of ethnicity and poverty in the relationship between temperature and trust and intention to protest and vote against the incumbent. Across 7 specifications, the results show that ethnic diversity and exposure to the historic slave trade amplify the effects of perceived temperature on trust and poverty making it likely that people are willing to engage in protests. In column 8, we include each component of the heat index separately and find that humidity has the strongest effect. These results are consistent with predictions in the literature and our expectations. Spatial HAC Conley standard errors with 180km radius and one day lag are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

Table 2.3: Perceived temperature, trust in government and voting intentions

Dependent variables:	(1) =100 if resp. does not trust president	(2) =100 if resp. does not trust parliament	(3) =100 if resp. believes that politicians are out for themselves	(4) =100 if resp. disapproves of one party rule	(5) =100 if resp. disapproves of president can do what he wants	(6) =100 if resp. believes that president must obey the laws	(7) 1^{st} principal component z-score for trust	(8) =100 if resp. intends to vote against president
	Panel A: Effect of perceived temperature on day of interview							
Feel factor (F)	0.822**	1.138***	0.800***	0.764***	0.644**	0.472	0.031***	0.779**
on day of interview	(0.324)	(0.333)	(0.284)	(0.247)	(0.271)	(0.315)	(0.007)	(0.332)
Air temperature (T)	0.229	0.376**	-0.121	-0.019	-0.243*	-0.228*	0.002	0.455***
on day of interview	(0.172)	(0.157)	(0.123)	(0.106)	(0.136)	(0.133)	(0.004)	(0.143)
	Panel B: Leads and lags for the two days before and after interview							
Feel factor (F)	0.705**	1.185***	0.857***	0.610**	0.546*	0.460	0.029***	0.679*
on day of interview	(0.357)	(0.367)	(0.316)	(0.280)	(0.313)	(0.336)	(0.008)	(0.365)
Feel factor (F) on:								
1 day before interview	-0.283	-0.282	-0.432	0.068	-0.183	-0.071	-0.008	-0.100
	(0.349)	(0.349)	(0.290)	(0.275)	(0.318)	(0.325)	(0.007)	(0.355)
2 days before interview	0.466	0.287	-0.028	0.171	0.303	0.058	0.009	0.174
	(0.339)	(0.345)	(0.322)	(0.267)	(0.304)	(0.321)	(0.007)	(0.361)
1 day after interview	0.182	-0.087	0.201	0.271	0.157	-0.210	0.004	0.145
	(0.342)	(0.336)	(0.332)	(0.272)	(0.293)	(0.346)	(0.007)	(0.353)
2 days after interview	-0.058	-0.210	0.023	0.067	0.159	0.289	0.000	0.122
	(0.361)	(0.352)	(0.303)	(0.271)	(0.306)	(0.334)	(0.007)	(0.385)
	Panel C: Placebos: Dependent variable = 100 if respondent has ever							
	Contacted a Party official	Contacted a Trad. leader	Contacted a Rel. leader	Contacted a MP	Contacted a Govt agency	Feared crime	Felt unsafe	Physically attacked
Feel factor (F)	-0.019	0.125	-0.020	-0.088	-0.097	-0.187	-0.011	-0.142
on day of interview	(0.220)	(0.297)	(0.307)	(0.286)	(0.193)	(0.218)	(0.279)	(0.189)
Observations	50,018	50,022	50,012	50,002	50,021	50,017	49,968	48,828
Cell & Date fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Cell Climate average	yes	yes	yes	yes	yes	yes	yes	yes

Notes: This table reports results for perceived temperature, self-reported trust and voting intentions. We employ different measures of trust using questions in the Afrobarometer survey. In Panel A, across all 7 measures of trust(including the principal component z-score), the results show a strong relationship between perceived temperature and trust. Air temperature on the other hand weakly affects trust. Panel B tests for the robustness of results in panel A by including leads and lags as control. As expected, there is no effect for the leads and lags, confirming robustness. Panel C reports placebo results by checking for effects on events that occurred in the past and should not be affected by the current temperature. Spatial HAC Conley standard errors with 180km radius and one day lag are reported in parentheses. *** p<0.01,** p<0.05, * p<0.1.

Table 2.4: Perceived temperature and trust - different measurements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	1^{st} principal component							
Feel factor (F) on day of interview	0.026***	0.024***	0.026***	0.024***	0.018***	0.017***	0.028***	0.025***
	(.006)	(0.007)	(0.006)	(0.007)	(0.005)	(0.005)	(0.006)	(0.007)
Feel factor (F) on:								
Day before interview		−0.003		−0.003		−0.002		−0.003
		(0.006)		(0.006)		(0.005)		(0.007)
Two days before interview		−0.003		−0.003		−0.001		−0.004
		(0.007)		(0.007)		(0.00)		(0.007)
Day after interview		0.005		0.006		0.003		0.007
		(0.006)		(0.007)		(0.005)		(0.007)
Two days after interview		0.005		0.005		0.003		0.006
		(0.007)		(0.007)		(0.005)		(0.007)
Observations	50,034	50,034	50,034	50,034	50,034	50,034	50,034	50,034
Date & cell fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Surface area of human body	0.6	0.6	0.78	0.78	0.7	0.7	0.6	0.6
Non-cyclical shape of human body	0.483	0.483	0.645	0.645	0.483	0.483	0.446	0.446
Clothing of human body	0.37	0.37	21	21	0.57	0.57	0.21	0.21

Notes: This table shows parameter estimates for regression of self-reported trust on perceived temperature. The dependent variable is the z-score of the first principal component of the six measurements for trust used in different specifications. Different measures of the surface area of the human body, the non-cyclical shape of the human body and clothing of the human body are used. These numbers represent variations in assumptions that underlie measurements of the heat index in the literature (US vrs Canada, for instance). The results show that the conclusions from the main results hold for different assumptions. Spatial HAC Conley standard errors with 180km radius and one day lag are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

Table 2.5: Effect of perceived temperature on trust - robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variables:	1^{st} principal component for mistrust in government								Sum of dummies	
Feel factor (F) on day of interview	0.029***	0.027***	0.031***	0.026***	0.029***	0.026***	0.029***	0.026***	4.609***	4.341***
	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)	(1.050)	(1.146)
Feel factor (F) on:										
Day before interview		−0.008		−0.005		−0.003		−0.002		−1.140
		(0.007)		(0.007)		(0.007)		(0.007)		(1.077)
Two days before interview		0.008		0.011		−0.004		−0.005		1.229
		(0.007)		(0.007)		(0.007)		(0.007)		(1.081)
Day after interview		0.005		0.003		0.006		0.004		0.502
		(0.007)		(0.007)		(0.007)		(0.007)		(1.086)
Two days after interview		0.002		0.004		0.006		0.007		0.251
		(0.007)		(0.007)		(0.007)		(0.007)		(1.100)
Observations	49,968	49,968	49,968	49,968	49,968	49,968	49,968	49,968	49,968	49,968
Cell fixed effects	yes	yes	no	no	no	no	no	no	yes	yes
Date fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country fixed effects	yes	yes	no	no	no	no	no	no	no	no
Cell by Month fixed effects	no	no	yes	yes	no	no	no	no	no	no
Region by Month fixed effects	no	no	no	no	yes	yes	no	no	no	no
Region fixed effects	no	no	no	no	no	no	yes	yes	no	no

Notes: This table shows parameter estimates for regression of self-reported trust in government on perceived temperature. Dependent variable is z-score of first principal component of the six measurements for trust (in columns 1 to 8); dependent variable is the sum of dummies for the six measurements for trust (in columns 9 and 10). For robustness, we control for combinations of time and location variables. Results remain robust to inclusion of different combinations of controls. Spatial HAC Conley standard errors with 180km radius and one day lag are reported in parentheses.

Table 2.6: Temperature and voting

	(1)	(2)
Dependent variable:	Votes cast for president %	Voter turnout %
Feel factor (F)	-3.407**	3.196*
	(1.701)	(1.764)
Air temperature (T)	0.962	0.765
	(1.952)	(1.062)
Observations	98	98
Number of Registered Voters	yes	yes
Year and Month FE	yes	yes
GDP Per Capita in Election Year	yes	yes
Foreign Aid Received in Election Year	yes	yes
Annual Inflation in Election Year	yes	yes
Cell Level Long-Run Mean Temperature	yes	yes
Country FE	yes	yes

Notes: This table reports the effect of temperature on protests and riots and on votes cast at presidential elections. Spatial HAC Conley standard errors with 180km radius and one month lag are reported in parentheses. $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Column 1 of table 2.6 shows that a positive 1°C anomaly in the feel factor on the election day decreases the percentage of votes cast for the incumbent government by 3.4 percentage points. As before, air temperature shows no significant effect.[21] Temperature may affect votes cast through voter turnout. For example, the negative effect documented in column 1 could be explained by heat discouraging government sympathisers to vote. It is often the case that when a government is underperforming, all voters realise it but die-hard supporters of the incumbent regime will rather not vote than vote for the opposition. This will result in lower voter turnout for government supporters but will increase turnout for opposition supporters and neutrals. We explore this possibility by estimating temperature's effect on voter turnout. In fact, column 2 shows that temperature increases voter turnout by 3.2 percentage points suggesting that temperature's effect on attitudes outlined in section 2.5.2 mobilises voters. Certainly, it is more likely that dissatisfied voters will turn out to vote for change in a democracy.

The estimates in column 1 suggest that one standard deviation in the feel factor (1.9°C) decreases the votes cast for the president by around 6.5 percentage points. In the context of the African elections in our sample, this estimate is not large. In contrast to many high-income countries, African elections are not generally tightly fought. For instance, in our sample, 76 per cent of incumbent presidents are reelected. Moreover, in only 6 per cent of elections did the incumbent lose by 6.5 per cent or less. This suggests that temperature is not currently a decisive factor in determining winners of elections, but in stronger democracies, this could be significant.

[21] In columns 1 and 2 we allow for 10-year lags when clustering Conley standard errors to account for long voting cycles.

2.5.4 Socio-economic Correlates of Trust and Violence

Ethnic Diversity and Marginalisation: A section of the literature has suggested that any effect of climate variability on violence must be that it amplifies existing grievances (Collier and Hoeffler, 2004). Grievances are more likely to exist for groups that are marginalised (Blakeslee et al., 2021). To test for this, we identify groups that have been shown in related studies to be less likely to be trusting and estimate whether temperature's effect is stronger for these sub-samples (Collier et al., 2008). Across four independent measures, we find that the effect of temperature is consistently stronger for less trusting, more marginalised groups(Blakeslee et al., 2021).

In column (2) of table 2.2 we test for the role of ethnicity in shaping trust (Depetris-Chauvin et al., 2020; Green, 2018). Comparing each respondent's self-reported ethnicity with the president's, we define a dummy taking the value one if the respondent and the head of state are from the same ethnicity (the base consists of respondents from other ethnic groups). Second, in column(3) we test whether the effect of temperature is stronger in ethnically diverse countries. Using the Ethnic Fragmentation Index (Alesina et al., 2002), we define a dummy taking the value one if the index is below the median (the base consists of countries which are ethnically more fragmented). Third, in column(4) we use the finding by Nunn and Wantchekon (2011) that ethnic groups that experienced a greater intensity of slave trade were less trusting (figure 2.2) by matching the ethnic homeland of respondents' residence with historical slave trade data. We define a dummy equal to one if slave exports were below the median (the base consists of ethnicities with high slave trade). In all specifications, we find that ethnic diversity and exposure to the slave trade amplify the effects of climate variability on trust.

History cannot be changed and it is not practical to separate ethnic groups. However, measures can be designed to promote trust and reduce violent conflicts. Findings from a lab-in-the-field experiment in Africa by Robinson (2016b) shows that people with stronger national identities were blind to ethnicity, but those with a stronger ethnic identity trusted non-coethnics less. Green (2018) also finds that people had stronger national identities in Uganda if they are from the ethnic group of the president and a stronger ethnic identity if they were from other groups. Similarly, Hodler et al. (2020) shows that economic and social stratification in Africa is along ethnic lines. Therefore, promoting a stronger sense of national identity and reducing

economic inequalities can mitigate the effects we find.

Poverty Amplifies Effects: Poverty has been cited as a factor that amplifies grievances. Hodler et al. (2020) shows that mistrust between two individuals was determined by economic distance. Following Manacorda and Tesei (2020), we distinguish rich from poor countries. Using data on the incidence of poverty by the World Bank, we define a dummy for whether the percentage of individuals living on less than USD1.90 a day lies below the median (the base consists of countries with high incidences of poverty). Columns (5) and (6) of table 2.2 show that the effect of temperature on the intention to vote for opposition parties is stronger in poorer countries. The link between climate and conflict, column (7) also shows that a 1°C positive temperature anomaly on the day of the interview increases self-reported intentions to protest by around 0.8 percentage points in poor countries.

The relationship between income inequality and political mistrust is well documented (Zmerli and Castillo, 2015; Farah and Hook, 2017). This can be explained to be because poor people feel that the ruling political class has not implemented effective poverty alleviation policies. At election time, it becomes untenable for the ruling class to convince the poor that if they win, they will implement pro-poor policies. Thus poor people are expected to reject the incumbent and prefer the opposition. They are also likely to engage in violent conflict because the opportunity costs may be lower.

2.6 Conclusion

To reiterate, the main argument of this paper is that (1) extreme ambient temperature is associated with higher incidents of protests and riots. This is within the context of the broader literature on the effect of climate change on violent conflicts and crime. (2) This effect happens through a direct impact on people's attitudes, such as trust. While much of the existing literature suggests that the effect of climate change is via impacts on agricultural income shocks, others show that climate variability is associated with violence and aggression in nonagricultural contexts. The latter implies that an agricultural income channel may not be universal.

We explored trust- as a unit of attitude- as another channel that is not context specific. We do not suggest that trust is the only channel-indeed we show that other channels exist. However, trust as a channel has not been previously explored in the climate-violence literature. We demonstrate our conclusions by showing that (1)

protests and riots are more likely on extremely hot days, (2) people are less trusting on warmer days, (3) people are more willing to engage in protests and riots on warmer days, and (4) people are more likely to vote against incumbent governments on warmer days. These results show that violent intentions and mistrust are more likely on warmer days and people take action on these intentions and mistrust. Our findings are informative and have implications for policing, crime, security, and government engagement with the public, including policy dissemination.

Our findings show that people trust elected officials less on hotter days. As policymakers, important public engagements aimed at rallying citizens to action or building consensus should be avoided on hotter days. As much as possible, protests should not be permitted on warm days. We do not have enough data to check the effects of trust in the police and interpersonal violence. However more policing on warm days may be beneficial for reducing interpersonal crimes (Baysan et al., 2019). Existing crime studies show that interpersonal violent crime is more likely on warmer days and in summer. Especially, domestic violence has been found to be common on warmer days. It is plausible that mistrust can trigger domestic violence. Television and radio programming could be designed to suppress aggressive thoughts on warmer days and in summer.

We find that ethnic fragmentation is associated with higher incidences of protests and riots. Existing literature has shown that mistrust is also more likely in these contexts. Many African countries are ethnically diverse and have also been found to have lower levels of inter-ethnic trust. Governments in ethnically diverse countries must design and implement policies to increase interethnic trust within their country. We could not get reliable data to test whether the president, being from a different ethnic group, increases mistrust. Nonetheless, if inter-ethnic mistrust extends to elected officials, the risk of ethnic-based civil wars aimed at changing governments is higher.

Existing literature shows that mistrust of government was more likely among marginalised groups and the poor. Our findings also show that this was the case during extremely hot days. The idea that poverty is a national security issue is not new. Implementation of poverty reduction strategies needs to be accelerated as part of global security policy especially given that inequality is increasing in many countries. These findings could explain why violence and crime, including terrorism, are more prevalent in poorer parts of several African countries, especially in parts where temperatures are

high and rising.

It would be interesting to extend this study by examining the effects of climate variability on interpersonal crimes in Africa. Existing research in this area is limited. The approach we follow to identify the location of violence can be useful in the context of crime, to effectively deploy crime prevention and to identify other social and economic correlates of crime specific to a given locale. Future studies can take this up as data becomes available.

Chapter 3 BE FRUITFUL AND MULTIPLY: RELIGION AND FERTILITY IN AFRICA

Abstract

Africa is known for its religiosity and high fertility rates. Empirical evidence linking the two is however sparse. This essay contributes to this strand of the literature by building on evidence from Nunn (2010) to instrument religion using Roome (1925)'s data on Christian missionary stations in econometric analysis. This approach which has not been previously used allows for the identification of the effects of religion on fertility. The findings show that the ideal number of children, the total number of children ever born, son preference and contraceptive use vary significantly between Christians and Muslims. This result is largely driven by married women which further confirms that religious beliefs may influence fertility choices.

3.1 Introduction

The dominant view among economists is that a large family strains household budgets and adversely affects the ability of parents to provide adequate nutrition, healthcare, and education for their children. This results in a cycle of poverty (Burgess et al., 2006; Polizzi et al., 2022; Libois and Somville, 2018; Adebowale et al., 2020). Hence, poverty alleviation programs have included efforts to reduce fertility (Fanti and Gori, 2012; Herbst-Debby et al., 2021). These efforts have yielded impressive results globally. Alongside declining poverty rates, global fertility rates reduced from 4.2 children in 1975 to 2.4 children in 2017 (World Bank, 2019). Much of this decline, however, occurred outside Africa. Fertility rates in Sub-Saharan Africa declined from 6.8 children per woman in 1975 to 4.8 in 2017 but within the sub-region, countries differ significantly. Niger had a fertility rate of 7.2 children per woman in 2017 compared to 1.4 in Mauritius which together with Cape Verde, were the only two of the 54 countries in Africa below the 2017 global fertility rate of 2.4 (World Bank, 2019). Theoretical models explaining this demographic transition have cited economic development as the main driver of the transition (Leibenstein, 1975, 1981; Becker and Barro, 1988; Becker, 1992; Mason, 1997). However, evidence linking economic development and fertility decline

in countries outside America and Europe has been inconclusive (Ibeji et al., 2020; World Bank, 2019; Chouhan et al., 2020). Alternative explanations such as education (Berrington and Pattaro, 2014; Monstad et al., 2008; Khraif et al., 2017; Kohler et al., 2006), employment status (Kreyenfeld and Andersson, 2014), quality of healthcare (Hatton et al., 2018) and culture (Fernandez and Fogli, 2006; Nwogu et al., 2021; Chouhan et al., 2020) have been proposed. An aspect of culture that has received little attention, however, is religion (Nwogu et al., 2021). This paper examines the role of religion as a socio-cultural determinant of fertility in Sub-Saharan Africa.

Human fertility is a complex construct affected by many factors. The proximate factors can be classified into three. The first includes factors affecting the exposure of women to sexual intercourse such as puberty rites, sex education, the legal age for marriage and sexual relations, and other factors that contribute to the sexual socialization of girls (Adegoke, 2001; Munthali and Zulu, 2007). The second category includes factors such as fecundity, sterility, and intrauterine mortality that regulate fertility unintentionally (Bongaarts, 1987; Zhang, 1990). The third category includes factors such as contraceptive use and induced abortion that are used intentionally to regulate fertility (Bhalotra et al., 2021; Chauhan and Prasad, 2021; Bongaarts, 2010). Religion affects the first and third categories. For instance, among Christians and Muslims, sexual intercourse is acceptable only within the context of marriage. This means Christians and Muslims committed to this religious injunction would not engage in extramarital sexual activities; a high legal age for marriage in such contexts will lead to lower fertility. Abortions are also not supported by some major world religions; which can contribute to high fertility rates in societies where those religions are prevalent.

Neoclassical microeconomic theories of fertility regard children as economic goods and fertility choices as economic decisions. According to these theories, family size is determined by the opportunity cost of having children, household income, and the preference for children relative to other consumption goods (Becker, 1992; Becker and Barro, 1988; Rosenzweig and Schultz, 1985). Couples maximize their utility for children subject to these constraints. Observational evidence, however, does not bear the predictions of these theories up in developing country contexts. While neoclassical theorists think of fertility choices as consumption goods, fertility choices in current developing countries are determined by cultural factors, not economic considerations (Chouhan et al., 2020). For instance, contrary to conclusions of economic theories,

more recent evidence shows that poor people tend to have more children (Birdsall, 1988; Bongaarts, 2010); and women's fertility choices have been shown not to change their preferences for, or the opportunity cost of, other goods (Martin and Juarez, 1995). Economic theories also ignore key factors in fertility decision-making such as socialization (Rossi and Rouanet, 2015; Rossier and Bernardi, 2009). This paper argues that economic considerations are not the most important in Sub-Saharan Africa in fertility decisions: cultural and religious norms are.

This paper also argues that intention precedes fertility behaviour (figure 3.1). A big initial appetite for a large family will result in a big family. Religious affiliation engenders the formation of subjective norms about fertility. Religious affiliation puts people in a social network. Interactions within the network contribute to shaping fertility ideals and practices. This may happen in three identifiable ways: social learning; social influence; and social support (Lehrer, 1996). Heaton (1986) and Billari et al. (2009) give clear examples of the network effect of religion on fertility. The US state of Utah for instance has a majority Mormon population (Conley, 1990). Consequently, fertility rates in that state are strikingly higher than the national average; partly because Mormons provide social support for their pronatalist theology (Conley, 1990; Heaton, 1986). Pronatalist religions orient adherents towards large families. Thus, their default intention will be to have a large family; in the context of fertility behaviour, intentions have been shown to be a good predictor of actual fertility (Conner and Norman, 2005). This study seeks to answer the question of whether religious affiliation affects women's fertility intentions, preferences, and outcomes.

This paper is not the first to argue that fertility is affected by religious affiliation. Bassi and Rasul (2017) showed that exposure to religious messages against artificial contraception during papal visits was associated with a spike in the number of births 9 to 12 months later, in mostly Catholic Latin American countries. Smith-Lovin and Tickamyer (1978) used religious affiliation as a predictor of family size but only as an instrument for family size. This paper contributes to the strand of literature that emphasises the role of socialisation in explaining fertility using cross-national data for Africa. This study is similar to Heaton (2011, 1986) and Lehrer (1996) in the larger context of providing evidence linking fertility intentions and outcomes to religious affiliation and the socialisation associated with religious affiliation. Heaton (1986)'s was a case study motivated by theological considerations; with a sample from Mormons in

America. Lehrer (1996)'s also compared different religious groups in America but was interested in how husbands' religious affiliation interacted with wives' to determine wives' fertility outcomes. Heaton (2011) examined religious affiliation and fertility in developing countries across different continents but focused on current fertility whereas this paper examines total and completed fertility. I compare Christians with Muslims.

Sub-Saharan Africa is highly religious, and its religiosity is forecasted to grow (Pew Research Center, 2015). Most Africans profess either Christianity or Islam- two foreign religions that have become dominant in the region in the last century (Pew Research Center, 2015). Together with the region's high fertility rates, the religiosity of Sub-Saharan Africa presents an opportunity to explore the question of the relationship between religion and fertility. This paper explores this question and finds significant relationships between religious affiliation and fertility. I explore rarely used historical data on missionary stations in Africa as an instrument for religion to establish that affiliation with a religion affects one's fertility. This instrument, inspired by the work of Nunn (2010), takes GIS/GPS data of the locations of Christian missionary stations from Roome (1925) and combine them with respondents' location to identify effects. This approach to instrumenting religion is new.

I make at least two contributions to the literature. First, studies on the link between fertility and religious affiliation are dwarfed by those on other social determinants of fertility. More so for Africa. Africa is, however, both highly religious and highly fertile. This paper contributes to the literature on the socio-cultural determinants of fertility by providing new evidence for religious affiliation. Secondly, the few studies on the role of religion on fertility have focused mostly on small groups/towns/ethnicities within a country. I examine a cross-national dataset. Heaton (2011) used cross-national data for developing countries but aggregates countries from Africa, Asia, and Latin America. I use data for Africa only and disaggregate the data by sub-regions to reflect the uniqueness of the regions of Sub-Saharan Africa. Similarly, empirical studies on religion and gender preferences and contraception use in Africa are limited. This paper contributes to this strand of the literature on the social determinants of health by providing new empirical evidence.

Section 3.2 presents an overview of the literature, section 3.3 discusses the data, section 3.4 describes the methods used for this study, section 3.5 presents and discusses the results of the data analysis and section 3.7 concludes.

3.2 Related Literature

3.2.1 Theoretical Literature

Fertility intentions and behaviour are complex constructs that are bound to defy simple models as with any form of human decision-making and behaviour. Consequently, I draw on multiple theories for the analysis. I summarise key theories and findings of prior literature in the following paragraphs and in figure 3.1.

Economic Theories

Neoclassical microeconomic theories of fertility start by regarding children as economic goods and fertility choices as economic decisions. According to these theories, the proximate determinants of fertility are (1) the relative cost of children in terms of other consumption goods (that is, opportunity costs of having children), (2) the income level of the couple and (3) their preference for children compared to other goods (Becker, 1992; Becker and Barro, 1988; Rosenzweig and Schultz, 1985). According to these theories, women or couples maximize their utility for children by observing these constraints on their desires. The argument of these microeconomic theories though sound is implausible, especially in the context of developing countries. The commodification of fertility choices oversimplifies a complex process such as fertility intentions and outcomes. For instance, more recent data has shown that poor people tend to have more children although economic theories suggest otherwise (Birdsall, 1988; Bongaarts, 2010); and desire for children did not change women's preferences for or the opportunity cost of other goods (Martin and Juarez, 1995). These theories also ignore key factors in fertility decision making such as socialisation (Rossi and Rouanet, 2015; Rossier and Bernardi, 2009)

Easterlin (1973, 1975) attempted to remedy the weakness of the microeconomic theories by recognising the role of social factors and introducing another proximate determinant: the supply of children. His supply of children axiom acknowledged the fact that fertility choices have biological and medical dimensions. He also took a broader view of what constitutes the costs of children to include social costs. Unfortunately, this remedy does not resolve the problems mentioned earlier. These theories appear to associate having children with a sort of disutility or diminishing utility. The term *"risk of getting pregnant"* seems to support this assertion. On the contrary, religious

people might not regard pregnancy as a risk. The Quran, for instance, tells Muslims that children are a blessing for the present life in the same way that wealth is (18:46). Similarly, the Bible tells Christians that Children are gifts and rewards from the Lord (Psalm 127:3). Additionally, among the Akan of Ghana, women (and their husbands) are rewarded for their 10th child. Neither of these implies a disutility in having more children.

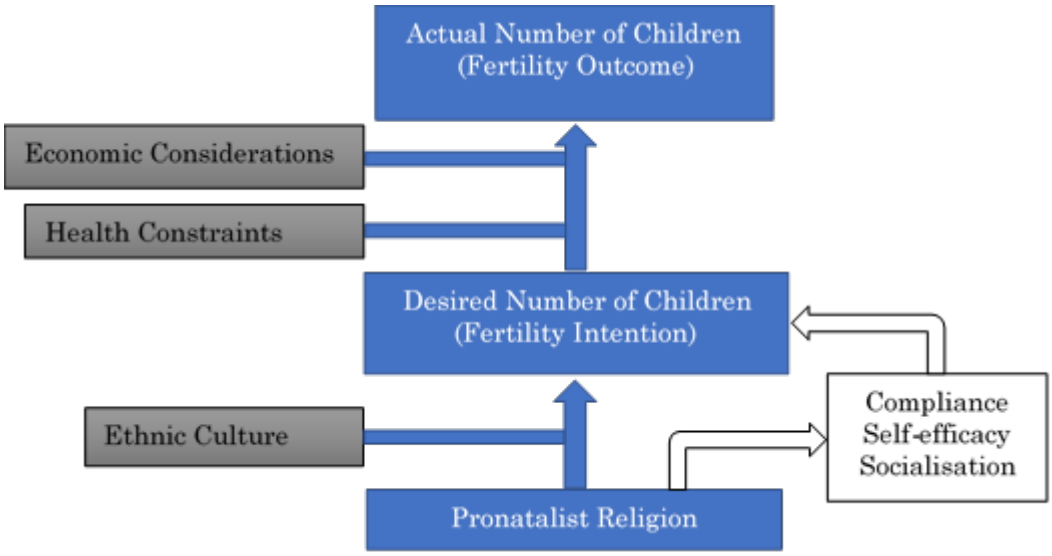
Transition Theories

Outside economics, demographic transition theories have also explained variations in fertility at the macro-level. These theories argue that fertility is determined by social factors such that variation in fertility is explained by changes in social factors. The transition theories argue that industrialisation and urbanisation are the main processes that drive fertility choices over time (Hirschman, 1994; Neumayer, 2006; van de Kaa, 1996). When tested with data, the predictions of the theory were found to hold for centennial data but not decadal data suggesting that it is able to explain fertility in the very long run only (Mason, 1997). Additionally, the conclusions of the theory hold for aggregated data but not for country-level data. This had been observed in Asian and Latin American countries. As expected, transition theories have been shown to work in Europe and Asia but not in Africa (Choudhry and Elhorst, 2010). This could be explained by the fact that Africa is not industrialised and only marginally urbanised; even so not in the same way that New York is urbanised, for instance.

Lesthaeghe and Surkyn (1988) extended the transition theory by arguing that in addition to economic development, the individualism and self-fulfilment that accompany affluence and secularisation explain the fertility transition. Empirical evidence in the decade following showed that his theory is only well suited to data from Europe but not developing countries (Mason, 1997). In Africa for instance, the extended family system remains so the individualism argument might not be applicable. The continent's increasing religiosity, as shown by the Pew Research Center (2015) also limits the applicability of the secularisation argument.

The theory of wealth flow argues that fertility is determined by the nature of the family system in the community a woman lives in and the net flow of wealth between parents and children (Caldwell, 1982; Kaplan, 1994). Building on the neoclassical economic theories and the transition theories, the theory of wealth flow posits that

Figure 3.1: Religious Socialisation, fertility intentions and outcomes



Notes: Combining cross-disciplinary theories on behaviour and fertility, this framework shows the relationship between religious affiliation and fertility outcomes. The main argument is that belonging to a pronatalist religious group orients one to want more children; and the more children one wants, the more they will have relative to others who want fewer. These desires are however subject to, or conditional on, biological, medical, economic and cultural factors. In the case of Africa, culture or tradition usually tends to be pronatalist and may reinforce higher fertility when it interacts with pronatalist religions. These arguments are tested empirically using both cross-regional aggregated data and regional data.

economic and cultural changes bring along with them emotional nucleation of family life that makes couples desire to have fewer children (Kaplan, 1994). This, Caldwell (1982) attributes to the desire of parents to build a bright future for their children under the nuclear family system (and minimize the negative net wealth flows associated with high levels of economic development) unlike in the extended family system where parents maximize old age security (net positive wealth flows) not just by investing in their children but also via other children. A consequence of the extended family system is that there is a communal pooling of resources to raise quality children. The absence of this form of pooling in the nuclear system means that returns to raising a child depends entirely on what the parents put in; couples choose to have as many children as they can adequately invest in which usually means fewer. Caldwell (1982) proposed this theory following his work on countries in SSA, and so this theory may be regarded to be well suited to developing country contexts.

The Theory of Planned Behaviour

The theory of planned behaviour is a behavioural theory that has been drawn into explaining fertility behaviour (Billari et al., 2009; Caplescu, 2014). According to this theory, actual behaviour is predicted by intention and the perception of ability to carry out the action (Ajzen, 1987). Intention is influenced by three factors. The theory

names these factors as perceived behavioural control, attitude toward the behaviour and subjective norm.

Perceived behavioural control is the belief of the individual of how easy or difficult it is to perform the behaviour intended. In the absence of known biological and medical constraints, females are expected to be able to have as many children as they wish. This will feed into the formation of fertility intentions. This dimension of planned behaviour implies that women form realistic intentions. That is, intentions that are probable. Before they perform the intention (and perhaps before they form the intention), they will evaluate the intention for desirability. They are more likely to intend it and to perform it if they have a positive evaluation of it; otherwise, they would not perform it. Religion by its nature, is a set of beliefs and ideas that have a bearing on many life choices. Indeed, we have already discussed the positions of major religions on fertility behaviour. These beliefs would inevitably affect the fertility decision making of adherents of these religions. Thus, religious considerations may affect their evaluation of any form of fertility behaviour.

People also consider the expectations (subjective norm) of other people and other social factors. Religions expect their members to adhere to their beliefs- for that is what it takes to belong. Bearing this expectation in mind, religious people tend to conform. In the context of fertility behaviour, intentions have been shown to be a good predictor of actual fertility (Conner and Norman, 2005). Hence, if the religion leans towards a large family, adherents will have large families, all things equal. There is however a mismatch between fertility intentions and actual fertility; people tend to want more than they end up having (Rossier and Bernardi, 2009). The microeconomic theories may explain this mismatch. For instance, women wanting a large family may realise that after a few births, they are unable to cope with the expanding family budgets. Doctors may advice that having more children will have adverse effects on their health. In the face of medical concerns, most religions allow all forms of birth control and abortion (Bhalotra et al., 2021). Some combination of attenuating factors may cause them to give up wanting more children, but this tend to happen only after they have had quite a number already. Perceived fertility behavioural control will therefore depend on health status and the quality of healthcare accessible to them and their permanent income or projected lifetime earnings, given their religious beliefs.

Religious affiliation puts people in a large social network. Interactions within

the network contribute to shape fertility ideals and practices. This may happen in three identifiable ways: social learning; social influence; and social support (Lehrer, 1996). The clearest example of the network effect of religion on fertility we have seen is by Heaton (1986) and Billari et al. (2009). The US state of Utah for instance, has a majority Mormon population. Consequently, fertility rates in that state are strikingly higher than the national average; largely because Mormons provide the social support for their pro-natalist theology (Conley, 1990; Heaton, 1986). The conceptual framework (figure 3.1) used for the analysis presented in this paper draws from all three categories of theories that have been taken from three disciplines, economics, demography and psychology respectively, to explain micro level fertility intentions and behaviour.

3.2.2 Determinants of Fertility behaviour

Son/daughter preference

Sons and daughters are wanted unequally in some cultures. In many developing countries, tribal customs make one of the genders more desirable (Chauhan and Prasad, 2021). For instance, in some Indian tribes, women pay dowry to get married (Alfano, 2017). Having more daughters than sons could thus generate net losses for families. Alfano (2017) argues that in such cultures if the first child is male, other things equal, the desire for another child is reduced. If the first child is female, couples would try a second time with the hope to get a son. If their second attempt does not yield a son, they have a tendency to keep trying for a son. This would lead to higher fertility for women whose first deliveries are females. If the first two children are males, the desire for a third child is lower than if the first and second are female.

In other cultures, matrilineal inheritance makes daughters more desirable than sons. For instance, among the Ashanti people of Ghana, men pay dowry but the children belong to their mother's clan rather than their father's (Awusabo-Asare, 1990; Kutsoati and Morck, 2016). This means having more daughters is a double win. Another win in this culture is that if they have any sons the future wealth of these sons will be bequeathed to members of their mother's clan (Kutsoati and Morck, 2016; Gedzi, 2009). The system of inheritance differs within and across countries in Sub-Saharan Africa. The preference for a certain gender could thus drive high fertility rates if the desired gender does not appear in earlier births.

I examine the relationship between religious affiliation and gender preferences.

Evidence in the literature suggests that Muslims may prefer sons to daughters, but this may interact with other cultural customs. This has been observed in Malaysia and China (Cohen, 1998; Zhang, 1990) and is observed also in the data used for this study. In the case of China, Zhang (1990) notes that the preference for sons is in terms of wanting to have at least one son rather than wanting more sons than daughters. Such a preference could mean that but for the fertility restrictions in China, the typical family whose first delivery is a female would have tried until at least when they get their first male. In Korea, Chung and Gupta (1998) showed that son preference was a predictor of higher fertility rates. These studies are relevant because these countries were at lower levels of development during those periods. Thus, finding that gender preference leads to higher fertility can provide lessons for developing countries.

Education and Age

Education is one of the variables that has traditionally been cited as a determinant of fertility (Monstad et al., 2008). A common finding is that fertility is negatively correlated with education and age (Keats, 2018; Osili and Long, 2008). This is often attributed to the delay of marriage due to the time spent in school (Chouhan et al., 2020). While the two are not strictly mutually exclusive, it is conventional for young ladies to drop out of school as a result of pregnancy and childbirth. Young ladies who have the ambition to achieve higher levels of education, therefore, avoid pregnancy while schooling (Monstad et al., 2008). This means they start having children when they are older and have fewer, overall.

Some studies have, however, shown that the relationship between education and age and fertility is not linear because the influence of education and age on reproductive behaviour is mediated by other factors such as attitudes and cognitive and economic assets (Chouhan et al., 2020). This has been documented in the study by Rossier and Bernardi (2009) in nine Latin American countries and by other studies (Eg. Berrington and Pattaro (2014); Testa (2014); Chouhan et al. (2020); Grönqvist and Hall (2013)).

Access to Contraceptives

Contraceptive use is an important determinant of fertility generally (Chauhan and Prasad, 2021). They include artificial and natural methods. In Africa, fertility levels and use of contraceptives have shown an inverse relationship over the last three decades

(Cohen, 1998; Alemayehu et al., 2010). This might be seen as an indication that using contraceptives results in fewer childbirths. Cohen (1998) however finds that whiles use of contraception has led to significant decline in fertility globally, its impact in Africa has been the slowest.

Women in Sub-Saharan Africa tend to use contraceptives to space rather than limit child birth (Rossi and Rouanet, 2015; Nwogu et al., 2021). After all, these birth control methods are presented to these women as "family planning" devices rather than "family size reduction" tools. Thus the downward trend in Africa has been attributed to other factors such as rising rates of formal education attainment and late marriage Bokek-Cohen et al. (2022). The latter is the result of legislation on compulsory minimum education and higher marriageable age for women. Some authors argue that the use of contraception is dependent on and may be increased by higher educational attainment and economic development (Khraif et al., 2017; Medoff, 2012; White et al., 2018).

Cultural Context

The determinants of fertility need not all be quantifiable. Context matters (Nwogu et al., 2021). Culture varies widely among Africa's many tribes. Each of these cultures has aspects that affect fertility differently. Some tend to be more malleable and others less so. Across Africa's sub-regional groups, Cohen (1998) and Caldwell et al. (1992) confirm a characteristic of our data that shows that fertility varies across sub-regional groups. This reflects the cultural homogeneity within sub-regional groups.

Another dimension of context is whether a woman lives in an urban or rural area (Ibeji et al., 2020). Available evidence suggests a relationship between this and fertility (Zhang, 1990). Rural communities are characterised by lower levels of income because of fewer formal employment opportunities and poorer health statuses due to lower access to quality healthcare. Necessities also tend to be cheaper or freely available in rural communities making it cheaper to rear children. Family life in rural areas tends to be organised on extended family systems which allows communal rearing of children and a form of economies of scale that reduces the cost of child-rearing (Conley, 1990; Hondroyiannis, 2010; Rossier and Bernardi, 2009).

3.3 Data

This study includes women aged 15 to 49 that were interviewed in the DHS[1] surveys for 18 countries (table C.1). The most recent survey round for each country is included. To make respondents comparable, only countries with data for rounds 6 and 7 are included in this study. "Protestant" is a label for several independent Christian churches other than the Catholic church. Women who did not self-identify with any Christian denomination or Islam were excluded from the dataset, but the included group represents 93.7% of the target population (Pew Research Center, 2015). A total of more than 307 thousand women are included. About 26% of the respondents self-reported to be Catholics, 57% to be Christians in a denomination other than Catholic (i.e Protestants) and 16% self-reported to be Muslims.

There are clear variations in the fertility intentions (ideal number of children) and outcomes of the women included in our sample across religions (figure 3.3). There is a stronger preference for sons among Muslims relative to Christian women. About 1 in 4 Catholic women ($mean = 4.5$) and 3 in 10 Protestant women ($mean = 4.8$) want more than 5 children compared to more than half of Muslim women ($mean = 6.5$). About 1 in 5 Catholic women ($mean = 2.9$) and 1 in 4 Protestant women ($mean = 3.3$) had more than 5 children, compared to 1 in 4 for Muslim women ($mean = 3.3$).

The mean ages of the respondents were 29 for Catholics, 30 for Protestants, and 28 for Muslims (figure 3.2a). The mean years of schooling completed were 6.1 for Catholics, 6.4 for Protestants, and 3.4 for Muslims (figure 3.2b). Measured as the probability of ever enrolling in primary school, Catholics and Protestants had a probability of 0.82 and 0.85 compared to 0.45 for Muslims (figure 3.2c). Consistent with the pattern of education, the mean household wealth quintile was 3 for Catholics, 3.12 for Protestants and 2.8 for Muslims. About 62% of the women in the sample live in rural communities; this does not differ by religion (figure 3.2d). About 29% of respondents reported that they used contraceptives. Muslims were the least likely to use any contraceptives, with 14% using compared to 29% for Catholics and 33% for Protestants (figure 3.3d). Among Christians, the variations in usage are consistent with doctrine.

Consistent with the arguments presented in section 3.1, there is a positive and

[1]Demographic and Health Surveys

Table 3.1: Summary Statistics, Combined Christian sample and Muslims

Descriptive Statistics for Muslims and Christians								
	Muslims				Christians			
	Fertility Intention	Total Number of children	Education in single Years	Rural	Fertility Intention	Total Number of children	Education in single Years	Rural
				All women				
Mean	6.50	3.29	3.37	0.38	4.69	3.19	6.28	0.38
Std. dev	3.40	3.01	4.41	0.49	2.28	2.88	4.20	0.49
Min	0	0	0	0	0	0	0	0
Max	30	17	21	1	30	18	24	1
				Women over 40				
Mean	7.57	6.80	2.04	0.37	5.79	6.33	5.13	0.34
Std. dev	3.81	3.07	3.75	0.48	2.74	2.84	4.23	0.47
Min	0	0	0	0	0	0	0	0
Max	30	17	19	1	30	18	24	1

Notes: Summary statistics are presented for the combined sample of Christians and Muslims.

Table 3.2: Correlation Coefficients

(a) Panel A- All Women

	Fertility intention	Total children born	Religion	Education	Rural
Fertility intention	1.0000				
Total children born	0.3968*	1.0000			
Religion	0.2166*	0.0449*	1.0000		
Education	-0.2981*	-0.3395*	-0.1660*	1.0000	
Rural	-0.1266*	-0.1600*	0.0067*	0.3436*	1.0000

(b) Panel B- Women Over 40

	Fertility intention	Total children born	Religion	Education	Rural
Fertility intention	1.0000				
Total children born	0.3577*	1.0000			
Religion	0.1698*	0.0716*	1.0000		
Education	-0.2147*	-0.2824*	-0.1315*	1.0000	
Rural	-0.0831*	-0.1979*	0.0222*	0.3295*	1.0000

Notes: Two sets of correlations are presented in this table. Panel A includes correlations for the full sample and panel B includes correlations for a sub-sample of women over 40years old. Coefficients with a star(*) are statistically significant at 5%.

significant correlation between fertility intentions and actual fertility. It can also be seen from table 3.2 that fertility intentions and religion are positively correlated whiles fertility intention and outcomes are both inversely correlated with education and rural. These correlations hold for women regardless of age.

When over 40s are taken separately, the patterns change in important ways which suggest, first, that overall fertility may be declining, as is well established in recent statistics; and secondly, that there may be differences in the timing of birth, possibly mediated by differences in educational attainment. Over 40s are interesting demography because most people tend to complete childbirth before 40. Hence, it is possible to make inferences about completed fertility using the over-40 sample. Summary statistics are also presented for the combined Christian sample in table 3.1

For those over 40, the proportion of Catholics remains unchanged at 26.5%.

The Protestant population is however higher at 61% and the Muslim population is lower at 13%. The proportions living in rural areas versus urban areas are unchanged (figure 3.4d). Mean age is 44.9 for Catholics, 44.7 for Protestants and 45 for Muslims (figure 3.4a). Educational attainment is lower in the over-40s sample. Total years of schooling was 4.7 for Catholics, 5.3 for Protestants, and 2 for Muslims (figure 3.4b). When measured as a probability of ever enrolling, Catholics had a probability of 0.71, Protestants, 0.77, and 0.30 for Muslims (figure 3.4c).

Consistent with estimates in Caplescu (2014) The patterns of fertility intentions and outcomes are identical to the full sample but with higher magnitudes. The ideal number of children for Catholics was 5.6, 5.9 for Protestants, and 7.6 for Muslims (figure 3.5b). Actual number of children (completed fertility in this case) is 6.1 for Catholics, 6.4 for Protestants, and 6.8 for Muslims (figure 3.5a). There is a strong preference for sons in the over-40's sample as in the all-women sample (figures 3.5c and 3.3c). These numbers also show that the ideal family size and actual family size of African women might be on a decline. As in the full sample, there is a positive correlation between how many children a woman wishes to have and how many they actually end up having. This is among the arguments of this study that the religious affiliation of a woman affects the size of her fertility intention through the doctrines of her religion and fertility outcomes.

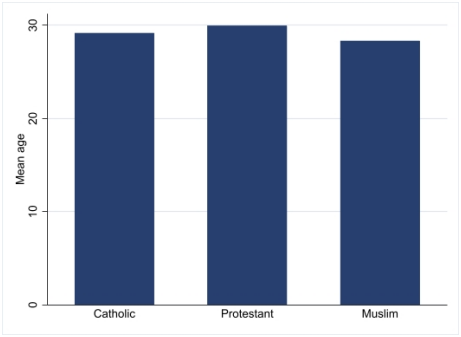
3.4 Empirical Strategy

3.4.1 Identification

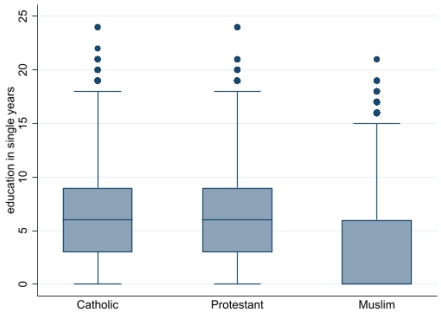
The effect of religion on fertility is estimated using the two stage least squares method. Because religious affiliation is not random, religion is potentially endogenous. People are more likely to adopt the religion of their parents or guardians. In some instances, religious affiliation is synonymous with ethnicity (or tribe) and culture which also influences fertility decisions (Chouhan et al., 2020; Avong, 2001). For instance, Nwogu et al. (2021) finds that the mbaise people of Nigeria who were predominantly Catholic, had fertility behaviour and outcomes that was consistent with both Catholic teachings and indigenous culture. I confirm the endogeneity by testing. To resolve the endogeneity problem, religion is instrumented with the proximity of the respondent's residence to a mission station.

Figure 3.2: Summary statistics for control variables-all women

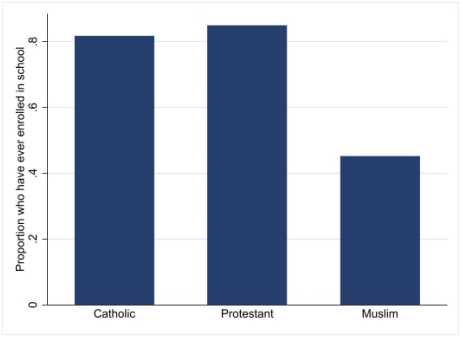
(a) Mean age



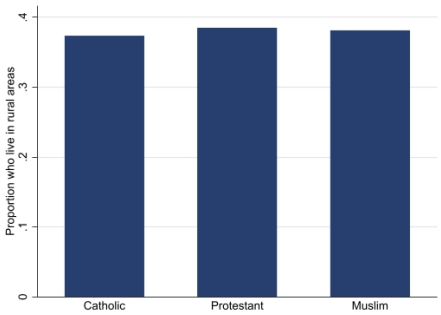
(b) Mean years of schooling



(c) Proportion who have ever enrolled in school



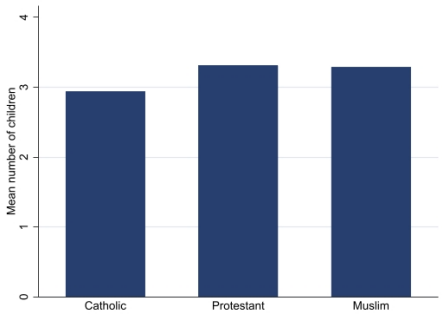
(d) Proportion who live in rural areas



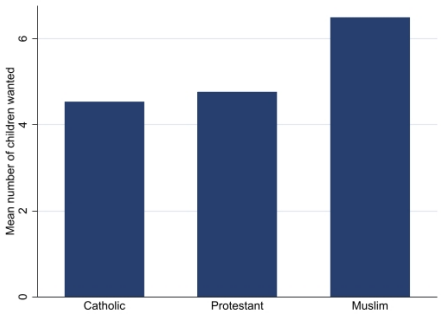
Notes: The data presented here shows the mean ages of respondents by religion in (a). Generally, Protestants were the oldest and Muslims were youngest. This is largely consistent with findings elsewhere that imply a wider base for the Muslim demographic pyramid. The mean years of schooling in (b) shows Catholics had about 6years of schooling compared to about 6.5 for Protestants and less than 4 for Muslims. These patterns are also consistent with probabilities of ever enrolling in school shown in (c). (d) shows that Protestants and Muslims were more likely to be rural dwellers but the differences are very small.

Figure 3.3: Summary statistics for outcome variables-all women

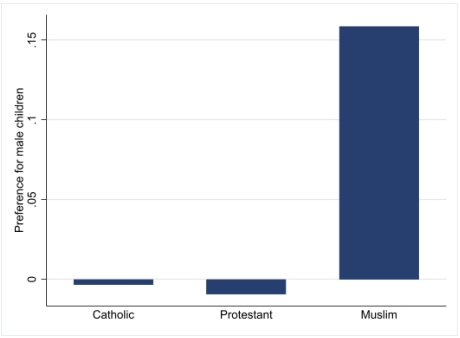
(a) Mean number of children



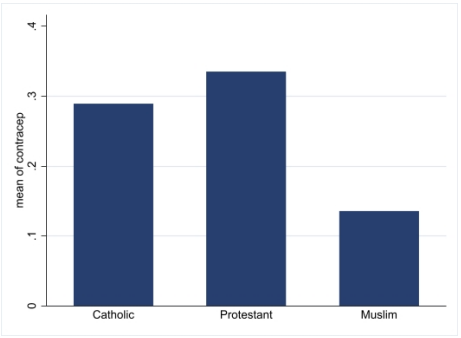
(b) Mean number of children wanted



(c) Preference for Sons



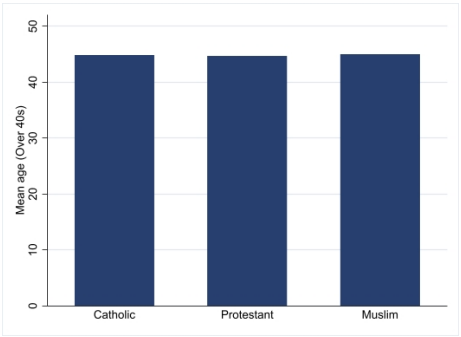
(d) Proportion who use contraceptives



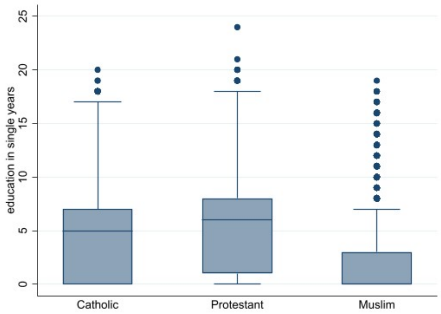
Notes: (a) shows that Protestants and Muslims had an identical mean number of children and both were higher than for Catholics. (b) shows that Muslims wanted the most number of children, followed by Protestants and then Catholics. Taken together, these two statistics suggest that Christians are more effective in attaining their desired fertility outcomes than Muslims. This is likely due to differences in the usage of contraceptives shown in (d). I compute the measure of preference for sons as the difference between the ideal number of sons and ideal number of daughters. A positive number is indicative of a higher preference for sons. The results in (c) show that on overage, Christians prefer more daughters, Protestants preferring more than Catholics, and Muslims preferring more sons. The closeness of the Catholic mean to zero can be taken to suggest that Catholics prefer a balance overall.

Figure 3.4: Summary statistics for controls-Over 40s

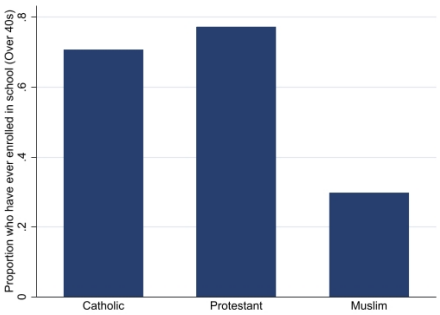
(a) Mean age



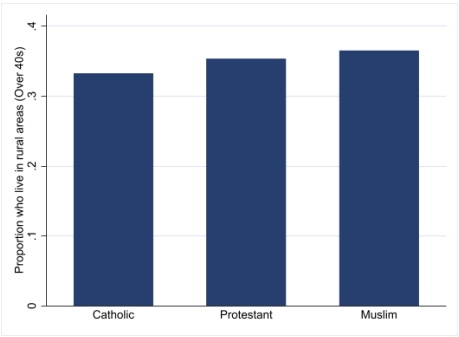
(b) Mean years of schooling



(c) Proportion who have ever enrolled in school



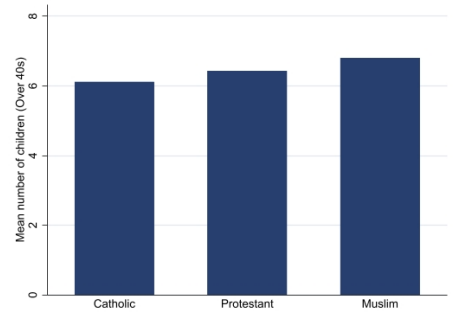
(d) Proportion who live in rural areas



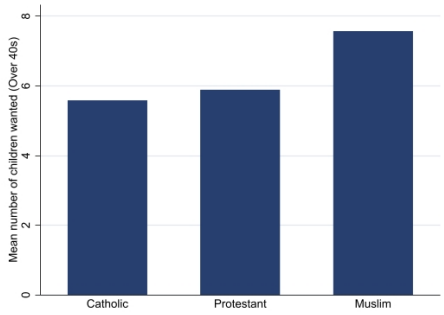
Notes: The statistics shown here are for women over 40. The idea is that women over 40 are close to completing childbearing and so data for them is identical to completed fertility. (a) shows that regardless of religion, these women had identical mean ages, around the median of the age range in this sub-sample. Mean years of schooling in (b) follow a similar pattern to the full sample but differences tend to be wider than in the full sample. Similarly, the probability of ever enrolling in school in (c) follows an identical pattern as in the full sample. These are also lower overall than the full sample and suggest an upward intergeneration shift in women's educational attainment. Unlike the full sample, however, Muslim women in this sub-sample were more likely to be rural dwellers and Catholic women were most likely to be urban dwellers. As argued in this paper, if being a rural resident is correlated with higher fertility, controlling for this will ensure that we recover estimates of the effects of religion (Ibeji et al., 2020).

Figure 3.5: Summary statistics for outcome variables-Over 40s

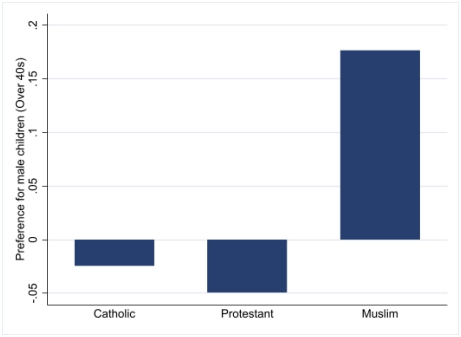
(a) Mean number of children



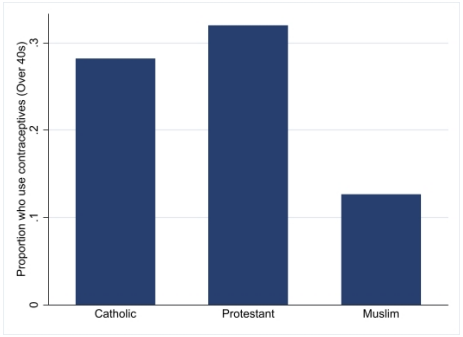
(b) Mean number of children wanted



(c) Preference for Sons



(d) Proportion who use contraceptives



Notes: Patterns of fertility variables differ slightly in the over 40 sample from the full sample. The mean number of children in this sub-sample shown in (a) is highest for Muslims and lowest for Catholics as is the mean number of children wanted in (b). The use of contraceptive shown in (d) is consistent with the patterns in the full sample but means are lower in absolute values. While male preference follows a similar pattern to the full sample, it can be seen that the strength of preference for sons relative to daughters among Muslims is higher than in the full sample. Also, among Protestants and Catholics, the relative preference of daughters to sons is stronger. Taken together, this could be indicative of changing views on the equality of men and women across generations.

Figure 3.6: Maps of Missionary Station Locations

(a) Protestant Missionary Stations

(b) Catholic Missionary Stations

(c) All Missionary Stations

Notes: These maps show the locations of historical mission stations in colonial Africa obtained from Roome (1925). Missionaries from the Catholic church are identified in the map and those of other Christian denominations are collectively classified as Protestant missionaries. The distribution of the missionaries is characteristic of both colonial presence and current distributions of Christian denominations across Africa. The parts on the maps with the least Christian missionary activities are also the most likely to be Muslim. Extending the findings of Nunn (2010), I use the distribution of missionaries and the proximity of respondents to missionary locations as an instrument for religion.

Data for measuring proximity to mission stations are obtained from Roome (1925). Roome (1925) provides a map of precise locations for Christian mission stations in Africa (figure 3.6). That is, the geographic coordinates of the central points that the missionaries operated from. Nunn (2010) shows that people living close to a former mission station were more likely to belong to the denomination of the missionaries and those furthest from any mission station were more likely not to be Christians. One mechanism by which this happens is the intensity of missionary work that might have occurred in a community because the missionaries lived there. The greater the intensity, the more likely the members of the community are to remain in that denomination. Hence, proximity to the mission station is a good predictor of current religion. Nunn (2010) documents that people who live in places that are within 10km of a historic Christian mission station were more likely to be Christians today. Roome (1925)'s map gives the specific name of the mission, making it possible to determine whether they were Catholic or Protestant.

Islam in Sub-Saharan Africa was spread through trade rather than missions and so there is no missionary data (Michalopoulos et al., 2018). However, places that had lower intensities of Christian mission activities were more likely to have Muslim residents than Christian; and were also the places that had contact with Muslim traders from the North. Thus, following Nunn (2010) it is expected that if a person lives close to a historic Christian mission station, they are more likely to be Christian. To the best of my knowledge, this approach to instrumenting religion in a fertility study is new.

3.4.2 Two-Stage Least Squares (2SLS) Estimation

Equations 3.1 and 3.2 are estimated using the consistent IV-2SLS estimator. Fertility decisions are complex and many of the factors that go into the process include cognitive and social factors that are either unobservable or not measurable. This creates an omitted variables problem in fertility models. For some of the right-hand side variables, there are potential measurement errors. For instance, 5 years of education may measure slightly different things due to differences in education systems across countries and within-country variation in quality. Moreover, religion may be endogenous. The IV estimator, unlike OLS, considers these factors and so produces consistent estimates in the face of these violations of the Gauss-Markov assumptions. While the IV estimator

may produce biased estimates for small samples, the sample size in this study voids this concern.

$$fertility_i = \pi_0 + \pi X_i + \mathbf{V}_{ij} + \mathbf{W}_{ck} + \varepsilon_i \tag{3.1}$$

$$X_i = \tau_0 + \tau_1 Z_{1c} + \tau_2 Z_{2c} + \epsilon_i \tag{3.2}$$

Where $fertility_i$ is fertility outcome or fertility intention for woman i, X_i is religious affiliation of woman i in country j, $\mathbf{V}$ is a vector of individual level determinants of fertility, $\mathbf{W}$ is vector of other controls and Z_{1c} and Z_{2c} are proximity to Protestant and Catholic mission stations, respectively. ε_i and ϵ_i are error terms.

3.4.3 The Instrument: Measurement and Validity

Proximity to historic mission station is calculated using geographic data from Roome (1925)'s missionary map and location data from the DHS Surveys for each country. The two map datasets are matched using ArcMap^{TM} and the distance between each cluster and the nearest historic mission station is calculated in 100s of kilometres for both Catholic and Protestant mission stations. Respondents were matched to a Catholic and a Protestant mission station by their DHS cluster. Respondent's location was determined using GIS[2] data from DHS by respondents' clusters. By design, the DHS location data makes it possible to approximately identify a respondent's town but not their house.

For validity, proximity to historic mission station must satisfy at least equations 3.3 and 3.4. Let Proximity to Historic Mission Station be Z and X be religion dummy.

$$Cov(z, x) \neq 0 \tag{3.3}$$

$$Cov(z, \mu) = 0 \tag{3.4}$$

Equation 3.4 is assumed to hold since we do not have reason to believe that any unobserved explainers of religion could be correlated with the citing of a historical

[2]Geographic Information System

mission station more than a century ago. Equation 3.3 is tested. The first test is by regressing religion on the proximity variables to confirm that proximity to historical mission stations is associated with religion. This is done using equation 3.2. The results confirm that proximity to a historic mission station is significantly associated with being a Christian and the denomination that one belongs to. This is what was found by Nunn (2010) as well.

The strength of an Instrumental Variable is an important econometric concern (Andrews and Kasy, 2019). Weak instruments tend to be associated with wrong and varied outcomes for inferences (see Dickson (2013) for an overview). To verify that our instrument is strong, an F-test is done. An F-stat greater than 10 is considered to indicate a strong instrument (Stock and Yogo, 2005). Small values of F-stat lead to a breakdown in asymptotic assumptions about the distribution of the IV estimates (Cramer, 1980). Andrews and Kasy (2019) and Wooldridge (2009) suggest that remarkably high R^2 in the first stage regressions could indicate weakness of the instrument. The F-stats and R^2 in table 3.3 show that proximity to a historical mission station is a strong instrument for religion.

In the present context, it is worthwhile to recognise that the instrument could suffer one setback at least in theory. This potential setback is that because the instrument is fixed in space, it may be correlated with other factors that vary in a certain way by location. It is not immediately obvious what such factors may be but it is important to acknowledge that if this assumption is found to hold, then the instrument only partially resolves the concerns already discussed. Another potential setback to the estimates is that the instrumental variable results are likely to be bigger than the OLS estimates because employment which is expected to have a strong negative correlation with education and religion has not been controlled for.

3.5 Results and Discussion

3.5.1 Proximity to Mission Station is a predictor of religious affiliation

For more than four centuries, European missionaries took the Christian gospel of salvation to Africa. For the most part, the missions had a central location they operated from. We use the term Mission Station in this study to refer to this central location. It is assumed that the communities closest to these stations received greater intensity of

Table 3.3: First Stage Estimates

Dependent Variable	(1) Christian=1 Muslim=0	(2)
Proximity to Protestant Mission	-0.1011***	-0.0782***
	(0.0010)	(0.0010)
Proximity to Catholic Mission	-0.0267***	-0.0281***
	(0.0004)	(0.0004)
Age		0.0030***
		(0.0001)
Education		0.0190***
		(0.0002)
Rural		-0.0759***
		(0.0014)
Constant	0.9522***	0.7680***
	(0.0008)	(0.0026)
Observations	307,128	307,014
R-squared	0.1164	0.1584
F-stat	10750	8795

Notes: The results presented here show the first stage results for the analysis of the relationship between fertility and religious affiliation. The results show that there is a strong association between proximity to a missionary station and current religious affiliation. This finding is similar to Nunn (2010). Robust standard errors in parentheses.*** p<0.01,** p<0.05, * p<0.1.

evangelisation and so were more likely to have accepted the gospel. Nunn (2010) tested this assumption using Roome (1925)'s maps and found that people who presently live close to the location of a historic mission station were more likely to be Christians and more likely to be in the denomination of the missionaries. Following Nunn (2010), I explore proximity to mission stations as an instrument for religion. The results are shown in table 3.3.

The results show that with and without controls, proximity to either Catholic or Protestant mission stations was significantly correlated with current religious affiliation. The result is interpreted as: for every 111 kilometres one lives away from a mission station, they were up to 10% less likely to be Christian than Muslim. Put differently, living further from a historic mission station reduces the likelihood of being a Christian by up to 10% for every 111 kilometres. It also shows that for Christians, living closer to a Protestant mission station makes one more likely to be Protestant than living close to a Catholic mission station. A closer examination of the data reveals that Muslims were likely to live more than 200 kilometres from a Christian mission station, thus reinforcing the conclusion that proximity is a determinant of religion.

It is conceivable that as a result of greater mobility, individuals do not necessarily live in their native places, that is, where their ancestors lived when they had contact with the missionaries. Nonetheless, there is no information to suggest that any ethnic groups have migrated from their land in the last century and so it is assumed that except for some urban centres, the natives constitute the majority. To capture the effect of urbanisation and migration, this is controlled for by *rural* (Ibeji et al., 2020).

The strength of the instruments is tested using an F-test and comparing the R-squares. The F-stats and R-squares in all columns of table 3.3 show that the instruments are strong (Stock and Yogo, 2005).

3.5.2 Religion Affects Fertility for women of all ages

Total fertility is the fertility of all women in the entire population. In this study, that includes the full sample. Completed fertility, on the other hand, refers to fertility for people who have completed childbearing. It is generally the case that most women complete childbearing by 40. I examine the relationship between religion and completed fertility by analysing the fertility behaviour of women over 40. Table 3.4 presents the results for the full sample and table 3.5 for the over-40s sample. Both sets of results are discussed below.

Religion and Total children ever born

The a priori expectation is that according to differences in pronatalist orientation, Christians should have more children than Muslims. These are shown by the results in table 3.4. The results show that on average Christians have 0.37 more children than Muslims. Similarly, Christian women had 0.74 more children by age 40 than Muslim women. This pattern may not be exclusive to Africa. For instance, Perry and Schleifer (2019) document that Protestants' fertility in the United States has declined relative to Catholics. As expected, older women had more children on average and women with higher educational attainment had fewer children. Rural women, however, had fewer children than urban women, contrary to expectations.

The effect of religion on fertility can be explained mainly by the teachings or otherwise of one's religion (Rossier and Bernardi, 2009; Inhorn et al., 2020). For instance, the Catholic church's teachings directly discourage the use of artificial contraceptives and encourage abstinence as an alternative (Inhorn et al., 2020). What

we know today suggests that abstinence is more unlikely hence the probability of getting pregnant is sure to be higher without contraceptives. Once a pregnancy has occurred, the Catholic church prohibits abortions- except where the pregnancy poses a threat to the life of the mother. Thus, once pregnancy has occurred, even if unwanted, the mother is required to have the baby. It is not surprising therefore that in Uganda, where about 41% of the people identify to be Catholic, Keats (2018) reports that more than 75% of girls had had at least one child by age 21, regardless of marital status and education.

On the other hand, Protestant churches either expressly encourage contraception and abortion or have no teachings that directly discourage these (Inhorn et al., 2020). Similarly, Muslims do not have a unified stance on both practices. It is important to note also that (re)formation of the Protestant churches that undertook missionary work in Africa began in countries and at a time when capitalist ideas were becoming popular. Thus, the idea of having just the number of children one can afford might have been transmitted as well. The connection between Protestant reformation and capitalist influence is well documented by Weber (1905). These findings are consistent with the findings by Avong (2001) who examined differences in fertility outcomes among Christian women from the Atyab ethnic group in Nigeria.

Religion and Fertility Intentions

As discussed above, one of the arguments of this paper is that religious teaching affects women's fertility orientation such that women in pronatalist religions have a favourable disposition towards having more children (Inhorn et al., 2020; Bokek-Cohen et al., 2022). This is seen in the results. The results in table 3.4 show that on average Christian women wanted 3.6 fewer children than Muslim women. This is similar to findings by Perry and Schleifer (2019) in the US. This is seen also for the over 40 sample in table 3.5 where results in column 4 show that on average Christian women wanted 3.8 fewer children than Muslim women.

These findings can be explained to be a result of social interaction effects that occur within religious groups (Rossier and Bernardi, 2009; Laliotis and Minos, 2022). This can occur through social learning, social influence and social support. Female educational attainment has generally improved in recent decades. It is generally regarded that higher education for women leads to lower fertility (Osili and Long,

Table 3.4: Religion and Fertility-all women sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Son preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	-0.0088	0.3753***	-1.5796***	-3.6087***	-0.1636***	-0.3948***	0.1310***	0.3384***
	(0.0094)	(0.0320)	(0.0165)	(0.0548)	(0.0070)	(0.0239)	(0.0019)	(0.0070)
Age	0.2185***	0.2171***	0.0621***	0.0697***	-0.0010***	-0.0001	0.0064***	0.0056***
	(0.0004)	(0.0004)	(0.0005)	(0.0006)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Education	-0.1315***	-0.1413***	-0.1127***	-0.0651***	-0.0004	0.0050***	0.0154***	0.0102***
	(0.0008)	(0.0011)	(0.0011)	(0.0016)	(0.0005)	(0.0007)	(0.0002)	(0.0003)
Rural	-0.4201***	-0.3910***	-0.2837***	-0.4242***	-0.0088**	-0.0248***	0.0047***	0.0203***
	(0.0071)	(0.0074)	(0.0095)	(0.0108)	(0.0045)	(0.0048)	(0.0018)	(0.0019)
Constant	-2.3025***	-2.5349***	5.2442***	6.5093***	0.1904***	0.3345***	-0.1001***	-0.2257***
	(0.0127)	(0.0222)	(0.0218)	(0.0406)	(0.0097)	(0.0178)	(0.0028)	(0.0049)
Observations	307,044	307,014	268,940	268,940	268,423	268,423	303,550	303,520
R-squared	0.6182	0.6160	0.1775	0.1011	0.0032	0.0024	0.0551	0.0287

Notes: This table presents results for the relationship between fertility variables and religious affiliation. In each case, the reference category for Christian is Muslim. The discussions in the report are based on IV results but OLS results are shown for comparison; to replicate correlations commonly reported in the literature. These results show a strong difference between members of the two religions both statistically and numerically. They are also consistent with predictions for each religious group. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

2008; Keats, 2018; Boahen and Yamauchi, 2018). This effect may be sticky, however for women included in this study who grew up in environments where women had many children. This social learning effect is unlikely to fade in one generation. The gap between the point estimates of fertility intention and total children in both samples suggests this might be the case. Moreover, religious people have been found to be very supportive of people whose actions are consistent with their religious beliefs (Inhorn et al., 2020). For instance, Conley (1990) documented that there is a very strong social support for new mothers among Mormons such that motherhood is less burdensome. Outside Africa, Laliotis and Minos (2022) find that religious people had deeper social interactions in Western Germany. Apart from religion, Africans generally support new mothers socially. However, for people who do not live in their native towns, the members of their religious congregation become a substitute for their families such that an outcome consistent with the teachings of the congregation would generate social support (Inhorn et al., 2020). This process may explain this finding.

Religion and son preference

The notion that some women prefer children of one gender to the other is well documented. This is sometimes rooted in cultural factors such as family systems (Rossi and Rouanet, 2015; Bhalotra et al., 2021), inheritance practices (Carranza, 2012) and dowry at marriage (Alfano, 2017; Rossi and Rouanet, 2015). The role of religion in gender preference is documented in Asia and the Middle East but little is known about

Table 3.5: Religion and fertility-Over 40s

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Son preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.0392	0.7432***	-1.4047***	-3.8570***	-0.2113***	-0.5601***	0.1238***	0.4280***
	(0.0409)	(0.1394)	(0.0556)	(0.1820)	(0.0232)	(0.0784)	(0.0050)	(0.0195)
Age	0.0866***	0.0884***	0.0674***	0.0592***	0.0037	0.0025	-0.0257***	-0.0249***
	(0.0047)	(0.0048)	(0.0054)	(0.0056)	(0.0025)	(0.0025)	(0.0008)	(0.0008)
Education	-0.1606***	-0.1756***	-0.1143***	-0.0660***	-0.0019	0.0050**	0.0163***	0.0099***
	(0.0030)	(0.0042)	(0.0033)	(0.0048)	(0.0015)	(0.0020)	(0.0005)	(0.0007)
Rural	-0.7164***	-0.6657***	-0.1703***	-0.3285***	-0.0086	-0.0311**	-0.0276***	-0.0059
	(0.0278)	(0.0294)	(0.0306)	(0.0342)	(0.0139)	(0.0149)	(0.0045)	(0.0048)
Constant	3.4951***	2.8559***	4.8294***	7.1840***	0.0193	0.3545***	1.2618***	0.9832***
	(0.2159)	(0.2480)	(0.2491)	(0.3086)	(0.1130)	(0.1349)	(0.0347)	(0.0391)
Observations	48,667	48,663	41,602	41,602	41,538	41,538	48,210	48,206
R-squared	0.0982	0.0919	0.0727	0.0042	0.0031	-0.0041	0.0623	0.0153

Notes: The results shown here repeats table 3.4 using the over 40s sub-sample. The reference category of Christian is Muslim and the discussions are based on IV results. The results in the Over 40s sample are identical to the full sample in terms of the direction of effect but magnitudes tend to be larger. This is explained by the fact that these older women have more children and are less educated. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Africa. However, Rossi and Rouanet (2015) documents that, in North Africa- which is predominantly Muslim, there is a strong preference for sons.

Son preference is measured here as the difference between a woman's ideal number of sons and their ideal number of daughters. A positive number indicates a preference for more sons than daughters. The results in table 3.4 show that Christians want about 0.39 fewer sons than Muslims. Similarly, in table 3.5, the results in column 6 show that on average Christian women over 40 had a preference of 0.56 fewer sons than Muslim women over 40. These numbers represent how much more sons the women wanted over and above their preference for daughters. Compared to older women, the results suggest that younger women might be less particular about the gender of their children. This could also indicate an intergenerational shift in the desire for child gender towards wanting a balance.

These findings are consistent with Carranza (2012) for Indonesia who found that Muslims had a stronger preference for sons than non-Muslims. It however diverges from Rossi and Rouanet (2015) who finds that except for North Africa where there is a strong son preference, Sub-Saharan Africans preferred a balance.

Religion and use of Contraceptives

Up to this point, the religious basis for expecting women to use contraceptives at different levels of intensity has been discussed. Studies in this area are lacking in Sub-Saharan Africa. In Latin America, for instance, Bassi and Rasul (2017) documents that following a papal visit to Brazil in October 1991, there was more than a 40% increase in intention to not contracept and an increase in unprotected sex by at least

30%. They also found that the total number of children born to women who were exposed to the pope's speeches during the visits was 1.6% higher 9 to 12 months later. They cited the anti-contraception and anti-abortion themes in the pope's public speeches as the reason. In the US, Griffin (2015) documents that Catholic bishops lobbied successfully to restrict access to contraception and abortion for Catholics in the Affordable Care Act. These patterns are generally consistent for the Catholic Church in all parts of the world, but because of other constraints to access in Africa, there appear to be few public conversations on the issue and so research on this area is generally limited. Consistent with a priori expectations, Christians were more likely than Muslims to contracept. The results in table 3.4 show that Christians were 34% more likely to use contraceptives than Muslims. For women over 40, the results in table 3.5 show that Christians were 43% more likely to use contraceptives than Muslim women. This is consistent with the view that most women complete childbirth by 40. Thus, these findings provide evidence that the use of contraceptives in Africa is affected by religious affiliation.

3.6 Robustness

3.6.1 Formal checks

The results are subjected to a battery of checks to assure their robustness. Some of the checks, including the instrument validity and econometric assumptions of the instrumental variables method, have been discussed. Secondly, the conclusions remain robust across all specifications that religious affiliation affects women's fertility behaviour and fertility intentions.

3.6.2 Heterogeneity

Married versus unmarried women

Religious people generally consider marriage as the ideal context to have children. I reestimate the main results using sub-samples of women who have never been married or in a committed relationship versus women who are currently married or have ever been married.

The results for never-married women of all ages presented in table C.2 show that the actual number of children born does not differ significantly between Christians and

Table 3.6: First stage-clustered errors

	(1)	(2)
	Dependent variable=Religion	
Near Protestant mission	0.0984***	0.0725***
	(0.0068)	(0.0067)
Near Catholic mission	0.0560***	0.0578***
	(0.0034)	(0.0032)
Age		-0.0022***
		(0.0002)
Education		-0.0222***
		(0.0009)
Rural		0.1015***
		(0.0091)
Constant	0.7440***	0.9171***
	(0.0058)	(0.0126)
Observations	307,128	307,014
R-squared	0.0671	0.0859
F-stats	404.95***	367.77***

Notes: The results in this table reestimate the first stage of the main results for robustness by clustering errors at survey clusters. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Muslims. This can be taken to suggest a possibility that religious women are generally committed to having children only within the context of marriage. The relationship between religious affiliation and fertility intention, son preference, and contraceptive use are statistically significant and follow the pattern shown in the combined sample.

The result in table C.3 shows that there is no statistically significant difference among women over 40 in terms of the total number of actual children born and preference for sons. Christians however wanted more children but were also more likely to use contraceptives.

For women who have ever been married, the results are presented in tables C.4 and C.5. Consistent with expectations, women who have ever been married show identical patterns to the main findings already discussed. Thus the main findings are driven by married women.

3.7 Conclusion

Africa has for a long time had the highest fertility rates and while global fertility rates have declined in recent decades, fertility in Africa has seen the slowest decline. Over the same period, the continent has become increasingly religious. Existing theories have suggested that economic development should have led to a faster fertility decline; prompting an interest in the role religion may be playing in this. This paper makes a contribution to an emerging strand of the economics literature that is interested in

Table 3.7: Religion and fertility-All sample-clustered errors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Children		Fertility Intention		Son preference		Use of contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	-0.0088	0.3753***	-1.5796***	-3.6087***	-0.1636***	-0.3948***	0.1310***	0.3384***
	(0.0200)	(0.0756)	(0.0509)	(0.1592)	(0.0110)	(0.0392)	(0.0039)	(0.0162)
Age	0.2185***	0.2171***	0.0621***	0.0697***	-0.0010**	-0.0001	0.0064***	0.0056***
	(0.0010)	(0.0010)	(0.0009)	(0.0011)	(0.0004)	(0.0004)	(0.0001)	(0.0002)
Education	-0.1315***	-0.1413***	-0.1127***	-0.0651***	-0.0004	0.0050***	0.0154***	0.0102***
	(0.0016)	(0.0025)	(0.0023)	(0.0041)	(0.0008)	(0.0011)	(0.0003)	(0.0005)
Rural	-0.4201***	-0.3910***	-0.2837***	-0.4242***	-0.0088	-0.0248***	0.0047	0.0203***
	(0.0218)	(0.0218)	(0.0289)	(0.0333)	(0.0080)	(0.0086)	(0.0040)	(0.0042)
Constant	-2.3025***	-2.5349***	5.2442***	6.5093***	0.1904***	0.3345***	-0.1001***	-0.2257***
	(0.0281)	(0.0527)	(0.0570)	(0.1123)	(0.0156)	(0.0294)	(0.0049)	(0.0110)
Observations	307,044	307,014	268,940	268,940	268,423	268,423	303,550	303,520
R-squared	0.6182	0.6160	0.1775	0.1011	0.0032	-0.0024	0.0551	0.0287

Notes: The results in this table reestimate the main results for women of all ages with errors clustered at the survey clusters. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.8: Religion and fertility-over 40s-clustered errors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Son preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.0392	0.7432***	-1.4047***	-3.8570***	-0.2113***	-0.5601***	0.1238***	0.4280***
	(0.0625)	(0.2281)	(0.0875)	(0.2878)	(0.0284)	(0.0956)	(0.0075)	(0.0329)
Age	0.0866***	0.0884***	0.0674***	0.0592***	0.0037	0.0025	-0.0257***	-0.0249***
	(0.0088)	(0.0087)	(0.0097)	(0.0101)	(0.0047)	(0.0047)	(0.0015)	(0.0015)
Education	-0.1606***	-0.1756***	-0.1143***	-0.0660***	-0.0019	0.0050*	0.0163***	0.0099***
	(0.0055)	(0.0073)	(0.0055)	(0.0081)	(0.0024)	(0.0030)	(0.0008)	(0.0011)
Rural	-0.7164***	-0.6657***	-0.1703***	-0.3285***	-0.0086	-0.0311	-0.0276***	-0.0059
	(0.0684)	(0.0674)	(0.0653)	(0.0723)	(0.0253)	(0.0259)	(0.0092)	(0.0095)
Constant	3.4951***	2.8559***	4.8294***	7.1840***	0.0193	0.3545	1.2618***	0.9832***
	(0.3996)	(0.4338)	(0.4440)	(0.5313)	(0.2104)	(0.2305)	(0.0669)	(0.0713)
Observations	48,667	48,663	41,602	41,602	41,538	41,538	48,210	48,206
R-squared	0.0982	0.0919	0.0727	0.0042	0.0031	-0.0041	0.0623	0.0153

Notes: The results in this table reestimate the main results for women over 40 years with errors clustered at the survey clusters. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

the role of culture in economic decision-making and behaviour. This literature takes the view that beyond the axioms of economic theory, culture determines economic behaviour. Traditionally, economists have characterised fertility choices as economic decisions. Indeed, it is straightforward to see that fertility outcomes have economic implications for the household. Prior studies have mainly focused on small groups within a country. However, to be able able to generalise any relationship between fertility and religion would require cross-national data. This paper examines the role of religion, as a manifestation of culture, in determining fertility behaviour across 18 countries.

I use proximity to historical mission stations as a predictor of religious affiliation in a two-stage least square estimation. I find that living close to a historical mission station was a significant determinant of religious affiliation. This approach to instrumenting for religion has rarely been used. Having tested the instrument for validity, I estimate the effect of religious affiliation on fertility intentions and outcomes. The characteristics of the data are comparable to the target population. The results show that regardless of age, there were differences in fertility intentions and outcomes by religious affiliation. The results show that although Christians aspire to have smaller families, they have more children than Muslims on average after accounting for differences in age education, and place of residence. This finding is driven mainly by married women.

It would have been interesting to examine how the relationship observed in our results varies by the level of participation in religious activity. Data unavailability, however, constraints us. Future studies may examine this as data becomes available. The DHS survey in the future can include questions such as frequency of attendance to church or the regularity with which a Muslim observes the 5 daily Salaat in the survey to enable future studies to do this. Also, given that fertility choices among married people are joint decisions, future studies should explore how a couple's religious identity and devotion interact to determine fertility choice.

CONCLUSION

The afore chapters have included essays on three issues that are important to the socio-economic development of Africa. The first essay answered the question: Is there a causal relationship between education and health in Ghana? The answer obtained from the data is: Yes. This essay thus contributes new evidence supporting the existence of a causal relationship between education and health in developing countries. This answer is important because Ghana like many developing countries faces two devils: low education attainment and poor health outcomes. This finding, therefore, implies that interventions in education will generate positive long-run benefits for public health. Indeed, the theoretical literature has argued for the existence of health capital that is generated from schooling. This essay provides the first empirical evidence for this in the context of Ghana. It implies that investments in education have a spillover effect on health outcomes. The fact that countries with lower levels of school attainment are the most susceptible to public health crises means that investments in education can be viewed as indirect investments in public health. Therefore, authorities in those countries must increase investment in early childhood education now to reduce long-term public health expenditure. For poor countries and poor regions in rich countries, removing the financial cost of early education and making schooling compulsory, should be an important policy consideration.

More research is required on the role of education in health outcomes in developing countries. As discussed in the first essay, most studies seeking causal relationships between education and health have been from outside Africa. That essay used data for Ghana. It would be interesting for future studies to focus on other African countries and to compare results. This will be useful given the fact that each country may differ from others in important ways. Future research will allow us to understand whether any contextual factors affect this relationship. Still, future research should focus on interventions at higher levels of education. In the case of Ghana, the recent extension of the tuition fee waiver to senior secondary schools in 2017 will be a useful higher-level policy intervention to explore. Data permitting, it will also be useful to explore the differences between day students who are not fed or fed once-a-day, and students in boarding schools who are fed thrice a day for free; how the nutrition tips the balance.

The second essay provides evidence of a nonagricultural/noneconomic channel for the impact of climate variability on violence. That is trust in political authority. The finding of that essay has important implications for the prevention of violent conflict, violent crimes and economic development. In terms of violent conflicts, it is easy to see that conflict is less likely when there is an abundance of trust. While efforts are being made globally to tackle the climate crisis, policy needs to deliberately seek to engender trust among citizens. Recent world events have taught us, among other things, that citizens are increasingly having less trust in politicians and this has led to an unprecedented increase in protests, terrorism, extremism, hate crimes, domestic violence, etc. in all countries. The findings of this essay suggest that engendering trust in political authorities is a short to medium-term strategy to mitigate the social effects of climate change. Besides collective violence, *trust* may also explain the link between temperature and interpersonal crime. Previous studies have shown that trust is necessary for trade and commercial contracting; engendering trust as a deliberate policy outcome may have additional benefits for economic development via trade.

Future studies can extend our study on the relationship between climate variability and violence by drilling deeper into the role of trust. One way this can be done will be to find out what immediate factors determine trust in political office holders in specific contexts. This future research will enhance the ability of policy to target the finer issues. This will most likely require qualitative studies and longitudinal field observation. The current state of the empirical literature has been to focus on the entire continent. However, the factors that influence local politics can vary considerably. Our study did not make this distinction. Our study also assumes implicitly that civil unrest occurs only within the context of local partisan politics. However, ethnic-based violent conflicts are real in Africa and do not always necessarily relate to partisan politics. Future research should relax this assumption or consider interethnic trust and interethnic conflicts, in each case, within the context of climate variability. Additionally, interpersonal violence should be studied.

Finally, the third essay found that in the context of sub-Saharan Africa, fertility is potentially driven by religious doctrines. It finds, as suggested by previous literature, that there is a strong correlation between religious affiliation and fertility in Sub-Sahara Africa; but the direction and magnitude of the correlation across religions do not follow the causal direction. The religious groups commonly thought to be the most fertile are

not indeed the most fertile. This difference between correlations and causal direction is most likely driven mainly by underlying differences in school attainment rather than by doctrinal factors. While differences in education attainment appear to be correlated with religious affiliation, the findings demonstrate that after controlling for education, religion still influences fertility patterns. Thus, correlations are consistent with differences in schooling and causal directions are consistent with religious doctrines. Policy may not be effective in changing religious doctrines. Female education may be a more effective target. In the final analysis, it depends on which of the two has a greater influence on women's fertility decisions in a given context.

The question of religion and fertility will benefit from more analysis, however. If data can be found where two atheists from non-religious families; one converts to Christianity, and the other to Islam in adolescence, for instance; it will be useful for extending the question of causality further. Also, location-based regression discontinuity design can be applied to contexts where two neighbouring towns from the same ethnic group, one is predominantly Christian and the other is predominantly Muslim. Other questions are: as income levels grow across Africa in the future, will Africans become less religious as has happened in Europe? Will that cause a further fertility decline? As fertility declines in Asia and Europe should pronatalist religions send missionaries there? These are interesting questions that are left to future research to answer.

Appendix A

Excerpts of Grossman's Health Model

If we take current stock[1] of health to be given as:

$$H_t = H_{t-1} + \mathbb{N}_{t-1} \tag{A.1}$$

Where (H_t) is stock of health at any time *(t)*, I is investment and δ is depreciation. $\mathbb{N}_{t-1}$ is net investment in health in the previous period[2] and net investment is defined as gross investment (I) minus depreciation (δ):

$$\mathbb{N}_{t-1} = I_{t-1} - \delta_{t-1} H_{t-1} \tag{A.2}$$

Components of gross investment in health include exercise time, medical care, good nutrition (or better dieting), quality of dwelling (housing), et cetera.

By definition, the output of health production (healthy time) has an upper bound, 24 hours per day for instance.

$$h_t = 24 - \beta H_t^{-\alpha} \tag{A.3}$$

Where h_t is healthy time and β and α are positive constants. Consequently, health capital experiences diminishing marginal returns. The marginal product $(\Re)$, of healthy time, can be derived as follows:

$$\Re_t = \frac{\partial h_t}{\partial H_t} = \alpha\beta H_t^{-\alpha-1} \tag{A.4}$$

$$\Re' = \frac{\partial^2 h_t}{\partial H^2} = (-\alpha - 1)\alpha\beta H_t^{-\alpha-2} \tag{A.5}$$

In a pure investment model with fixed gross investments, the equilibrium stock

[1] Alternatively, future health is

$$H_{t+1} = H_t + I_t - \delta H_t$$
$$where, I_t - \delta H_t \text{is current net investment in health}$$

[2] Today's health is determined by yesterday's choices.

of health at any time can be derived by equating the marginal monetary rate of return on health capital to its opportunity cost. If $£_t$ is the hourly wage rate and π_t is the marginal cost of gross investment in health, the rate of return or marginal efficiency (γ_t) of health capital is defined as

$$\gamma_t = £_t/\pi_t \tag{A.6}$$

In equilibrium, this can be shown to be[3]

$$\gamma_t = \mathrm{r} - \pi'_t + \delta_t \tag{A.7}$$

where r is the rate of interest and π'_t is the continuously compounded percentage rate of change in marginal cost with age. If we define the cost equation for health as:

$$\ln I_t = \propto \ln X^t + \rho\varepsilon \tag{A.8}$$

where X is a vector of inputs into the health production function and ε is the stock of human capital or knowledge, $\propto$ is the output elasticity of inputs and ρ is the improvement in non-market productivity due to human capital. Also, let s be years of schooling completed, ρ a positive parameter and F a linear function that is homogeneous in M (medical care) and t (own time),

$$H = e^{\rho s} F(M, t) \tag{A.9}$$

then schooling has a productive efficiency effect on H in the sense that an increase in s raises the amount of H from any given combination of M and t. Assuming that H is homogeneous of degree 1 in M and t, an increase in schooling raises their marginal product ($\Re$) on average if a one-unit increase in s raises their marginal product by the same percentage (ρ). Because non-market uses of healthy time are difficult to measure, let's say the consumer maximises $£_h - \pi H$, the healthy time available for labour market earnings. The first order condition for optimal H will be $£\Re = \pi$. Using this equation, the optimal percentage changes in the quantity of H and M caused by a one-unit increase in s are:[4]

[3] See Grossman (1972, 1973, 2004, 2008) for full derivations and a detailed discussion.

[4] Equations and derivations are adapted from Grossman (1972, 1973). Interested readers should see the source for a detailed discussion.

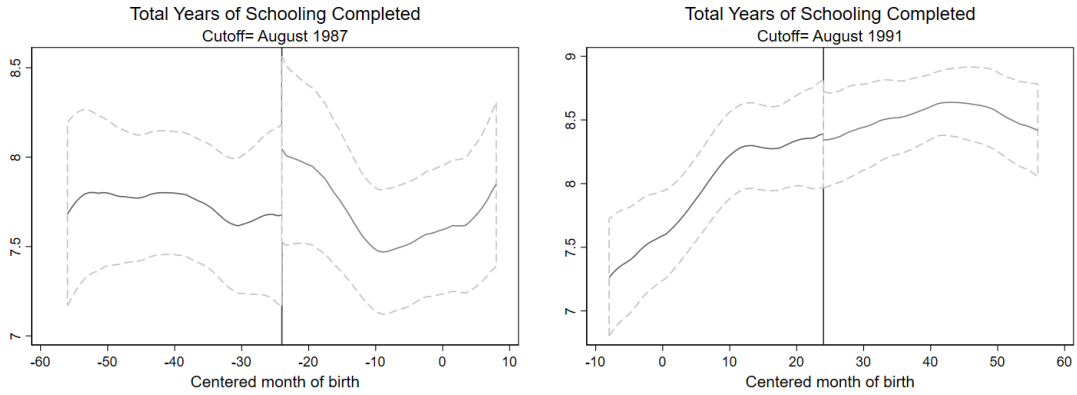
Table A.1: Fee Waiver, Schooling and Health- *with rdbust*

Health Outcomes	Coefficient	BW Left,Right
Weight for Height SD	0.0532 ***	51,29
	(0.0187)	
Body Mass Index	1.1181**	62,44
	(0.5653)	
Health Behaviours		
Healthy Eating	0.4560**	111,37
	(0.2106)	
Smokes	-0.0388*	32,32
	(0.0208)	
Fertility Intention	-0.1539*	104,52
	(0.8898)	
Antenatal Visits	1.1714**	50,33
	(0.5026)	

Notes: This table shows the effect of the policy on health outcomes and health behaviour. It uses the *rdrobust* Stata command by Calonico et al. (2014) (Davies et al., 2018). It includes controls for ethnicity and religion. Robust standard errors are reported in parentheses $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Figure A.1: Discontinuity at non-discontinuity point 2

(a) August 1987 as cut-off (b) August 1991 as cut-off



Notes: This figure tests for the robustness of discontinuity at cut-off points by using fake cut-offs for the optimal bandwidth. I choose one cut-off two years leftwards and another two years rightwards both within the optimal bandwidths. These cut-off points do not show significant jumps.

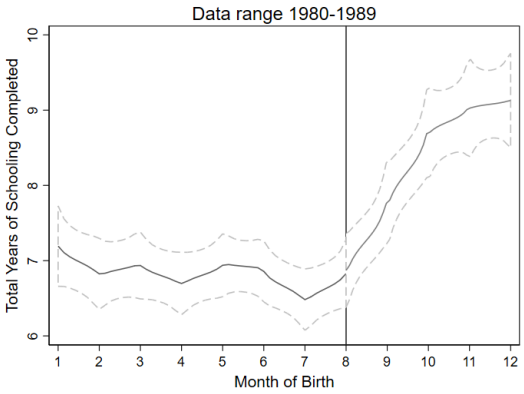
$$\frac{\partial \ln H}{\partial s} = \varepsilon\rho \qquad \textit{and} \qquad \frac{\partial \ln M}{\partial s} = (\varepsilon - 1)\rho \tag{A.10}$$

Holding the wage rate constant ε[5] is the inverse of the absolute value of the elasticity of the marginal product of health ($\Re$) with respect to H. Grossman (1972) shows that ε is smaller than one due to the upper limit of the output of health. Given this condition, an increase in schooling should increase the quantity of health demanded but decrease the quantity of medical care demanded.

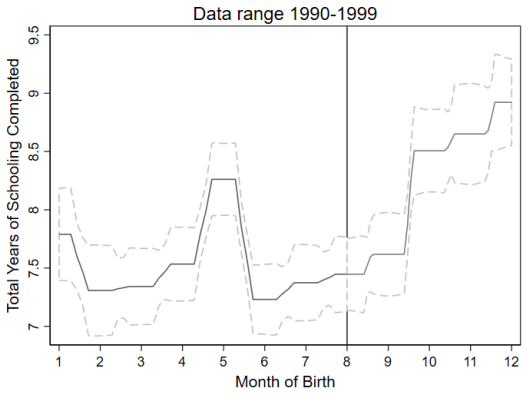
[5] $\varepsilon \equiv \frac{-\Re_t}{H\Re_t}$

Figure A.2: Discontinuity at random August

(a) August effect for partially treated only



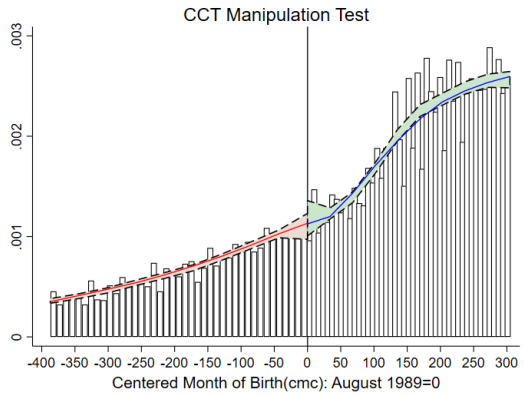
(b) August effect for fully treated only



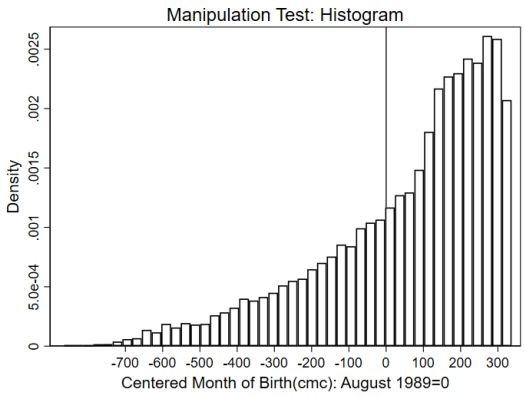
Notes: The literature shows that month of birth potentially affects the age of enrolment, performance in school and the total number of years of schooling. This is tested by checking for a month of birth effect in the data. If there is a jump in the month of the start of the school year, then the effects reported in the results would capture both the month of birth effect and the FCUBE effect. The results in the plots above are consistent with the literature in that those born after the start of the school year have more schooling for observations on either side of the cut-off but there is no discontinuity at August.

Figure A.3: Additional graphs using the Living Standards Survey

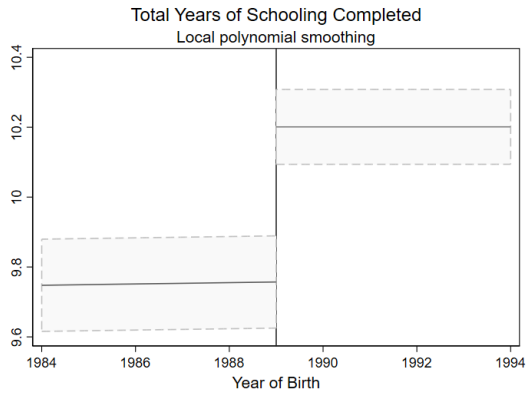
(a)



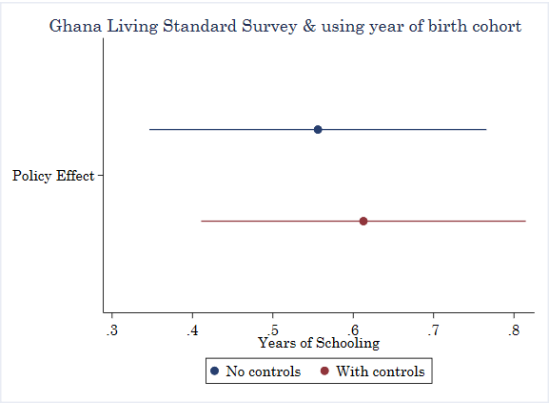
(b)



(c)

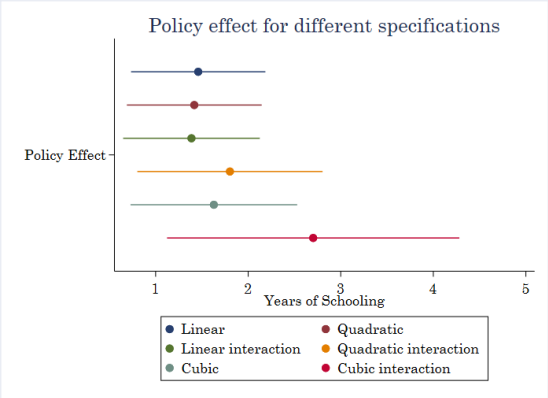


(d)



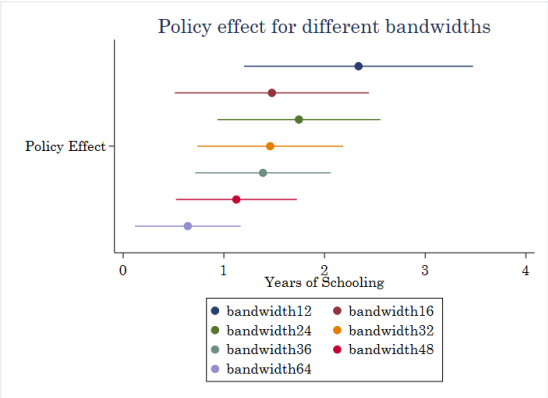
Notes: I repeat the graphs for manipulation and policy effect on total years of schooling using the Ghana living standards survey round 7 (GLSS7) to check for robustness across data types. The GLSS7 is a more recent data and it includes a more even distribution of males and females. Boahen and Yamauchi (2018) used an earlier round of this survey to show a discontinuity. This is thus not an exact replication of their results but the policy effects estimates are close. I maintain their definition of the cohort in the policy effect graph but use the standard definition adopted in this study for the manipulation tests. These confirm the robustness of earlier conclusions.

Figure A.4: Policy effect using different functional forms



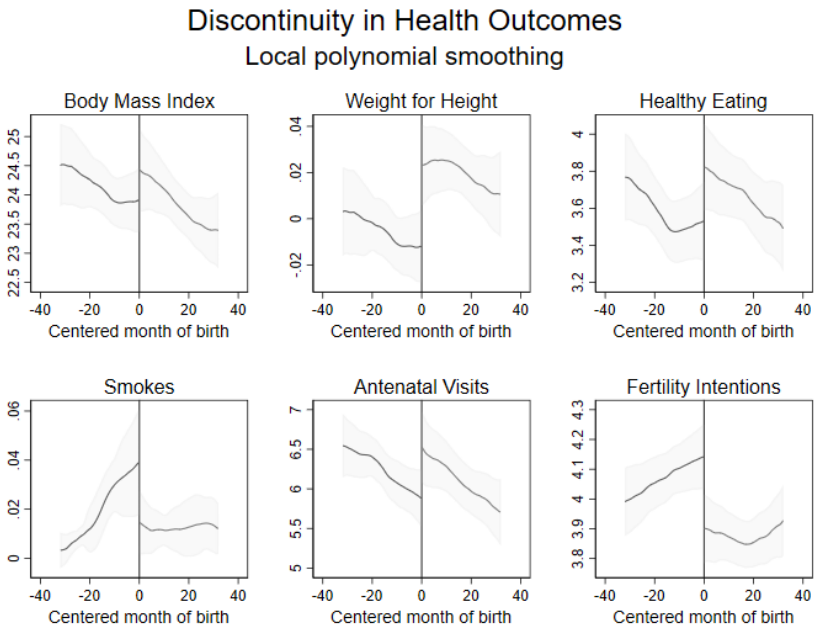
Notes: I check for robustness of the results for policy effects to functional form. I show the first stage results for various functional forms in this figure. The results presented here show that policy effects overlap for all functional forms.

Figure A.5: Policy effect using different bandwidths



Notes: I check for robustness of the results for policy effects to different bandwidths. I use the standard half bandwidth and double bandwidth suggested in the literature. Additionally, I check for different bandwidths. Smaller bandwidths yield larger effects than larger bandwidths and all are within identical ranges of the optimal bandwidth. As is expected, wider bandwidths have smaller effects because fully treated respondents furthest left were young and still in school whereas partially treated and untreated respondents were older yet had completed fewer years of schooling. Also, as the bandwidth gets larger and approaches the bandwidth used by Boahen and Yamauchi (2018), the effect becomes identical to theirs.

Figure A.6: Discontinuities in health outcomes at cut-off point



Notes: The graphs presented here show the existence of discontinuities at the FCUBE intent-to-treat cut-off point. These can be taken as graphical illustrations of the treatment effect for each of the outcomes of the results presented in the tables. Keep in mind however that the graphs do not include controls but the tables do. The presence of significant jumps in the graphs confirms the point estimates in the tables.

Appendix B

Details on election data

Estimation sample: the following elections make up our sample.

- Benin: 1996, 2001, 2006, 2011, 2016
- Botswana: 1994, 1999, 2004, 2009, 2014, 2019
- Burkina Faso: 1998, 2005, 2010
- Central African Republic: 1999, 2011
- Gabon: 1993, 1998, 2005
- Ghana: 1992, 1996, 2000, 2004, 2008, 2012, 2016
- Guinea: 2015
- Guinea-Bissau: 2009, 2019
- Kenya: 2007, 2013 2017
- Liberia: 2005, 2011, 2017
- Madagascar: 1993, 1996, 2006, 2013
- Malawi: 1999, 2004, 2009, 2014, 2019
- Mali: 1997, 2002, 2007, 2018
- Mozambique: 1999, 2004, 2009, 2014, 2019
- Namibia: 1994, 1999, 2004, 2009, 2014, 2019
- Niger: 2004, 2011, 2016
- Nigeria: 2003, 2007, 2011, 2015, 2019
- Senegal: 1993, 2000, 2007, 2012, 2019
- Sierra Leone: 2002, 2007, 2012, 2018
- South Africa: 1999, 2004, 2009, 2014, 2019
- Tanzania: 1995, 2000, 2005, 2010, 2015
- Togo: 2010, 2015
- Uganda: 2001, 2006, 2011
- Zambia: 1996, 2001, 2006, 2008, 2011, 2015, 2016

Appendix C

Table C.1: List of Countries included in this study

West Africa	**East Africa**
Benin	Burundi
Côte d'Ivoire	Kenya
Ghana	Uganda
Nigeria	Ethiopia
Togo	Rwanda
Central Africa	**Southern Africa**
Angola	Lesotho
Cameroon	Malawi
The Democratic Republic of the Congo	Zambia
Gabon	Mozambique

Notes: DHS and geographic data from a total of 18 countries are included in this study. These countries are listed here and classified according to sub-region.

Table C.2: Never married Sample-All ages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Male child preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.1431***	0.0049	-1.1264***	-3.6102***	-0.0871***	-0.2104***	0.0283***	-0.0300**
	(0.0059)	(0.0303)	(0.0310)	(0.1403)	(0.0133)	(0.0585)	(0.0034)	(0.0140)
Age	0.0858***	0.0866***	0.0068***	0.0200***	0.0034***	0.0040***	0.0076***	0.0080***
	(0.0012)	(0.0012)	(0.0016)	(0.0018)	(0.0007)	(0.0007)	(0.0002)	(0.0002)
Education	-0.0501***	-0.0484***	-0.0514***	-0.0251***	0.0056***	0.0069***	0.0134***	0.0141***
	(0.0010)	(0.0011)	(0.0022)	(0.0027)	(0.0010)	(0.0011)	(0.0004)	(0.0004)
Rural	0.0001	-0.0108*	-0.0973***	-0.2793***	-0.0113	-0.0203**	0.0437***	0.0392***
	(0.0057)	(0.0062)	(0.0152)	(0.0199)	(0.0073)	(0.0083)	(0.0027)	(0.0029)
Constant	-1.1379***	-1.0405***	5.2018***	6.9973***	-0.0149	0.0742	-0.1563***	-0.1153***
	(0.0188)	(0.0287)	(0.0431)	(0.1120)	(0.0193)	(0.0475)	(0.0053)	(0.0109)
Observations	73,654	73,647	66,201	66,201	66,100	66,100	73,654	73,647
R-squared	0.3259	0.3233	0.0503	-0.1168	0.0018	-0.0002	0.0561	0.0532

Notes: The results presented here reestimate the results in table 3.4 for women who have never been married. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table C.3: Never married Sample- Over 40

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Male child preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.0063	-4.3295	-0.6932	-12.6806**	-0.0251	0.1573	-0.0134	0.6268*
	(0.5169)	(3.3429)	(0.5251)	(4.9365)	(0.1757)	(1.2017)	(0.0509)	(0.3622)
Age	0.0002	0.0022	0.0153	0.0269	0.0185	0.0183	-0.0099***	-0.0102***
	(0.0306)	(0.0323)	(0.0358)	(0.0459)	(0.0141)	(0.0141)	(0.0037)	(0.0039)
Education	-0.1194***	-0.0939***	-0.0845***	-0.0268	0.0083	0.0075	0.0070***	0.0033
	(0.0150)	(0.0241)	(0.0185)	(0.0303)	(0.0075)	(0.0093)	(0.0019)	(0.0029)
Rural	-0.3220*	-0.4492**	0.0323	-0.1882	-0.1736**	-0.1703**	0.0175	0.0363
	(0.1737)	(0.2037)	(0.1852)	(0.2528)	(0.0773)	(0.0810)	(0.0209)	(0.0247)
Constant	3.6168**	7.6076**	4.7373***	15.5653***	-0.7985	-0.9632	0.5178***	-0.0715
	(1.5234)	(3.3950)	(1.7189)	(4.9791)	(0.6454)	(1.2871)	(0.1704)	(0.3791)
Observations	1,073	1,073	910	910	909	909	1,073	1,073
R-squared	0.0637	-0.0225	0.0301	-0.6269	0.0072	0.0063	0.0239	-0.1081

Notes: The results presented here reestimate the results in table C.2 for women over 40years who have never been married. It is expected that there should be no effects for all variables because these women are close to ending childbirth and so for them, the question of fertility intentions and outcomes is almost done. The results are not far from expectation; results are either not statistically significant or very weak. It is somewhat surprising to find that contraceptive use has the strongest statistical coefficient for protestant women in this sample. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table C.4: Ever married Sample-All ages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Male child preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.0610***	0.5259***	-1.6392***	-3.6800***	-0.1787***	-0.4268***	0.1728***	0.4321***
	(0.0115)	(0.0377)	(0.0192)	(0.0596)	(0.0082)	(0.0263)	(0.0022)	(0.0080)
Age	0.2067***	0.2042***	0.0580***	0.0690***	-0.0020***	-0.0007**	-0.0002*	-0.0016***
	(0.0005)	(0.0006)	(0.0007)	(0.0008)	(0.0003)	(0.0003)	(0.0001)	(0.0001)
Education	-0.1253***	-0.1381***	-0.1175***	-0.0651***	-0.0020***	0.0044***	0.0195***	0.0124***
	(0.0010)	(0.0014)	(0.0013)	(0.0019)	(0.0006)	(0.0009)	(0.0002)	(0.0003)
Rural	-0.4783***	-0.4430***	-0.3168***	-0.4606***	-0.0075	-0.0250***	0.0007	0.0205***
	(0.0090)	(0.0094)	(0.0116)	(0.0130)	(0.0055)	(0.0058)	(0.0022)	(0.0023)
Constant	-1.8077***	-2.0549***	5.5283***	6.6474***	0.2481***	0.3841***	0.0991***	-0.0388***
	(0.0168)	(0.0251)	(0.0273)	(0.0427)	(0.0123)	(0.0190)	(0.0037)	(0.0055)
Observations	229,896	229,873	202,739	202,739	202,323	202,323	229,896	229,873
R-squared	0.4923	0.4884	0.1525	0.0771	0.0042	-0.0019	0.0648	0.0252

Notes: The results presented here reestimate the main results in table 3.4 for women who have ever been married, of all ages. The expectation is that the results from this sample resemble the original findings since the question of fertility is more relevant in the context of married people. In each case, this expectation is met and confirms that the original results are robust to marital status. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table C.5: Ever married Sample- Over 40

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total children		Fertility intention		Male child preference		Uses Contraception	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Christian	0.0872**	0.7567***	-1.3845***	-3.8256***	-0.2121***	-0.5612***	0.1268***	0.4274***
	(0.0411)	(0.1375)	(0.0558)	(0.1815)	(0.0233)	(0.0784)	(0.0050)	(0.0195)
Age	0.0861***	0.0880***	0.0675***	0.0591***	0.0033	0.0021	-0.0262***	-0.0254***
	(0.0047)	(0.0048)	(0.0054)	(0.0057)	(0.0025)	(0.0025)	(0.0008)	(0.0008)
Education	-0.1583***	-0.1727***	-0.1139***	-0.0649***	-0.0021	0.0049**	0.0170***	0.0105***
	(0.0030)	(0.0042)	(0.0033)	(0.0048)	(0.0015)	(0.0021)	(0.0005)	(0.0007)
Rural	-0.6699***	-0.6214***	-0.1583***	-0.3200***	-0.0048	-0.0278*	-0.0263***	-0.0044
	(0.0278)	(0.0294)	(0.0309)	(0.0347)	(0.0142)	(0.0151)	(0.0045)	(0.0048)
Constant	3.5393***	2.9250***	4.8317***	7.1799***	0.0334	0.3695***	1.2832***	1.0078***
	(0.2155)	(0.2474)	(0.2513)	(0.3105)	(0.1146)	(0.1364)	(0.0351)	(0.0395)
Observations	47,137	47,133	40,692	40,692	40,629	40,629	47,137	47,133
R-squared	0.0948	0.0889	0.0715	0.0025	0.0032	-0.0041	0.0653	0.0193

Notes: The results presented here reestimate the results in table 3.5 for women over 40 years who have ever been married. As before, these results are identical to the main findings and coefficient sizes reflect the fact that these women are close to completion of childbirth as expected. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

REFERENCES

Abadie, A., Athey, S., Imbens, G. W., and Wooldridge, J. (2017). When should you adjust standard errors for clustering? Working Paper 24003, National Bureau of Economic Research.

Abor, P. A., Gordon Abekah-Nkrumah, K. S., Adjasi, C. K., and Abor, J. (2011). The socio-economic determinants of maternal health care utilization in ghana. *International Journal of Social Economics*, 38(7):628–648.

Abramson, J. (2015). Trust and democracy. Aspen institute working paper 07, Aspen Institute.

Acemoglu, D., Johnson, S., and Robinson, J. A. (2002). Reversal of fortune: Geography and institutions in the making of the modern world income distribution. *Quarterly Journal of Economics*, 117(4):1231–94.

Addo, J., Smeeth, L., and Leon, D. A. (2009). Obesity in urban civil servants in Ghana: association with pre-adult wealth and adult socio-economic status. *Public Health*, 123(5):365–70.

Adebowale, A. S., Fagbamigbe, A. F., Akinyemi, J. O., Olowolafe, T., Onwusaka, O., Adewole, D., Sadiku, S., and Palamuleni, M. (2020). Dynamics of poverty-related dissimilarities in fertility in nigeria: 2003-2018. *Scientific African*, 9:e00468.

Adegoke, A. A. (2001). Pubertal development and traditional support systems in africa: An overview. *African Journal of Reproductive Health*, 5(1):20–30.

Ajzen, I. (1987). Attitudes, traits, and actions: Dispositional prediction of behavior in personality and social psychology. In *Advances in Experimental Social Psychology*, volume 20, pages 1–63. Academic Press.

Akyeampong, K. (2009). Revisiting free compulsory universal basic education (FCUBE) in Ghana. *Comparative Education*, 45(2):175–195.

Alahmer, A., Omar, M., Mayyas, A. R., and Qattawi, A. (2012). Analysis of vehicular cabins' thermal sensation and comfort state, under relative humidity and temperature control, using berkeley and fanger models. *Building and Environment*, 48:146–163.

Albarran, P., Hidalgo-Hidalgo, M., and Iturbe-Ormaetxe, I. (2020). Education and adult health: Is there a causal effect? *Social Science and Medicine*, 249:112830.

Alemayehu, T., Haider, J., and Habte, D. (2010). Determinants of adolescent fertility in ethiopia. *Ethiopian Journal of Health Development*, 24:30–38.

Alesina, A., Devleeschauwer, A., Easterly, W., Kurlat, S., and Wacziarg, R. (2002). Fractionalization. Technical Report 1959, Harvard Institute of Economic Research: Discussion Papers.

Alfano, M. (2017). Daughters, dowries, deliveries: The effect of marital payments on fertility choices in india. *Journal of Development Economics*, 125:89–104.

Algan, Y. and Cahuc, P. (2010). Inherited trust and growth. *American Economic Review*, 100:2060–2092.

Allen, J. J., Anderson, C. A., and Bushman, B. J. (2018). The general aggression model. *Current Opinion in Psychology*, 19:75–80. Aggression and violence.

Altindag, D., Cannonier, C., and Mocan, N. (2011). The impact of education on health knowledge. *Economics of Education Review*, 30(5):792–812.

Ambaw, D. T. and Sim, N. (2019). Real exchange rate misalignment and civil conflict: Evidence from sub-Saharan Africa. *Oxford Economic Papers*, 73(1):178–199.

Amin, V., Behrman, J. R., and Kohler, H. P. (2015). Schooling has smaller or insignificant effects on adult health in the us than suggested by cross-sectional associations: new estimates using relatively large samples of identical twins. *Social Science and Medicine*, 127:181–9.

Amo-Adjei, J., Anku, P. J., Amo, H. F., and Effah, M. O. (2016). Perception of quality of health delivery and health insurance subscription in ghana. *BMC Health Services Research*, 16.

Anderson, C., Anderson, K., Dorr, N., DeNeve, K., and Flanagan, M. (2000). Temperature and aggression. *Advances in Experimental Social Psychology*, 32.

Anderson, C. A., Anderson, K. B., and Deuser, W. E. (1996). Examining an affective aggression framework weapon and temperature effects on aggressive thoughts, affect, and attitudes. *Personality and Social Psychology Bulletin*, 22(4):366–376.

Anderson, R. W., Johnson, N., and Koyama, M. (2017). Jewish persecutions and weather shocks: 1100–1800. *The Economic Journal*, 127(602):924–958.

Anderson, W., You, L., Wood, S., Wood-Sichra, U., and Wu, W. (2014). A comparative analysis of global cropping systems models and maps. Working Paper 01327, International Food Policy Research Institute.

Andrews, I. and Kasy, M. (2019). Identification of and correction for publication bias. *American Economic Review*, 109(8):2766–2794.

Angrist, J. D. and Krueger, A. B. (1990). Does compulsory school attendance affect schooling and earnings? Working Paper 3572, National Bureau of Economic Research.

Angrist, J. D. and Pischke, J.-S. (2008). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press.

Arcaya, M. C. and Saiz, A. (2020). Does education really not matter for health? *Social Science and Medicine*, 258:113094.

Arendt, J. N., Christensen, M. L., and Hjorth-Trolle, A. (2021). Maternal education and child health: Causal evidence from denmark. *Journal of Health Economics*, 80:102552.

Ashenfelter, O. and Krueger, A. (1992). Estimates of the economic return to schooling from a new sample of twins. *In NBER Working Paper*, No. 4143.

Aslam, M. and Kingdon, G. G. (2012). Parental education and child health—understanding the pathways of impact in pakistan. *World Development*, 40(10):2014–2032.

Avong, H. N. (2001). Religion and fertility among the atyap in Nigeria. *The Journal of Biosocial Science*, 33(1):1–12.

Awusabo-Asare, K. (1990). Matriliny and the new intestate succession law of ghana. *Canadian Journal of African Studies*, 24(1):1–16.

Ayyagari, P., Grossman, D., and Sloan, F. (2011). Education and health: evidence on adults with diabetes. *International Journal of Health Care Finance and Economics*, 11(1):35–54.

Baltagi, B. H., Flores-Lagunes, A., and Karatas, H. M. (2019). The effect of education on health: Evidence from the 1997 compulsory schooling reform in Turkey. *Regional Science and Urban Economics*, 77:205–221.

Bassi, V. and Rasul, I. (2017). Persuasion: A case study of papal influences on fertility-related beliefs and behavior. *American Economic Journal: Applied Economics*, 9(4):250–302.

Baysan, C., Burke, M., González, F., Hsiang, S., and Miguel, E. (2019). Non-economic factors in violence: Evidence from organized crime, suicides and climate in mexico. *Journal of Economic Behavior and Organisation*, 168:434–452.

Becker, G. S. (1964). Human capital: A theoretical and empirical analysis, with special reference to education. *National Bureau of Economic Research:General Series*, XVI(80):187.

Becker, G. S. (1992). Fertility and the economy. *Journal of Population Economics*, 5(3):185–201.

Becker, G. S. and Barro, R. J. (1988). A reformulation of the economic theory of fertility. *The Quarterly Journal of Economics*, 103(1):1–25.

Becker, G. S. and Mulligan, C. B. (1997). The endogenous determination of time preference. *The Quarterly Journal of Economics*, 112(3):729–758.

Belfield, C. R. and Kelly, I. R. (2013). Early education and health outcomes of a 2001 u.s. birth cohort. *Economics & Human Biology*, 11(3):310–25.

Berrington, A. and Pattaro, S. (2014). Educational differences in fertility desires, intentions and behaviour: A life course perspective. *Advances in Life Course Research*, 21:10–27.

Bhalotra, S., Clots-Figueras, I., and Iyer, L. (2021). Religion and abortion: The role of politician identity. *Journal of Development Economics*, 153:102746.

Bijwaard, G. E., van Kippersluis, H., and Veenman, J. (2015). Education and health: The role of cognitive ability. *Journal of Health Economics*, 42:29–43.

Billari, F. C., Philipov, D., and Testa, M. R. (2009). Attitudes, norms and perceived behavioural control: Explaining fertility intentions in bulgaria. *European Journal of Population*, 25(4):439–465.

Birdsall, N. M.and Griffin, C. C. (1988). Fertility and poverty in developing countries. *Journal of Policy Modeling*, 10(1):29–55.

Blakeslee, D., Chaurey, R., Fishman, R., Malghan, D., and Malik, S. (2021). In the heat of the moment: Economic and non-economic drivers of the weather-crime relationship. *Journal of Economic Behavior & Organization*, 192:832–856.

Blanco, L. and Ruiz, I. (2013). The impact of crime and insecurity on trust in democracy and institutions. *American Economic Review: Papers and Proceedings*, 103(3):284–288.

Boahen, E. A. and Yamauchi, C. (2018). The effect of female education on adolescent fertility and early marriage: Evidence from free compulsory universal basic education in Ghana. *Journal of African Economies*, 27(2):227–248.

Bokek-Cohen, Y., Marey-Sarwan, I., and Tarabeih, M. (2022). Violating religious prohibitions to preserve family harmony and lineage among sunni muslims. *Marriage & Family Review*, 58(3):245–270.

Bollfrass, A. and Shaver, A. (2015). The effects of temperature on political violence: global evidence at the subnational level. *PLoS One*, 10(5):e0123505.

Bongaarts, J. (1987). The proximate determinants of fertility. *Technology in Society*, 9(3–4):243–260.

Bongaarts, J. (2010). The causes of educational differences in fertility in sub-saharan africa. in poverty, gender and youth. *Social and Behavioural Sciences Research.*, 20.

Bonney, E. (2021). Zimbabwe's parliamentary delegation understudies ghana's FCUBE programme. *Daily Graphic*.

Bosetti, V., Cattaneo, C., and Peri, G. (2020). Should they stay or should they go? climate migrants and local conflicts. *Journal of Economic Geography*.

Brückner, M. and Ciccone, A. (2011). Rain and the democratic window of opportunity. *Econometrica*, 79(3):923–947.

Buhaug, H. (2010). Reply to burke et al.: Bias and climate war research. *Proceedings of the National Academy of Sciences*, 107(51):E186–E187.

Burgess, S., Propper, C., and Dickson, M. (2006). The analysis of poverty data with endogenous transitions. *Fiscal Studies*, 27(1):75–98.

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., and Lobell, D. B. (2009). Warming increases the risk of civil war in africa. *Proceedings of the National Academy of Sciences of the United States of America*, 106(49):20670 –20674.

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., and Lobell, D. B. (2010). Reply to sutton et al.: Relationship between temperature and conflict is robust. *Proceedings of the National Academy of Sciences*, 107(25):E103–E103.

Burton, J. (2020). Worldatlas:list of countries by literacy rate. www.worldatlas.com/articles/the-highest-literacy-rates-in-the-world.html#:~:text=Literacy%2520Rate%2520by%2520Country%2520%2520%2520%2520%25EF%25BB%25BFCountry,%2520100.0%2520%25%2520%2520106%2520more%2520rows.

Buscha, F. and Dickson, M. (2018). A note on the wage effects of the 1972 raising of the school leaving age in scotland and northern ireland. *Scottish Journal of Political Economy*, 65(5):572–582.

Caldwell, J. C. (1982). *The wealth flows theory of fertility decline*, page 169–188. Hohn C, Mackensen R.

Caldwell, J. C., Orubuloye, I. O., and Caldwell, P. (1992). Fertility decline in africa: A new type of transition? *Population and Development Review*, 18(2):211–242.

Calonico, S., Cattaneo, M. D., and Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, 82(6):2295–2326.

Cameron, C. and Miller, D. (2015). A practitioner's guide to cluster-robust inference. *Journal of Human Resources*, 50(2):317–373.

Caplescu, R. (2014). Using the theory of planned behaviour to study fertility intentions in romania. *Procedia Economics and Finance*, 10(14):125–133.

Card, D. (2001). Estimating the return to schooling: Progress on some persistent econometric problems. *Econometrica*, 69(5):1127–1160.

Carranza, E. (2012). *Islamic Inheritance Law, Son Preference and Fertility Behavior of Muslim Couples in Indonesia*. The World Bank.

Cervallati, M., Sunde, U., and Valmori, S. (2017). Pathogens, weather shocks and civil conflicts. *The Economic Journal*, 127(607):2581–2616.

Chauhan, B. G. and Prasad, J. B. (2021). Contraception use and fertility aspiration among currently married young men in india: Do gender attitudes matter? *Children and Youth Services Review*, 122:105920.

Chen, C. W. S. and Lee, S. (2017). Bayesian causality test for integer-valued time series models with applications to climate and crime data. *Journal of the Royal Statistical Society Series C*, 66(4):797–814.

Chen, Q. (2015). Climate shocks, dynastic cycles and nomadic conquests: evidence from historical china. *Oxford Economic Papers*, 67(2):185–204.

Chhibber, A. and Laajaj, R. (2008). Disasters, climate change and economic development in sub-saharan africa: Lessons and directions. *Journal of African Economies*, 17(Supplement 2):ii7–ii49.

Choudhry, M. T. and Elhorst, J. P. (2010). Demographic transition and economic growth in china, india and pakistan. *Economic Systems*, 34(3):218–236.

Chouhan, P., Saha, J., and Zaveri, A. (2020). Covariates of fertility behavior among ever-married women in west bengal, india: Analysis of the national family health survey-4. *Children and Youth Services Review*, 113:104956.

Chung, U. L. W. and Gupta, M. D. (1998). Fertility and son preference in korea. *Population Studies*, 52(3):317–325. PMID: 11623524.

Clark, D. and Royer, H. (2013). The effect of education on adult mortality and health: Evidence from Britain. *American Economic Review*, 103(6):2087–120.

Coccia, M. (2017). A theory of general causes of violent crime: Homicides, income inequality and deficiencies of the heat hypothesis and of the model of CLASH. *Aggression and Violent Behavior*, 37:190–200.

Cohen, B. (1998). The emerging fertility transition in sub-saharan africa. *World Development*, 26(8):1431–1461.

Collier, P. and Hoeffler, A. (1998). On economic causes of civil war. *Oxford Economic Papers*, 50(4):563–573.

Collier, P. and Hoeffler, A. (2004). Greed and grievance in civil war. *Oxford Economic Papers*, 56(4):563–595.

Collier, P., Hoeffler, A., and Rohner, D. (2008). Beyond greed and grievance: feasibility and civil war. *Oxford Economic Papers*, 61(1):1–27.

Conley, J. (1990). Childbearing and childrearing practices in mormonism. *Neonatal Network*, 9(3):48.

Conley, T. G. (1999). GMM estimation with cross sectional dependence. *Journal of Econometrics*, 92(1):1–45.

Conner, M. and Norman, P. (2005). Predicting health behaviour:a health cognition approach. in m. conner and p. norman (eds.). *Predicting Health Behaviour (Second). Open University Press.*

Courtin, E., Nafilyan, V., Avendano, M., Meneton, P., Berkman, L. F., Goldberg, M., Zins, M., and Dowd, J. B. (2019). Longer schooling but not better off? a quasi-experimental study of the effect of compulsory schooling on biomarkers in france. *Social Science and Medicine*, 220:379–386.

Cramer, J. C. (1980). Fertility and female employment: Problems of causal direction. *American Sociological Review*, 45(2):167–190.

Davies, N. M., Dickson, M., Davey Smith, G., van den Berg, G. J., and Windmeijer, F. (2018). The causal effects of education on health outcomes in the uk biobank. *Nature human behaviour*.

de Walque, D. (2007). Does education affect smoking behaviors? evidence using the vietnam draft as an instrument for college education. *Journal of Health Economics*, 26(5):877–95.

Dell, M., Jones, B. F., and Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, 4(3):66–95.

Dell, M., Jones, B. F., and Olken, B. A. (2014). What do we learn from the weather? the new climate-economy literature. *Journal of Economic Literature*, 52(3):740–798.

Delprato, M., Akyeampong, K., and Dunne, M. (2017). Intergenerational education effects of early marriage in sub-saharan africa. *World Development*, 91:173–192.

Depetris-Chauvin, E., Durante, R., and Campante, F. (2020). Building nations through shared experiences: Evidence from african football. *American Economic Review*, 110(5):1572–1602.

Desai, R., Mercken, L. A. G., Ruiter, R. A. C., Schepers, J., and Reddy, P. S. (2019). Cigarette smoking and reasons for leaving school among school dropouts in south africa. *BMC Public Health*, 19(1):130.

Dickson, A., MacKenzie, I. A., and Sekeris, P. G. (2022). The role of markets on resource conflicts. *The Scandinavian Journal of Economics*.

Dickson, M. (2013). The causal effect of education on wages revisited. *Oxford Bulletin of Economics and Statistics*, 75(4):477–498.

Dilmaghani, M. (2020). The causal effects of education on health over the life course: evidence from canada. *Public Health*, 186:170–177.

Dinçer, M. A., Kaushal, N., and Grossman, M. (2014). Women's education: Harbinger of another spring? evidence from a natural experiment in Turkey. *World Development*, 64:243–258.

Duda, R. B., Jumah, N. A., Hill, A. G., Seffah, J., and Biritwum, R. (2006). Interest in healthy living outweighs presumed cultural norms for obesity for Ghanaian women. *Health Qual Life Outcomes*, 4:44.

Duodu, P. A., Bayuo, J., Mensah, J. A., Aduse-Poku, L., Arthur-Holmes, F., Dzomeku, V. M., Dey, N. E. Y., Agbadi, P., and Nutor, J. J. (2022). Trends in antenatal care visits and associated factors in ghana from 2006 to 2018. *BMC Pregnancy and Childbirth volume*, 22(59).

Easterlin, R. A. (1973). The economics and sociology of fertility: A synthesis. paper prepared for seminar on early industrialization, shifts in fertility and changes in family structure,. *Institute for Advanced Study, Princeton, N.J.,*.

Easterlin, R. A. (1975). An economic framework for fertility analysis. *Studies in Family Planning*, 6(3):54–63.

Eastin, J. (2018). Hell and high water: Precipitation shocks and conflict violence in the philippines. *Political Geography*, 63:116–134.

Esteban, J. and Ray, D. (2008). Polarization, fractionalization and conflict. *Journal of Peace Research*, 45(2):163–182.

Fafchamps, M. (2006). Development and social capital. *Journal of Development Studies*, 42(7):1180–1198.

Fanti, L. and Gori, L. (2012). A note on endogenous fertility, child allowances and poverty traps. *Economics Letters*, 117(3):722–726.

Farah, M. J. and Hook, C. J. (2017). Trust and the poverty trap. *Proceedings of the National Academy of Sciences*, 114(21):5327–5329.

Fearon, J. D. and Laitin, D. D. (2000). Violence and the social construction of ethnic identity. *International Organization*, 54(4):845–877.

Fearon, J. D. and Laitin, D. D. (2003). Ethnicity, insurgency and civil war. *American Political Science Review*, 97(01):75–90.

Fernandez, R. and Fogli, A. (2006). Fertility: the role of culture. *Journal of the European Economic Association*, 4(2):552–561.

Fetzer, T. (2020). Can Workfare Programs Moderate Conflict? Evidence from India. *Journal of the European Economic Association*, 18(6):3337–3375.

Fletcher, J. M. (2015). New evidence of the effects of education on health in the us: compulsory schooling laws revisited. *Social Science and Medicine*, 127:101–7.

Fletcher, J. M. and Frisvold, D. E. (2011). College selectivity and young adult health behaviors. *Economics of Education Review*, 30(5):826–837.

Fonseca, R., Michaud, P.-C., and Zheng, Y. (2019). The effect of education on health: evidence from national compulsory schooling reforms. *SERIEs*, 11(1):83–103.

Fuchs, V. (1982). Time preference and health: An exploratory study. In *Economic Aspects of Health*, pages 93–120. National Bureau of Economic Research, Inc.

Fujiwara, T. and Kawachi, I. (2009). Is education causally related to better health? a twin fixed-effect study in the usa. *International Journal of Epidemiology*, 38(5):1310–22.

Gangopadhyay, P. and Nilakantan, R. (2017). Estimating the effects of climate shocks on collective violence: Ardl evidence from india. *The Journal of Development Studies*, 54(3):441–456.

Gedzi, V. (2009). *Principles and practices of dispute resolution in Ghana : Ewe and Akan procedures on females' inheritance and property rights*. Phd thesis, Erasmus University Rotterdam.

Gehrsitz, M. (2017). Speeding, punishment, and recidivism: Evidence from a regression discontinuity design. *The Journal of Law and Economics*, 60(3):497–528.

Gong, E. and Sullivan, K. A. (2017). Conflict and coffee: Are higher coffee prices fuelling rebellion in Uganda? *Journal of African Economies*, 26(3):322–341.

Green, E. (2018). Ethnicity, national identity and the state: Evidence from sub-saharan africa. *British Journal of Political Science*, 50(2):757–779.

Griffin, L. (2015). The catholic bishops vs. the contraceptive mandate. *Religions*, 6(4):1411–1432.

Grossman, H. I. (1991). A general equilibrium model of insurrections. *The American Economic Review*, 81:912–921.

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy*, 80(2):223–255.

Grossman, M. (1973). The correlation between health and schooling. Working Paper 22, National Bureau of Economic Research.

Grossman, M. (2004). The demand for health, 30 years later: a very personal retrospective and prospective reflection. *Journal of Health Economics*, 23(4):629–36.

Grossman, M. (2008). The relationship between health and schooling. *Eastern Economic Journal*, 34(3):281–292.

Grönqvist, H. and Hall, C. (2013). Education policy and early fertility: Lessons from an expansion of upper secondary schooling. *Economics of Education Review*, 37:13–33.

Haertzen, C., Covi, L., Buxton, K., and Richards, H. (1993). Seasonal changes in rule infractions among prisoners: A preliminary test of the temperature-aggression hypothesis. *Psychological Reports*, 72(1):195–200.

Hahn, J., Todd, P., and Van der Klaauw, W. (2001). Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica*, 69(1):201–209.

Hamad, R., Elser, H., Tran, D. C., Rehkopf, D. H., and Goodman, S. N. (2018). How and why studies disagree about the effects of education on health: A systematic review and meta-analysis of studies of compulsory schooling laws. *Social Science and Medicine*, 212:168–178.

Harari, M. and La Ferrara, E. (2018). Conflict, climate and cells: A disaggregated analysis. *The Review of Economics and Statistics*, 100(4):594–608.

Harrison, S., Davies, A. R., Dickson, M., Tyrrell, J., Green, M. J., Katikireddi, S. V., Campbell, D., Munaf, M., Dixon, P., Jones, H. E., Rice, F., Davies, N. M., and Howe, L. D. (2020). The causal effects of health conditions and risk factors on social and socioeconomic outcomes: Mendelian randomization in UK Biobank. *International Journal of Epidemiology*, 49(5):1661–1681.

Hatton, T. J., Sparrow, R., Suryadarma, D., and van der Eng, P. (2018). Fertility and the health of children in indonesia. *Economics and Human Biology*, 28:67–78.

Heaton, T. B. (1986). How does religion influence fertility?: The case of mormons. *Journal for the Scientific Study of Religion*, 25(2):248.

Heaton, T. B. (2011). Does religion influence fertility in developing countries. *Population Research and Policy Review*, 30(3):449–465.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences*, 104(33):13250–13255.

Heckman, J. J., Humphries, J. E., and Veramendi, G. (2018). Returns to education: The causal effects of education on earnings, health, and smoking. *Journal of Political Economy*, 126(S1):S197–S246.

Helman, D. and Zaitchik, B. F. (2020). Temperature anomalies affect violent conflicts in african and middle eastern warm regions. *Global Environmental Change*, 63:102118.

Herbst-Debby, A., Endeweld, M., and Kaplan, A. (2021). Differentiated routes to vulnerability: Marital status, children, gender and poverty. *Advances in Life Course Research*, 49:100418.

Hirschman, C. (1994). Why fertility changes. *Annual Review of Sociology*, 20(1):203–233.

Hodler, R., Srisuma, S., Vesperoni, A., and Zurlinden, N. (2020). Measuring ethnic stratification and its effect on trust in africa. *Journal of Development Economics*, 146.

Hoenig, K. and Wenz, S. E. (2021). Education, health behavior, and working conditions during the pandemic: evidence from a german sample. *European Societies*, 23(sup1):S275–S288.

Hondroyiannis, G. (2010). Fertility determinants and economic uncertainty: An assessment using european panel data. *Journal of Family and Economic Issues*, 31(1):33–50.

Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the caribbean and central america. *Proceedings of the National Academy of Sciences*, 107(35).

Hsiang, S. M. and Burke, M. (2013). Climate, conflict and social stability: what does the evidence say? *Climatic Change*, 123(1):39–55.

Hsiang, S. M., Meng, K. C., and Cane, M. A. (2011). Civil conflicts are associated with the global climate. *Nature*, 476(7361):438–41.

Hughes, A., Wade, K. H., Dickson, M., Rice, F., Davies, A., Davies, N. M., and Howe, L. D. (2021). Common health conditions in childhood and adolescence, school absence, and educational attainment: Mendelian randomization study. *Science of Learning*.

Ibeji, J. U., Zewotir, T., North, D., and Amusa, L. (2020). Modelling fertility levels in nigeria using generalized poisson regression-based approach. *Scientific African*, 9:e00494.

Imbens, G. and Kalyanaraman, K. (2011). Optimal bandwidth choice for the regression discontinuity estimator. *The Review of Economic Studies*, 79(3):933–959.

Imbens, G. W. and Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of Econometrics*, 142(2):615–635.

Inhorn, M. C., Birenbaum-Carmeli, D., Vale, M. D., and Patrizio, P. (2020). Abrahamic traditions and egg freezing: Religious women's experiences in local moral worlds. *Social Science & Medicine*, 253:112976.

Jacob, R., Zhu, P., Somers, M.-A., and Bloom, H. (2012). A practical guide to regression discontinuity. Technical report, MDRC.

Janke, K., Johnston, D. W., Propper, C., and Shields, M. A. (2020). The causal effect of education on chronic health conditions in the uk. *Journal of Health Economics*, 70:102252.

Janssens, C., Van den Broeck, G., Maertens, M., and Lambrecht, I. (2019). What if mothers are entrepreneurs? non-farm businesses and child schooling in rural ghana. *Journal of Rural Studies*, 66:95–103.

Jia, R. (2014). Weather shocks, sweet potatoes and peasant revolts in historical china. *The Economic Journal*, 124(575):92–118.

Johnson, R. C. (2010). The health returns of education policies from preschool to high school and beyond. *American Economic Review*, 100(2):188–94.

Johnson-Hanks, J. (2002). On the modernity of traditional contraception: Time and the social context of fertility. *Population and Development Review*, 28(2):229–249.

Jolliffe, D. (2004). The impact of education in rural ghana: examining household labor allocation and returns on and off the farm. *Journal of Development Economics*, 73(1):287–314.

Jones, A. M., Rice, N., and Rosa Dias, P. (2011). Long-term effects of school quality on health and lifestyle: Evidence from comprehensive schooling reforms in england. *Journal of Human Capital*, 5(3):342–376.

Jones, A. M., Rice, N., and Rosa Dias, P. (2012). Quality of schooling and inequality of opportunity in health. *Empirical Economics*, pages 369–394.

Jones, A. M., Roemer, J. E., and Rosa Dias, P. (2014). Equalising opportunities in health through educational policy. *Social Choice and Welfare*, 43(3):521–545.

Juergens, C., Dabin, B., French, J., Kritharides, L., Hyun, K., Kilian, J., Chew, D., and Brieger, D. (2016). English as a second language and outcomes of patients presenting with acute coronary syndromes: results from the concordance registry. *The Medical journal of Australia*, 204.

Jurges, H., Kruk, E., and Reinhold, S. (2013). The effect of compulsory schooling on health-evidence from biomarkers. *Journal of Population Economics*, 26(2):645–672.

Jurges, H., Reinhold, S., and Salm, M. (2011). Does schooling affect health behavior? evidence from the educational expansion in western germany. *Economics of Education Review*, 30(5):862–872.

Kaestner, R., Schiman, C., and Ward, J. (2020). Education and health over the life cycle. *Economics of Education Review*, 76.

Kahneman, D. (2012). *Thinking Fast and Slow.* Penguin Books.

Kaplan, H. (1994). Evolutionary and wealth flows theories of fertility: Empirical tests and new models. *Population and Development Review*, 20(4):753–791.

Keats, A. (2018). Women's schooling, fertility and child health outcomes: Evidence from Uganda's free primary education program. *Journal of Development Economics*, 135:142–159.

Kenkel, D. (1991). Health behavior, health knowledge and schooling. *Journal of Political Economy*, 99(2):287–305.

Kenny, N., Warland, J., Brown, R., and Gillespie, T. (2008). Estimating the radiation absorbed by a human. *International journal of biometeorology*, 52:491–503.

Kenrick, D. T. and MacFarlane, S. W. (1986). Ambient temperature and horn honking: A field study of the heat/aggression relationship. *Environment and Behavior*, 18(2):179–191.

Khraif, R. M., Salam, A. A., Al-Mutairi, A., Elsegaey, I., and al Jumaah, A. (2017). Education's impact on fertility: The case of king saud university women, riyadh. *Middle East Fertility Society Journal*, 22(2):125–131.

Knack, S. and Keefer, P. (1997). Does social capital have an economic payoff? a cross-country investigation. *Quarterly Jornal of Economics*, pages 1251–1288.

Kohler, H. P., Rodgers, J. L., Miller, W. B., Skytthe, A., and Christensen, K. (2006). Bio-social determinants of fertility. *International Journal of Andrology*, 29(1):46–53.

Kreyenfeld, M. and Andersson, G. (2014). Socioeconomic differences in the unemployment and fertility nexus: Evidence from denmark and germany. *Advances in Life Course Research*, 21:59–73.

Kutsoati, E. and Morck, R. (2016). *Family Ties, Inheritance Rights, and Successful Poverty Alleviation: Evidence from Ghana*, chapter Chapter 7. University of Chicago Press.

Laliotis, I. and Minos, D. (2022). Religion, social interactions, and covid-19 incidence in western germany. *European Economic Review*, 141:103992.

Larrick, R. P., Timmerman, T. A., Carton, A. M., and Abrevaya, J. (2011). Temper, temperature and temptation: heat-related retaliation in baseball. *Psychological Science*, 22(4):423–8.

Lee, D. S. and Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature*, 48(2):281–355.

Lehrer, E. L. (1996). Religion as a determinant of marital fertility. *Journal of Population Economics*, 9(2):173–196.

Leibenstein, H. (1975). The economic theory of fertility decline. *Quarterly Journal of Economics*, LXXXIX(1):1133–1165.

Leibenstein, H. (1981). Economic decision theory and human fertility behavior: A speculative essay. *Population and Development Review*, 7(3):381–400.

Lesthaeghe, R. and Surkyn, J. (1988). Cultural dynamics and economic theories of fertility change. *Population and Development Review*, 14(1):1–45.

Libois, F. and Somville, V. (2018). Fertility, household size and poverty in nepal. *World Development*, 103:311–322.

Linke, A. M., O'Loughlin, J., McCabe, J. T., Tir, J., and Witmer, F. D. W. (2015). Rainfall variability and violence in rural Kenya: Investigating the effects of drought and the role of local institutions with survey data. *Global Environmental Change*, 34:35–47.

Lleras-Muney, A. (2005). The Relationship Between Education and Adult Mortality in the United States. *The Review of Economic Studies*, 72(1):189–221.

Lochner, L. (2011). *Non-Production Benefits of Education: Crime, Health and Good Citizenship*, page 315–322. Elsevier Science.

Lundborg, P. (2012). The health returns to schooling—what can we learn from twins? *Journal of Population Economics*, 26(2):673–701.

Ma, Y., Nolan, A., and Smith, J. P. (2018). The value of education to health: Evidence from ireland. *Economics & Human Biology*, 31:14–25.

Makowiec-Dabrowska, T., Gadzicka, E., Siedlecka, J., Szyjkowska, A., Veibig, P., Kozak, P., and Bortkiewicz, A. (2019). Climate conditions and work-related fatigue among professional drivers. *International Journal of Biometeorology*, 63:121–128.

Maley, M. J., Minett, G. M., Bach, A. J. E., Zietek, Stephanie, A., Stewart, K. L., and Stewart, I. B. (2018). Internal and external cooling methods and their effect on body temperature, thermal perception and dexterity. *PLOS One*, 13(1).

Manacorda, M. and Tesei, A. (2020). Liberation technology: Mobile phones and political mobilization in africa. *Econometrica*, 88(2):533–567.

Martin, T. C. and Juarez, F. (1995). The impact of women's education on fertility in latin america: Searching for explanations. *International Family Planning Perspectives*, 21(2):52–80.

Mason, K. O. (1997). Explaining fertility transitions. *Demography*, 34(3):443–454.

Masuda, K. and Yamauchi, C. (2018). How does female education reduce adolescent pregnancy and improve child health?: Evidence from Uganda's universal primary education for fully treated cohorts. *The Journal of Development Studies*, 56(1):63–86.

Maystadt, J.-F. and Ecker, O. (2014). Extreme weather and civil war: Does drought fuel conflict in somalia through livestock price shocks? *American Journal of Agricultural Economics*, 96(4):1157–1182.

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics*, 142(2):698–714. The regression discontinuity design: Theory and applications.

McGuirk, E. F. and Nunn, N. (2020). Transhumant pastoralism, climate change, and conflict in africa. Working Paper 28243, National Bureau of Economic Research.

Medoff, M. H. (2012). Restrictive abortion laws, antiabortion attitudes and women's contraceptive use. *Social Science Research*, 41(1):160–169.

Mekonnen, A. (2014). Economic costs of climate change and climate finance with a focus on africa. *Journal of African Economies*, 23:ii50–ii82.

Michalopoulos, S., Naghavi, A., and Prarolo, G. (2018). Trade and geography in the spread of islam. *The Economic Journal*, 128(616):3210–3241.

Miguel, E. (2005). Poverty and Witch Killing. *The Review of Economic Studies*, 72(4):1153–1172.

Miguel, E. and Kremer, M. (2004). Worms: Identifying impacts on education and health in the presence of treatment externalities. *Econometrica*, 72(1):159–217.

Monstad, K., Propper, C., and Salvanes, K. G. (2008). Education and fertility: Evidence from a natural experiment. *The Scandinavian Journal of Economics*, 110(4):827–852.

Moscona, J., Nunn, N., and Robinson, J. A. (2017). Keeping it in the family: Lineage organization and the scope of trust in sub-saharan africa. *American Economic Review*, 107(5):565–571.

Munthali, A. C. and Zulu, E. M. (2007). The timing and role of initiation rites in preparing young people for adolescence and responsible sexual and reproductive behaviour in malawi. *African Journal of Reproductive Health*, 11(3):150–167.

Murdock, G. P. (1959). *Africa: Its Peoples and Their Culture History*. McGraw-Hill Book Company, New York.

Murdock, G. P. (1967). *Ethnographic Atlas*. University of Pittsburgh Press, Pittsburgh, PA.

Neumayer, E. (2006). An empirical test of a neo-malthusian theory of fertility change. *Population and Environment*, 27(4):327–336.

Nishimura, M. and Byamugisha, A. (2011). *The Challenges of Universal Primary Education Policy in Sub-Saharan Africa*, pages 225–245. Palgrave Macmillan US, New York.

Nketiah-Amponsah, E., Afful-Mensah, G., and Ampaw, S. (2018). Determinants of cigarette smoking and smoking intensity among adult males in ghana. *BMC public health*, 18(941).

Nordhaus, W. D. (1993). Climate and economic development: Climates past and climate change future. *The World Bank Economic Review*, 7:355–376.

Nudzor, H. P. (2013a). Exploring the policy implementation paradox: using the free compulsory universal basic education FCUBE policy in Ghana as an exemplar. *International Journal of Qualitative Studies in Education*, 26(8):933–952.

Nudzor, H. P. (2013b). Unearthing the discursive shift in the FCUBE policy implementation in Ghana: using critical discourse analysis. *International Journal of Research & Method in Education*, 36(2):179–201.

Nunn, N. (2010). Religious conversion in colonial africa. *American Economic Review*, 100(2):147–152.

Nunn, N., Qian, N., and Wen, J. (2018). Distrust and political turnover during economic crises. Working Paper 24187, National Bureau of Economic Research.

Nunn, N. and Wantchekon, L. (2011). The slave trade and the origins of mistrust in africa. *American Economic Review*, 101(7):3221–3252.

Nwogu, J. N., Igbolekwu, C. O., Nwokocha, E. E., Nwogu, E. C., Nwabugwu, O. N., and Arisukwu, O. (2021). Roman catholicism and fertility among the mbaise, southeast, nigeria. *Heliyon*, 7(2):e05929.

Odunowo, M. A. (2020). *Essays in Applied Microeconomics. Doctoral dissertation.* Texas A&M University.

Ofori-Asenso, R., Agyeman, A. A., Laar, A., and Boateng, D. (2016). Overweight and obesity epidemic in Ghana-a systematic review and meta-analysis. *BMC Public Health*, 16(1):1239.

Okedo-Alex, I. N., Akamike, I. C., Ezeanosike, O. B., and Uneke, C. J. (2019). Determinants of antenatal care utilisation in sub-saharan africa: a systematic review. *BMJ Open*, 9(10).

Oreopoulos, P. (2006). Estimating average and local average treatment effects of education when compulsory schooling laws really matter. *American Economic Review*, 96(1):152–175.

Osili, U. O. and Long, B. T. (2008). Does female schooling reduce fertility? evidence from Nigeria. *Journal of Development Economics*, 87(1):57–75.

Owusu-Dabo, E., Lewis, S., McNeill, A., Gilmore, A., and Britton, J. (2009). Smoking uptake and prevalence in Ghana. *Tobacco Control*, 18(5):365–70.

Passarelli, F. and Tabellini, G. (2017). Emotions and political unrest. *Journal of Political Economy*, 125(3).

Perry, S. L. and Schleifer, C. (2019). Are the faithful becoming less fruitful? the decline of conservative protestant fertility and the growing importance of religious practice and belief in childbearing in the us. *Social Science Research*, 78:137–155.

Pew Research Center (2015). Religious composition by country, 2010-2050. https://www.pewforum.org/2015/04/02/religious-projection-table.

Polizzi, A., Struffolino, E., and Van Winkle, Z. (2022). Family demographic processes and in-work poverty: A systematic review. *Advances in Life Course Research*, page 100462.

Post, R., Hudson, D., Mitchell, D., Bell, P., Perliger, A., and Williams, R. (2016). Rethinking the water-food-climate nexus and conflict: An opportunity cost approach. *Applied Economic Perspectives and Policy*, 38(4):563–577.

Prudkov, P. N. and Rodina, O. N. (2019). Cold temperatures, stress, and violence. *Heliyon*, 5(5):e01619.

Psaki, S. R., Chuang, E. K., Melnikas, A. J., Wilson, D. B., and Mensch, B. S. (2019). Causal effects of education on sexual and reproductive health in low and middle-income countries: A systematic review and meta-analysis. *SSM - Population Health*, 8.

Ranson, M. (2014). Crime, weather and climate change. *Journal of Environmental Economics and Management*, 67(3):274–302.

Rinderu, M. I., Bushman, B. J., and Van Lange, P. A. (2018). Climate, aggression and violence (CLASH): a cultural-evolutionary approach. *Current Opinions Psychology*, 19:113–118.

Robertson, E. (2011). The effects of quarter of birth on academic outcomes at the elementary school level. *Economics of Education Review*, 30(2):300–311.

Robinson, A. L. (2014). National versus ethnic identification in africa: Modernization, colonial legacy and the origins of territorial nationalism. *World Politics*, 66(4):709–746.

Robinson, A. L. (2016a). Internal borders: Ethnic-based market segmentation in malawi. *World Development*, 87:371–384.

Robinson, A. L. (2016b). Nationalism and ethnic-based trust: Evidence from an african border region. *Comparative Political Studies*, 49(14):1819–1854.

Rodrik, D., Subramanian, A., and Trebbi, F. (2004). Institutions rule: The primacy of institutions over geography and integration in economic development. *Journal of Economic Growth*, 9(2):131–65.

Rohner, D., Thoenig, M., and Zilibotti, F. (2013). War signals: A theory of trade, trust and conflict. *The Review of Economic Studies*, 80(3):1114–1147.

Roome, W. R. M. (1925). Ethnographic survey of africa: Showing the tribes and languages; also the stations of missionary societies. *Edward Stanford Ltd.*

Rosenzweig, M. R. and Schultz, T. P. (1985). The demand for and supply of births: Fertility and its life cycle consequences. *The American Economic Review*, 75(5):992–1015.

Rossi, P. and Rouanet, L. (2015). Gender preferences in africa: A comparative analysis of fertility choices. *World Development*, 72:326–345.

Rossier, C. and Bernardi, L. (2009). Social interaction effects on fertility: Intentions and behaviors. *European Journal of Population*, 25(4):467–485.

Sacks, W. J., Deryng, D., Foley, J. A., and Ramankutty, N. (2010). Crop planting date: an analysis of global patterns. *Global Ecology and Biogeography*, 19:607–620.

Salifu, I., Boateng, J. K., Kunduzore, S. S., and Serpa, S. (2018). Achieving free compulsory universal basic education through school feeding programme: Evidence from a deprived rural community in northern Ghana. *Cogent Education*, 5(1).

Sanderson, E. and Windmeijer, F. (2016). A weak instrument f-test in linear iv models with multiple endogenous variables. *Journal of Econometrics*, 190(2):212–221.

Sansani, S. (2011). The effects of school quality on long-term health. *Economics of Education Review*, 30(6):1320–1333.

Sarsons, H. (2015). Rainfall and conflict: A cautionary tale. *Journal of Development Economics*, 112:62–72.

Schinasi, L. H. and Hamra, G. B. (2017). A time series analysis of associations between daily temperature and crime events in philadelphia, pennsylvania. *Journal of Urban Health*, 94(6):892–900.

Schleussner, C. F., Donges, J. F., Donner, R. V., and Schellnhuber, H. J. (2016). Armed-conflict risks enhanced by climate-related disasters in ethnically fractionalized countries. *Proceedings of the National Academy of Sciences of the United States of America*, 113(33):9216–21.

Sekhri, S. and Storeygard, A. (2014). Dowry deaths: Response to weather variability in india. *Journal of Development Economics*, 111:212–223. Special Issue: Imbalances in Economic Development.

Selby, J. and Hoffmann, C. (2014). Beyond scarcity: Rethinking water, climate change and conflict in the sudans. *Global Environmental Change*, 29:360–370.

Smith-Lovin, L. and Tickamyer, A. R. (1978). Nonrecursive models of labor force participation , fertility behavior and sex role attitudes. *American Sociological Review*, 43(4):541–557.

Steadman, R. G. (1979a). The assessment of sultriness. part i: A temperature-humidity index based on human physiology and clothing science. *Journal of Applied Meteorology and Climatology*, 18(7):861 – 873.

Steadman, R. G. (1979b). The assessment of sultriness. part ii: Effects of wind, extra radiation and barometric pressure on apparent temperature. *Journal of Applied Meteorology and Climatology*, 18(7):874 – 885.

Steadman, R. G. (1994). Norms of apparent temperature in australia. *Australian Meteorological Magazine*, 43:1 – 16.

Stock, J. and Yogo, M. (2005). *Testing for Weak Instruments in Linear IV Regression*, pages 80–108. Cambridge University Press, New York.

Tabellini, G. (2010). Culture and institutions: Economic development in the regions of europe. *Journal of the European Economic Association*, 8(4):677–716.

Tadesse, G. T., Demlew, D., Gtsadik, M., Habte, F., Kassie, G. M., Kifle, Y., and Gebreegziabhier, G. (2020). The prevalence and associated factors of alcohol use among pregnant women attending antenatal care at public hospitals addis ababa, ethiopia. *BMC Psychiatry*.

Tann, C. J., Kizza, M., Morison, L., Mabey, D., Muwanga, M., Grosskurth, H., and Elliott, A. M. (2007). Use of antenatal services and delivery care in entebbe, Uganda: a community survey. *BMC Pregnancy Childbirth*, 7:23.

Templin, T., Cravo Oliveira Hashiguchi, T., Thomson, B., Dieleman, J., and Bendavid, E. (2019). The overweight and obesity transition from the wealthy to the poor in low- and middle-income countries: A survey of household data from 103 countries. *PLoS Medicine*, 16(11):e1002968.

Testa, M. R. (2014). On the positive correlation between education and fertility intentions in europe: Individual- and country-level evidence. *Advances in Life Course Research*, 21:28–42.

Theisen, O. M. (2012). Climate clashes? weather variability, land pressure and organized violence in Kenya, 1989–2004. *Journal of Peace Research*, 49(1):81–96.

Tiihonen, J., Halonen, P., Tiihonen, L., Kautiainen, H., Storvik, M., and Callaway, J. (2017). The association of ambient temperature and violent crime. *Nature: Scientific Reports*, 7(6543).

Tsutsumi, H., Tanabe, S.-i., Harigaya, J., Iguchi, Y., and Nakamura, G. (2007). Effect of humidity on human comfort and productivity after step changes from warm and humid environment. *Building and Environment*, 42(4034-4042).

UNDP (2020). Health index. human development reports. http://hdr.undp.org/en/content/health-index.

van de Kaa, D. J. (1996). Anchored narratives: The story and findings of half a century of research into the determinants of fertility. *Population Studies*, 50(3):389–432.

van Kippersluis, H. and Galama, T. J. (2014). Wealth and health behavior: Testing the concept of a health cost. *European Economic Review*, 72:197–220.

Van Lange, P. A. M., Rinderu, M. I., and Bushman, B. J. (2017). Aggression and violence around the world: A model of climate, aggression, and self-control in humans (CLASH). *Behavioral and Brain Sciences*, 40:e75.

van Weezel, S. (2014). Economic shocks & civil conflict onset in sub-saharan africa, 1981–2010. *Defence and Peace Economics*, 26(2):153–177.

Vellei, M., Herrera, M., Fosas, D., and Natarajan, S. (2017). The influence of relative humidity on adaptive thermal comfort. *Building and Environment*, 124:171–185.

Vrij, A., van der Steen, J., and Koppelaar, L. (1994). Aggression of police officers as a function of temperature: An experiment with the fire arms training system. *Journal of Community and Applied Social Psychology*, 4:365–370.

Wagstaff, A. (1986). The demand for health: theory and applications. *Journal of Epidemiology & Community Health*, 40(1):1–11.

Walker, I. and Pettigrew, T. F. (1984). Relative deprivation theory: An overview and conceptual critique. *British Journal of Social Psychology*, 23(4):301–310.

Weber, M. (1905). *The Protestant Ethic and the Spirit of Capitalism*. Routledge.

Wetherley, E. (2014). *Typhoons and Temperature Impact Crime Rates: Evidence from the Philippines*. Master thesis, University of San Francisco.

White, A. L., Mann, E. S., and Larkan, F. (2018). Contraceptive knowledge, attitudes, and use among adolescent mothers in the cook islands. *Sexual & Reproductive Healthcare*, 16:92–97.

Wooldridge, J. M. (2009). Introductory econometrics: A modern approach. *South-Western, Cengage Learning.*, 4th ed.

World Bank (2004). Books, buildings, and learning outcomes: An impact evaluation of world bank support to basic education in ghana. Report 28779, World Bank.

World Bank (2019). Fertility rate, total (births per woman. data.worldbank.org/indicator/SP.DYN.TFRT.IN.

World Education Service (2019). Education in ghana. https://wenr.wes.org/2019/04/education-in-ghana.

World Health Organization (2019a). Maternal mortality. https://www.who.int/news-room/fact-sheets/detail/maternal-mortality.

World Health Organization (2019b). World health statistics 2019: monitoring health for the sdgs, sustainable development goals. https://apps.who.int/iris/handle/10665/324835.

Xue, X., Cheng, M., and Zhang, W. (2020). Does education really improve health? a meta-analysis. *Journal of Economic Surveys*, 35(1):71–105.

Zhang, J. (1990). Socioeconomic determinants of fertility in china - a microeconometric analysis. *Journal of Population Economics*, 3(2):105–123.

Zhang, Z., Solazzo, A., and Gorman, B. K. (2020). Education and health: The joint role of gender and sexual identity. *SSM - Population Health*, 12:100668.

Zhao, Y., Wang, C., Wang, S., and Tibig, L. (2005). Impacts of present and future cllimate variability on agriculture and forestry in the humid and sub-humid tropics. *Climatic Change*, 70:73–116.

Zinyemba, P. T., Pavlova, M., and Groot, W. (2020). Effects of hiv/aids on children's educational attainment: A systematic literature review. *Journal of Economic Surveys*, 34(1):35–84.

Zmerli, S. and Castillo, J. C. (2015). Income inequality, distributive fairness and political trust in latin america. *Social Science Research*, 52:179–192.