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Gold mining and education: a long-run resource curse in Africa?

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Abstract

We provide micro-level evidence on an important channel through which mineral resources may adversely affect development in the long-run: lower educational attainment. Combining Afrobarometer survey data with geocoded data on the discovery and shutdown dates of of gold mines, we show that respondents who had a gold mine within their district when they were in adolescence have significantly lower educational attainment. These results are robust to the omission of individual countries, different definitions of adulthood, the use of alternative data from the Development and Health Surveys (DHS), and buffer-based approaches to define neighborhood. Regarding mechanisms, we conclude that the educational costs of mines are likely due to households making myopic educational decisions when employment in gold mining is an alternative. We explore and rule out competing mechanism such as endogenous migration, a lower provision of public goods by the government, and a higher propensity for violent conflicts in gold mining districts.

Keywords: Education, mineral resources, gold mining, survey data, Africa

JEL codes: H70, O10, D74

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1 Introduction

Since the turn of the century, the mineral resource sector has been booming in many African countries (AfDB et al., 2013; Chuhan-Pole et al., 2013). This growing importance of mineral resources will likely reshape the structure of African economies for the foreseeable future. It is, however, unclear what the resource boom portends for Africa's economic development and its inhabitant's well-being. On the one hand, mineral resources and the income they may deliver can have immediate positive effects. People can find employment and earn, compared to the available alternatives such as subsistence agriculture, relatively high wages (Hilson, 2016). Fiscally constrained governments might receive additional revenues, which they can use to fund essential public goods and generally better the living conditions of their citizens (Calder, 2014).

On the other hand, an influential literature argues that mineral resources are a curse rather than a blessing for developing countries (van der Ploeg, 2011). Mineral resource booms may lead to exchange rate adjustments that work to make non-resource sectors less competitive, an effect termed the "Dutch Disease" (Corden, 1984). The existence of mineral resources has also been associated with political economy mechanisms that have adverse effects: resources can be a tempting target for predatory political groups and lead to corruption (Leite and Weidmann, 2002; Knutsen et al., 2016) and political instability, including violent conflicts (Lujala et al., 2005; Ross, 2004b). Further adverse effects include heightened volatility in public revenues (Humphreys et al., 2007) and a reduced need for rulers to bargain with their citizens over taxation and thus less democracy and worse governance (Baskaran and Bigsten, 2013; Ross, 2004a).

In this paper, we contribute to the discussion on the benefits and drawbacks of mineral resources and, more specifically, to the debate on the implications of resource booms in Africa by focusing on the production of gold. One important feature of gold production is the disproportionate importance of small-scale, artisinal operations (Hilson, 2016). The ability to profitably extract gold in small-scale operations implies that children and young adults can easily find employment in gold mining. Families may hence neglect the education of their children and instead allow or even encourage them to work. Thus, one subtle curse of gold, one that could only be observable in the long-run, may be lower educational attainment.

In line with this hypothesis, we provide micro-level evidence that men and women have lower levels of education as adults if they had a gold mine in their neighborhood when they were in adolescence. We also offer suggestive evidence for the mechanism discussed above, i. e. that the lower educational attainment comes about because families in gold mining districts encourage their children to work, by ruling out other transmission channels, notably a lower provision of public goods in mining districts by the government, endogenous migration, and a higher propensity of conflicts. Various extensions confirm this interpretation further. In particular, we show that smaller gold mines have a more adverse effect on educational attainment than larger mines and that mineral resources other than gold have no significant effect on educational attainment. These results suggest that gold affects educational attainment negatively because of its amenability to small-scale activities.

Finally, our results indicate that respondents who had mines in their neighborhood during their youth face as adults no better and possibly even worse economic conditions than respondents without any gold mines. This particular result implies that in the long-run, the negative educational effects of gold mining are not outweighed by persistently higher incomes. Overall, our findings indicate that the presence of mines may induce children or their parents to make life choices that are myopic and do not pay off in the long-run. These broader implications of gold mines should be taken into account to properly assess the benefits and drawbacks of the mineral resource boom in Africa.

To explore individuals' educational attainment during adolescence in mining and non-mining districts, we match data on the location and dates of operation of gold mines to survey data on educational attainment from the 4th wave of the Afrobarometer surveys at the district level. Using a sample of 18 countries and controlling for country, region, ethnic group and cohort fixed effects, we identify a significantly negative effect of the presence of a gold mine in the district of a respondent when she was in adolescence on educational attainment. This effect is robust to the omission of individual countries, to different definitions of adolescence, to the use of the Development and Health Surveys (DHS) as an alternative source of data on educational attainment and to a buffer-based definition of neighborhood (rather than one based on administrative districts), and in a number of further robustness tests.

As indicated, our findings contribute to an influential literature on the drawbacks and benefits of mineral resources.[1] A substantial body of anecdotal evidence suggest that mineral resources do not necessarily lead to higher incomes and may, in fact, have depressing consequences. Bevan et al. (1999), for example, show that despite a large increase in oil revenues, income has stagnated and poverty has increased in Nigeria until the turn of the century. Growth and poverty reduction were similarly disappointing in many other resource rich countries (Stokke, 2008). On the other hand, Botswana is often cited as one prime example where natural resources can be beneficial: even as 40% of its GDP is due to diamonds, it has managed to generate high growth rates since 1965 and to invest a substantial share of its national income for public education (Sarraf and Jiwanji, 2001). Another positive example is the United Arab Emirates, where hydrocarbon wealth has led to better infrastructure and an expansion of various public goods and services (Fasano, 2002).

[1]For theoretical work on the effect of mineral resources, see e. g. Auty (2001) and Hodler (2006).

Anecdotal evidence on whether mineral resources are a curse or a blessing is thus contradictory. More systematic evidence is offered by a large literature that explores their consequences at the cross-country level. The seminal work by Sachs and Warner (1995) suggests that natural resources tend to depress economic growth. On the other hand, Bhattacharyya and Hodler (2009) and Mehlum et al. (2006) find that mineral resources have positive economic effects if pre-existing institutions are "producer friendly". Brunnschweiler and Bulte (2008) argue that commonly used measures for resource abundance conflate abundance with dependence. Using ostensibly more accurate measures for resource abundance than the previous literature, they find that natural resources have a positive effect on institutional quality and growth. James (2015) finds that the resource curse is a "statistical mirage": a slow-growing resource sector disproportionately affects overall growth in resource-dependent countries and may show up as a negative growth effect of natural resources in statistical analyses.

A related literature explores various transmission channels through which natural resources may depress long-run growth. Collier and Hoeffler (2004, 2005) suggest that mineral resources increase the propensity of conflicts. Jensen and Wantchekon (2004) find that resource wealth and the level of democracy are negatively correlated. Finally, Gylfason (2001), arguably the study that is most closely related to our work, observers that resource-rich countries tend to neglect education: public expenditures as share of national income for education as well as gross secondary-school enrollment is lower in these countries.

One problematic aspect of of the above literature is that it relies on cross-country variation. Given the heterogeneity across countries, it is unclear whether this literature is able to identify a causal effect. A new but relatively small literature hence uses micro-level data and exploits within-country variation. In the context of this literature, Tolonen (2014) finds with geocoded data on mines and survey data from the Demographic and Health Surveys that the opening of large, industrial-scale gold mines improves gender equality. Knutsen et al. (2016) find that the opening of mines increases bribe payments using Afrobarometer data. Aragón and Rud (2013) conclude that mines increase incomes even for unskilled workers in non-mining sectors due to backward linkages and thus have positive spillovers across sectors. Loayza et al. (2013) identify similarly positive effects on local incomes of mining. On the other hand, Berman et al. (2014) find with georeferenced data on both mining activities and violent conflicts that mining significantly increases the probability of conflicts. Wilson (2012) finds that mines have adverse local health effects in Zambian cities.

This paper is also related to the literature on the determinants of educational attainment. At the most basic level, individuals' educational attainment in equilibrium can be modeled as the outcome of a comparison between the opportunity costs of acquiring further education and its expected returns (Becker, 1964, 1965). In practice, opportunity costs or expected returns have been found to depend on the cognitive skills of a child (Bacolod and Ranjan, 2008; Sawada and Lokshin, 2009), the age of school entry (Angrist and Krueger, 1992), family or community background (Tansel, 2002), school and class characteristics (Altonji et al., 2005; Angrist and Lavy, 1999; Dee, 2005), and government policies (Duflo, 2004; Hanushek and Woessmann, 2006). Our findings suggests that available employment opportunities for children are another important determinant of educational attainment. Even if the higher income in mining districts enables households to invest in the education of their children, the employment opportunities offered by gold miens seem to be sufficiently large for the substitution effect to outweigh the income effect.

The reminder of this paper is structured as follows. The next section provides some background on gold mining and its potential implications for educational attainment. Section 3 describes the data. In Section 4 we introduce our empirical framework. Section 5 collects the main results and various extensions. We discuss the robustness of our results in Section 6 and potential mechanisms in Section 7. Section 9 concludes.

2 Background

2.1 The process of gold mining

Gold is one of the world's most economically important and versatile minerals. It can be used for jewelery, for coinage, in electronics, and various other industrial applications. This broad range of uses makes gold a highly valued commodity. At the same time, its rarity[2] ensures that gold mining can be a profitable even for small-scale operations.

Gold is extracted from various ores that contain small if not minuscule amounts of gold particles. Depending on the characteristics of a particular gold deposit, i. e., an expanse of ores with a significant concentration of gold, different extraction methods are employed. Some gold mines are exploited predominantly with capital intensive methods. In open pit mines, for example, the ore is excavated from the hard rock with dynamite. The ore is then transported with large trucks to be processed further using chemicals such as cyanide to separate the gold particles from other materials.

Gold can also be mined with more labor intensive methods. In particular, miners involved in placer mining use simple tools such as pans or sluices to extract gold from alluvial deposits at, e. g., stream beds. This method relies on the fact that gold particles are heavier than the host rocks and thus can be washed out.

Given that gold can be extracted with such relatively simple methods, small-scale (artisinal) mining activities are particularly common around gold mines. In fact, even large and capital-intensive mines provide opportunities for small-scale mining. For example, lower grade ore is often discarded and used as mine fill by mining companies. The fill can be

[2]The concentration of gold in one ton of earth is about 0.005 grams (Eugene and Mujumdar, 2009).

further mined by artisinal miners. The amenability of gold mines to small-scale activities is a notable feature given the importance of this form of mining in Africa and, more generally, in the developing world. It is estimated that about 13 million people are directly involved in small-scale mining globally; another 80-100 million depend in some indirect fashion on this type of mining (Hentschel et al., 2003). A significant fraction of the small-scale miners are engaged in the extraction of gold (Hilson, 2016).

2.2 The effect of gold mining on education

On the one hand, gold mines, as any type of mineral resources, can have a positive effect on educational attainment by increasing household incomes. The higher incomes that can be earned in the mining sector (compared to e. g. agriculture) should enable households to keep their children in school (Weber-Fahr et al., 2002). On the other hand, gold mining can have adverse effects on educational attainment through various channels. One obvious, and as shown below, presumably the most relevant channel in our context, is that parents may prefer to send their children to work for subsistence rather than to school. The children themselves may also prefer to earn money immediately rather than to invest in their education, possibly because they perceive the returns to education to be too uncertain. Even if large mining companies do not employ children or untrained youth, the importance of (often informal) small-scale mining for the excavation of gold implies that it is reasonably easy for children to find employment in the production of gold.

Children are known to work either directly in the mines or in ancillary roles. Children as young as three are employed to wash gold; from six years onward they may break rocks; from 12 years onward they can work underground and do the same work as adults (Hentschel et al., 2003). Ancillary roles include activities such as suppling provisions and tools to the miners. These ancillary roles are assumed by both boys and girls. Thus, the mining sector is not necessarily dominated by men even if work in the mines consist of hard manual labor (ILO, 2007; Tolonen, 2014). In fact, in some countries women constitute the majority in the mining sector; for example, Hentschel et al. (2003) note that 75% of the workforce in the artisinal mining sector of Guinea are women. Young women and girls may also be have opportunities for employment in sectors that are connected to gold mining through forward or backward linkages, i. e. because of local multiplier effects of gold mines (Moretti, 2010). Thus, any negative effect of mining on education could be observable for both genders.

In addition to children and young adults working in mines and connected sectors rather than attaining education, three possibly important alternative channels through which gold mines may appear to have adverse effects on education are the following. First, the government may provide fewer educational facilities in mining districts; it may anticipate that people living in mining districts have sufficient economic opportunities anyway and therefore are less in need of educational resources. Second, any negative relationship between gold mines and education may be due to endogenous migration of less educated workers to mining districts.[3] That is, gold mining districts may have a higher share of less educated inhabitants, not because inhabitants choose to acquire less education but because less educated individuals are more likely to migrate into gold mining districts. Third, gold mines may increase the likelihood of political conflicts and violence (Collier and Hoeffler, 2004, 2005; Berman et al., 2014). For example, conflicts may disrupt the education of children by displacing their families. We explore these alternative channels below.

[3] It is, of course, also possible that migrants into mining districts are more educated than the locals (Loayza and Rigolini, 2016).

3 Data

3.1 Afrobarometer

To analyze the effect of gold mining on educational attainment, we rely on the fourth wave of the Afrobarometer survey, which is an "independent, nonpartisan research project that measures the social, political, and economic atmosphere in Africa". The fourth wave was conducted in 2008 and 2009 and covers altogether 20 sub-Saharan African countries. Since we focus within-regional variation in the regressions, we drop two countries, Lesotho and Cape Verde, from the sample given their small geographical size. Our final sample thus includes 18 countries from all regions of Africa.[4] The total number of observations is 24,866.[5]

We use the following question from the Afrobarometer to measure educational attainment:

> What is the highest level of education you have completed? (Q89).[6]

We code the different stages of educational attainment using discrete values ranging form 0 to 9.[7]

In Figure 1, we plot the distribution of the educational attainment of the 24,866 respondents included in our sample. The median respondent has some but incomplete secondary education. There is also a substantial fraction of respondents who have only primary education or no education at all. Figure 2 describes the age distribution of respondents.

[4]The countries are: Benin, Botswana, Burkina Faso, Ghana, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zambia, Zimbabwe.

[5]This number is slightly lower than the full sample of 27,713 respondents. In addition to the dropping of Lesotho and Cape Verde, we also lose observations because of missing information on some respondent's educational attainment, age, and because we are not able to match two districts in the Afrobarometer to the shapefile data; see below for more information on this.

[6]Possible answers are: no formal schooling, informal schooling only (including Koranic schooling), some primary schooling, primary school completed, some secondary school/ high school, secondary school completed/high school completed, post-secondary qualifications, other than university e.g. a diploma or degree from polytechnic or college, some university, university completed, post-graduate.

[7]We also use some further questions form the Afrobarometer. We describe these in the relevant sections.

The age distribution is interesting because we will subsequently relate gold mines during adolescence to educational attainment. It is obvious from Figure 1 that the minimum age to be eligible for participation in the survey is 18 years. Most respondents are nevertheless quite young. The median respondent is 32 years old. There are, however, also some very old respondents in the sample.

The 4th of the Afrobarometer also provides information on the geographical location of a respondent. That is, we know her country, her "region", which is the name used by the Afrobarometer for the first-level administrative tier, and her "district", which is the name for the second-level administrative tier.

We use the information on the district to define the "neighborhood" of a respondent to which we match the presence of gold mines during her adolescence. One drawback of this definition is that districts can have different sizes[8] and thus gold mines that are equally far away from the actual location of a respondent may not always be classified in the same way. Another drawback is that administrative borders may change. Thus, mines that are classified as close according to contemporaneous borders because they are located in the same district in which a respondent currently lives may have been in a different district when the respondent was young. Related to this issue, the Afrobarometer only notes the current district of a respondent, not the district when the respondent was young.

Despite these drawbacks, a definition of neighborhood based on district is useful. First, even if districts can cover areas of different sizes, they are generally reasonably small and capture the concept of neighborhood well. Second, administrative boundaries provide a natural and "objective" measure of closeness. Third, there is considerable persistence in administrative boundaries. Given that most respondents in the Afrobarometer are relatively young, any border changes over time should affect only a small fraction of respondents. Fi-

[8]The minimum land are covered by a district in our sample is 2.4 km^2 (Katutura East in the region of Khomas, Namibia) while the maximum is 335,000 km^2 (Tombouctou in Timbuktu, Mali). The median district area is 2,012 km^2. Compare this to the area of Los Angeles county, which is 12,305 km^2.

nally, educational facilities are likely planned and operated based on administrative boundaries such as districts.

3.2 Data on gold mines

We match the Afrobarometer data with data on the location (as indicated by longitude and latitude coordinates) and dates of operation of a large share of current and historical gold mines of commercial interest in Africa. This data is from MinEx Consulting, which is a private mining consulting company. MinEx estimates that its data covers 99% of all giant-sized deposits, 95% of all major deposits, 70% of the moderate deposits and 50% of the minor deposits.[9]

Subfigure (a) of Figure 3 shows the location of the 359 gold mines included in our dataset.[10] There is clearly substantial variation across countries in the presence of gold mines: some have many while others have none. In countries with gold mines, there is also considerable variation at the within-country level.[11] Subfigure (b) shows mines in a particular region, Mashonaland West in Zimbabwe, and the district borders.

We project the latitude and longitude coordinates of the mines that were in operation in a given year onto a district-level map (shapefile) of the countries included in our sample.[12] We then match the mines data to the Afrobarometer data. Specifically, we calculate the

[9]The thresholds are: Minor ≥ 0.03 Moz (millions of ounces), Moderate ≥ 0.32 Moz, Major ≥ 2.24 Moz Au, Giant ≥ 11.18 Moz Au, Supergiant ≥ 80.00 Moz Au.

[10]The original MinEx data has a larger coverage of mines. When constructing the dataset for this study, we omit mines that are in countries not in our sample (except in one robustness test; see below for details). Of all mines noted in the MinEx data for the countries in our sample, we include those that have been discovered and not yet shut down as of 2015. (We include all discovered mines even if they have not formally been started up because (informal) small scale mining might take place even before formal mining activities begin). We drop mines where we do not know the discovery year(i. e. mines for which discovery year is missing in the MinEx data) and all mines where we know that they are closed as of 2015 but do not know the exact closing date (i. e. mines for which shutdown year is missing). In other words, we include all discovered mines where it is not unambiguously clear that they have been shut down and assume that they were still in operation as of 2015.

[11]The mines also vary considerably in their size: of the 359 mines in our sample, 10.8% are classifed as minor, 28.4% as moderate, 31.8% as major, 24.8% as giant, and 4.2% as supergiant.

[12]The shapefile data is from the *GADM database (www.gadm.org), version 2.5, July 2015.*

year in which a particular respondent was 12 years old based on the Afrobarometer data and then match the number of operating mines (and their various characteristics) in her district in that year. We generally define an age of 12 years as adolescence of a respondent (we explore the robustness of our results to other definitions of adolescence below).

The district names in the Afrobarometer and the names used in the shapefile to project the mines coordinates are often different. Hence, to match both data sources, we use a Google Maps routine to retrieve "characteristic" (as assessed by the Google Maps) longitude and latitude coordinates for the district names in the Afrobarometer. We then project these coordinates onto the shapefile and thus match the Afrobarometer district names with the names used in the shapefiles. Visual inspection indicates that most matches are accurate.[13] Overall, of the 1,697 unique districts in the Afrobarometer, we include 1,669 districts in our regressions.

4 Empirical framework

We estimate specifications that relate educational attainment to the presence of mines during adolescence. Our baseline model is:

$$y_{i,T} = \beta \text{Gold mine}_{i,t} + \gamma_r + \gamma_e + \gamma_t + \epsilon_{i,T}, \tag{1}$$

where $y_{i,T}$ is educational attainment of respondent i in the year T when the Afrobarometer survey was taken. As educational attainment is a categorical dependent variable, we rely

[13]We found only one error. In the case of Mabule district in the Barolong region, Botswana, the geocodes from Google Maps would have put the district in a different country than as indicated in the Afrobarometer (the problem was that there was a border town in South Africa with the same name as a district in Botswana; ostensibly, Google Maps confused the district in Botswana with the town in South Africa). We drop this district from the sample. There was also one case where we could not match districts in the Afrobarometer to the shapefile because of missing geocodes. Finally, some names in the shapefiles cannot be matched to the Afrobarometer districts due to border changes between the time of the Afrobarometer surveys and the date our shapefiles were drawn up (July 2015). We omit any mines located in district affected by such changes.

on ordered probit in the baseline regressions. In subsequent models, however, we use OLS for simplicity (after confirming that the ordered probit and OLS results are similar).

Gold mine$_{i,t}$ is a dummy that is 1 if the district of a respondent had at least one gold mine when she was 12, and 0 else. γ_r are region fixed effects (which when included encompass the country fixed effects), γ_e are ethnic group fixed effects, and γ_t are time dummies for the year of adolescence of a respondent (cohort fixed effects). Such cohort fixed effects are important to account for the systematically increasing educational attainment over time, i. e. younger respondents are more likely to be better educated due to general societal trends. $\epsilon_{i,T}$ is the error term. We rely on heteroscedasticity-robust standard errors for inference. We also cluster standard errors at the district level as this is the level at which treatment varies in our context (Bertrand et al., 2004).

We hence identify the effect of gold mines in adolescence on contemporaneous educational attainment while holding regional, ethnic group, and cohort effects constant. In particular, by including region fixed effects we are able to control for any geographical features that may be systematically related to educational outcomes and the presence of gold mines. This is important because gold mines may be less likely to be discovered or relatively unprofitable if they are located in remote areas. At the same time, educational attainment in such regions may be lower for other reasons, for example because countries invest less in education in regions that are remote. Similarly, ethnic group fixed effects account for any systematic correlation between the education levels of different ethnicities and the suitability of their settlement area for mineral resources or their propensity to migrate toward mining districts.[14] By accounting for such region- and ethnic-group specific features through appropriate fixed effects, we can credibly relate gold mines during adolescence to contemporaneous educational outcomes

[14]Note that we include separate dummies for respondents with non-standard responses, e. g. for those who do not know their ethnicities, refused to answer, etc. The results are similar if we drop these observations.

One underlying assumption in this empirical design is that respondents in districts with gold mines were more likely to work in the mining sector (and possibly in sectors connected with the mining sector through upward or downward linkages when they were young). While there is no data on employment histories in the Afrobarometer, this assumption is plausible. Given the high level of spatial disaggregation by which we define neighborhood and the importance of mines for the local economy in Africa, it is likely that at least some of the respondents who had a mine in their district during adolescence worked in the mining sector.

5 Baseline results

5.1 Main effects

Table 1 collects the baseline results. In model (I), we include country fixed effects. In model (II), we replace the county fixed effects with region fixed effects (which encompass the country fixed effects). Model (III) finally adds ethnic group fixed effects. All models include cohort fixed effects. These first three models are estimated with ordered probit. In model (IV), we re-estimate model (III) with OLS.

Overall, we find that the presence of (at least) one mine in one's district during adolescence reduces educational attainment by 0.11 points in the ordered probit regression. The estimate is statistically significant at the 1% level. The OLS coefficient estimate, while not directly comparable with the ordered probit estimates, is qualitatively similar and indicates that mines reduce educational attainment on average by 0.21 points. One interpretation of the magnitude of this estimate is, for example, that the presence of a mine leads one in five respondents who would have otherwise completed secondary education to drop out and end up with only some incomplete secondary education.

5.2 Extensions

5.2.1 Transition to higher educational stages

While the specifications reported in Table 1 estimate an average effect across all educational stages, gold mines presumably affect some stages more adversely than others. More specifically, it is unlikely that the presence of gold mines at the age of 12 dissuades an individual, who is otherwise able and qualified, from entering tertiary education or deters university graduates from pursuing post-graduate studies. The economic opportunities that gold mines offer may be more attractive for children and their parents at lower stages of education; gold mines may have a more adverse effect on transition probabilities at these stages. Moreover, an analysis of transition probabilities arguably allows for a meaningful quantitative interpretation of the estimation results.

Hence, we estimate the following variants of Equation 1. Rather than a continuous variable, we specify a binary dependent variable that is one if a respondent has achieved a certain level of education and 0 else. First, we construct a dummy that is 1 if a respondent has at least some informal (e. g. Koranic) schooling and 0 else and re-estimate equation 1 with this dummy as dependent variable. Next, we construct a dummy that is one if a respondent has at least some formal primary education and 0 else and again re-estimate Equation 1 with this dummy as dependent variable. We adopt this approach for all further stages of education. These models allow us to asses at which educational stages gold mining matters most.

The results are collected in Figure 4. They indicate that gold mining matters most during the period between primary and secondary education. Specifically, gold mines have the most adverse effect on the likelihood that a respondent attempts to pursue or completes secondary education: the probability is about 6 percent lower. Gold mines have, however, also large negative effects on the likelihood that primary education is completed or that post-secondary (but not university) education is taken up. On the other hand, gold mines do not affect the propensity of transitioning to university or post-graduate education.[15]

5.2.2 Gender-specific effects of gold mines

As discussed in Section 2.2, gold mines may adversely affect the educational attainment of men and women in a similar fashion given that mining is not exclusively a male activity. On the other hand, while the gap is narrowing, educational attainment of women is generally lower in Africa. Thus, gold mining might carry a relatively smaller educational cost for women: i. e., they may receive less education anyways and working in gold mining may overall be preferable to, for example, agricultural employment.[16]

To explore possible gender-specific effects, we append Equation 1 with a dummy for female respondents and an interaction between the female dummy and the gold mines dummy. The sign and significance of the interaction effect indicates whether the education of men or women is affected more adversely by gold mines during adolescence. The results are collected in model (I) of Table 2. We find that the dummy for female respondents is significantly negative, reflecting the fact that there still remains a gender gap in educational attainment in Africa. However, the interaction effect is insignificant, which suggests that the educational cost of gold mining affects men and women equally.

5.2.3 The size of gold mines

Another important question is whether the educational cost of gold mines is mostly confined to smaller mines. Answering this question is important because it helps us to understand further why gold mines have adverse educational effects (it is thus related to the question

[15] Note that these results are not an artifact of defining adolescence at age 12. We get similar results if we use older ages, e. g. 18, to define adolescence. These results are available upon request.

[16] In fact, Tolonen (2014) finds that gold mines improve gender equality in Africa. Kotsdam and Tolonen (2016) also show that mine openings cause a shift in the employment pattern, with women switching from the agricultural to the service sector.

of transmission channels which we explore in more detail further below). Specifically, given the importance of artisinal mining for the excavation of gold and the relatively low level of governmental monitoring of these activities, children and young adults may easily find employment in smaller gold mines as artisinal miners. Larger gold mines, in contrast, are likely exploited by corporations, which may be scrutinized more heavily; the corporations themselves may also prefer to hire a better trained and older workforce. If the susceptibility of gold to small-scale mining is the reason for why gold mines have adverse educational effects, this would validate the interpretation that the direct employment opportunities offered by gold mines are an important reason for their adverse effect on educational attainment.

To explore whether the educational impact of gold mining varies according to the size of a mine, we report in model (II) of Table 2 estimates for dummy variables indicating "smaller" (mines that are classified either as minor or moderate) and "larger" gold mines (mines that are classified as either major, giant, or supergiant).[17] We generally find that the adverse effect of gold mining is particularly pronounced for smaller mines. This result suggests that the amenability of gold to artisinal small-scale mining is an important reason why gold mines affect educational attainment negatively. We also observe a negative, albeit smaller and insignificant, coefficient estimates for larger mines. This negative yet smaller effect for larger mines is consistent with the interpretation that the employment opportunities in gold mining are responsible for the lower educational attainment. First, artisinal mining takes place at larger mines as well, for example if discarded minefill is further exploited by artisinal miners. Moreover, there may also be indirect effects on children in districts with large gold mines due to employment opportunities in sectors that are connected to the mining sector through forward and backward linkages.

[17]Note that since a district can have multiple mines, both dummies can simultaneously be one for a given respondent.

5.2.4 The price of gold, frictions in educational choices, and income and substitution effects

To further understand the relationship between gold mining and educational outcomes, we explore the impact of the price of gold on educational attainment. On the one hand, if the gold price is high, gold mining should become more attractive relative to going to school in mining districts. Wages in the mining sector should increase and artisinal miners should be able to sell their produce for a higher price. On the other hand, the income effect may also outweigh the substitution effect. That is, an increase in the price of gold may raise household income sufficiently for parents to be able to forgo the extra income from sending their children to work, allowing them instead to send their children to school. Alternatively, educational choices may be subject to frictions. Once parents have decided to send their children to work rather than to school, the current price of gold, and thus any variation in the returns to gold mining, may not matter much at the margin.

We explore this question by extending Equation 1 with a continuous variable measuring the price of gold when a respondent was in adolescence[18] and an interaction effect between gold mines and the price of gold. The results are collected in model (II) of Table 2 and suggest that the contemporaneous price of gold is unimportant for educational attainment. That is, the interaction effect between gold mines and the price of gold is insignificant. The main effect for the presence of gold mines continues to be negative and of the same order of magnitude as in the baseline regressions.[19] These results suggest that educational choices are either subject to some frictions and the income effect following an increase in gold prices does not outweigh the substitution effect.

[18]The data is from the World Bank's Commodity Price Data Database, Feb. 04, 2016.

[19]The significance levels on the main effect by themselves are not informative about whether gold mines have a significant effect as the marginal effect of gold mines and the associated standard errors change with the value of for the gold price.

5.2.5 Other mineral resources

To understand the baseline results further, we explore the effect of minerals other than gold on educational attainment. The discussion in Section 2 suggests that, in general, mineral resources may have either a negative or a positive effects on educational attainment: the income effect likely works to increase households' demand for the education of their children while the substitution effect incentivizes households to send their children to work in the mining sector.

For gold mines, we offered a number of reasons why the substitution effect could outweigh the income effect – in particular, that children can find employment in the gold mining sector with relative ease given the amenability of gold mining to artisinal methods. For other types of mines, the overall effect may be different. If a mineral resource is produced with capital-intensive methods and can therefore only be exploited by large corporations, children may be unable to find employment in the relevant mines.

To explore this issue, we report in Table 3 regression results similar to the baseline specifications but with three alternative dummy variables. The first dummy variable, *Only non-gold mines*, is one when a respondent had a non-gold mine but no gold mine in her district during adolescence.[20] The second variable, *At least one non-gold mine*, is one if a respondent had at least one non-gold mine in her district at adolescence (irrespective of the number of any additional gold mines). Finally, *Exclusively gold mine* is one if a respondent only had gold mines but no other types of mines in her district during adolescence. The first two dummy variables thus allow us to explore the effect of non-gold mines on educational attainment while the third enables us to confirm that it is indeed gold rather than other mineral resources that is responsible for the baseline results.

[20]We consider the following minerals: Andalusite, Asbestos, Barium, Calcium, Chromium, Cobalt, Copper, Diamonds, Flourine, Fluorite, Gold, Graphite, Lead, Manganese, Mercury, Mineral Sands, Molybdenum, Nickel, Niobium, PGE, Platinum, Rare Earths, Ruby, Sapphire, Silver, Sulphur, Tantalum, Tin, Tungsten, Uranium, Vermiculite, Zinc, Zircon.

We find that the first two dummies are positive and statistically insignificant. This suggests that non-gold mines have no adverse effect on educational attainment. In contrast, respondents who only had a gold mine in their district during adolescence have lower educational attainment. Overall, these results provide further evidence that the negative effect of mining is specific to gold and comes about because its production is amenable to artisinal methods.

6 Robustness

6.1 Different years of adolescence

The baseline results suggest gold mines have a negative effect on educational attainment. However, these results may simply be a statistical artifact due to our particular definition of adolescence, which we assumed to be at age 12. To confirm that the results are robust to different definitions of adolescence, we re-estimate model (IV) in Table 1 after matching the number of mines at age 1 to 50. That is, we explore the presence of mines at age 1, 2, ..., 50 on educational attainment at the time the 4th wave of the Afrobarometer was conducted.[21]

We plot the coefficient estimates for these 50 models in Figure 5. This figure confirms that the baseline results are not a artifact of defining adolescence at the age of 12. In fact, the presence of mines at age 1 up to age 37 years result in a similarly negative coefficient estimate. Only when we focus on very old respondent, we begin to observe insignificant coefficient estimates.

The explanation for why the coefficient remains stable for an adolescence year as young as 1 – even though at this age no educational decisions should be made – and up to an age

[21] Respondents that are younger in 2008/9 than the age defined as adolescence year are not included in the sample used for a particular regression.

of 37 – even though it is likely that no further investments in education are undertaken at this age – is that mines are persistent. A mine that has existed when a respondent was 12 generally continues to exist when she was 37. More specifically, around 84% of respondents that had a mine in their district when they were young also had a mine in 2007, i. e. shortly before the Afrobarometer surveys were taken. In line with this interpretation, we show below (in Section 6.3) that respondents who had no mines in their district only after they had passed adolescence do not have lower educational than a generic respondent.

6.2 Dropping countries

Another concern with the baseline estimates is that they are driven by one particular country. According to Figure 3, gold mines seem to be particularly prevalent in a few countries, for example South Africa, Botswana, and Ghana. Even though we rely on within-region variation for identification, our estimates could be driven by a particular country, limiting the external validity of our findings. To address this concern, we re-estimate our preferred model (model IV in Table 1) after dropping in turn each country otherwise included in the sample.

The results are collected in Figure 6. This figure collects the 18 coefficient estimates and 95% confidence interval after dropping each of the countries in turn. The coefficient estimates are remarkably stable. Dropping Burkina Faso, Mali, or Uganda increases the coefficient slightly, but it remains significantly negative. Overall, these results suggest that the baseline results are not only due to one country.

6.3 Placebo tests

One further strategy to validate that the effect of gold mines on educational attainment found in the baseline regressions is not spurious is placebo tests. In this section, we implement two types of placebo tests. First, we explore educational attainment of respondents whose districts had no mines when they were in adolescence but which bordered districts with mines. If the baseline estimates are biased due to omitted variables, we should observe a similarly low level of educational attainment for such respondents if any omitted variables are spatially correlated.[22]

We construct a dummy variable that is one for respondents who had no mines in their district when they were in adolescence but whose district bordered a mining district. We ignore country borders when identifying neighboring mines (i. e. we include mines in neighboring district that are in another country) and also consider mines in African countries that are otherwise not included in our sample because they are not covered in by the Afrobarometer (i. e., mines just across the border).

We relate this dummy variable to educational attainment by estimating variants of Equation 1. Model (I) of Table 4 only includes the dummy for mines in neighboring districts during adolescence and is estimated with a sample that includes only respondents who had no mines in their districts during adolescence. This model thus compares the educational attainment of respondents without any mines during adolescence in their own and in neighboring districts with the attainment of respondents who had no mines in their own district but had a mine in at least one neighboring district. Model (II) includes all districts and controls both for the dummy for mines in one's own district and the dummy for mines in neighboring districts during adolescence. Both sets of models indicate that educational attainment of respondents in non-mining districts that neighbor mining districts is not significantly different than of respondents in generic non-mining districts. This suggests that our baseline results are not due to (spatially-correlated) omitted variables.[23]

[22]Note that lower educational attainment in non-mining districts that border mining districts may not necessarily be due to omitted variables. It is also possible that mines have spillovers across district boundaries.

[23]A fortiori, these results also suggest that mines have no significant spillovers across district boundaries. This is in line with the results in Loayza and Rigolini (2016), who find that the effects of mines are highly local.

The second placebo test explores whether respondents who had no gold mines in their district during adolescence but have mines in 2007, i. e. shortly before the Afrobarometer survey was conducted, have lower educational attainment than respondents that neither had a mine during adolescence nor in 2007. If there are unobserved district-specific variables that are systematically related to the prevalence of mines and educational attainment within a district, respondents who only had a mine in their district in 2007 (i. e. after they had passed adolescence) should still have lower educational attainment than respondents that had no mines in their district during their adolescence nor in 2007.

We hence construct a dummy variable that is 1 if a respondent has a mine in 2007 but not during her adolescence and relate it to her educational attainment. The results are collected in models (III) and (IV) of Table 4. Model (III) only includes this dummy and is estimated with a sample that omits all respondents who had gold mines in their adolescence. We find no significant effect of "current" gold mines (i. e. in 2007) on educational attainment. Model (IV) is estimated with the full sample and includes both the dummy for mines in adolescence and in 2007. As before, we find that respondents with gold mines in their adolescence have lower educational attainment. Respondents who have only currently a gold mine in their district, on the other hand, do not display lower educational attainment.

6.4 Replication with Development and Health Surveys data

In this section, we validate the baseline results further by estimating Equation 1 with data from a different source than Afrobarometer. Specifically, we use data on educational attainment of women and men from the Development and Health Surveys (DHS).

One difference between the DHS and the Afrobarometer is that the DHS does not record the district of a respondent. Instead, it provides geocodes for the location of a respondent's sampling cluster.[24] We construct buffers with a radius of 30 km around each sampling

[24]There are, however, some minor and random displacements to protect the anonymity of respondents.

cluster and match the mining data to the buffers. We define a respondent as affected by a gold mine if there was a gold mine within 30 km of the sampling cluster of a respondent when that respondent was in adolescence. A radius of 30km translates to an area of about 2800 km^2, which is roughly similar to the median area of the districts in the Afrobarometer (about 2,012 km^2). The DHS data hence allows us to check whether the results are robust (i) to the use of a data source other than the Afrobarometer and (ii) to a different definition of neighborhood than one based on district boundaries.

We attempted to replicate the Afrobarometer sample as closely as possible and thus limit the DHS data to those countries that are also covered by the 4th wave of the Afrobarometer. However, the DHS sample covers only 16 of these countries; it does not provide data for two countries that are included in the Afrobarometer (South Africa and Botswana). The DHS provides information on respondent's who are aged less than 18 years. As some of these respondents may be still in school, we drop them from the sample (recall that the Afrobarometer also only includes respondents above 18). Educational attainment is coded in the DHS into six categories, ranging from no education, incomplete primary education, complete primary education, incomplete secondary education, complete secondary education, and higher education.

The results are collected in Table 5. The specifications replicate those of the baseline models reported in Table 1. Specifically, Model (I)-(III) are estimated with ordered probit while model (IV) is estimated with OLS. Model (I) only includes country fixed effects, model (II) replaces the country fixed effects with region fixed effects, i. e. the region in which a DHS respondent lives, and model (III) additionally includes ethnic group fixed effects as noted in the DHS. Model (IV) also includes region and ethnic group fixed effects. While quantitative comparisons are difficult given the different scaling of the educational attainment variable, the results are qualitatively similar to the those from the baseline regressions. We find that gold mines during adolescence have a significantly negative effect on educational attainment of adults.

7 Mechanisms

The results reported above suggest that mining has a negative effect on educational attainment. As argued, the most important channel is likely that respondents decide to work in the mining sector and in turn neglect their education. However, there are further channels that may also be important. In this section, we explore three alternative channels and asses to what extent they can explain the baseline findings.

7.1 Gold mines and contemporaneous public goods

Besides respondents preferring to work and thus dropping out of school, gold mines may have a negative effect on educational attainment because the government provides fewer public goods, in particular schools, in mining districts. We explore the importance of this alternative transmission channel by relating the presence of gold mines around 2007, i. e. shortly before the 4th wave of the Afrobarometer was taken, to the presence of public goods in 2008/9. If governments provide fewer public goods, notably schools, to districts with mines, we should observe a negative correlation between whether a district had a mine around 2007 and public goods provision. The results are collected in Table 6. Overall, there is no evidence that contemporaneous public goods provision is lower in districts with gold mines. Districts with gold mines are neither more or less likely to have a school, a health clinic, a sewage system, an electricity grid, or a post office.

Another test for this transmission channel is to control for the presence of public goods during adolescence. However, the Afrobarometer does not provide such data and thus we cannot implement this strategy. As an alternative, we control for contemporaneous public goods provision in a respondent's district. Contemporaneous public goods may be a good proxy for public goods during adolescence if there is some persistence in their provision. Thus, we include in model (V) of Table 6, the public goods as covariates and estimate the baseline model with the full sample. However, one problematic feature of this model is that the full sample includes individuals that are very old. Contemporaneous public goods may be an imperfect proxy for public goods during adolescence particularly for these respondents. Therefore, we report in model (VI) estimates where we limit the sample to the set of respondents that were in adolescence after 1997, i. e. to those where were 12 years old at most 10 years before the surveys were taken.

The results from model (V) and (VI) in Table 6 indicate that there is a strong correlation between the presence of public goods, notably schools, in a respondents neighborhood and her educational attainment. However, the inclusion of the variable measuring whether public goods were present does not attenuate the negative coefficient estimate for gold mines. These results suggest that the negative effect of gold mines is not due to underinvestments by the government.

7.2 Endogenous migration

Another potentially important channel is that individuals who are in search of employment migrate to mining sectors. It is possible that migrants are relatively less educated than the natives. If this would be the case, then we may observe a negative relationship between mines and the educational attainment of some respondents not because mines lead children to drop out of school, but rather because they attract relatively uneducated individuals from other regions.

The Afrobarometer provides no information on whether a respondent migrated to her district. However, we can explore this issue by matching the self-described ethnic group of a responded from the Afrobarometer to data on the native homelands of African ethnicities according to Murdock (1959).[25] The idea is that respondents who belong to one of the native groups of the district are less likely to have migrated due to the presence of mines while respondents with a non-native ethnicity are more likely to have done so. Thus, by focusing on whether a respondent belongs to the native ethnic group we can rule out, to some extent, this alternative interpretation.[26]

Table 7 collects regression results that operationalize this strategy. In model (I), we only add to model (IV) in Table 1 a dummy for whether a respondent's ethnicity matches with one of the native groups of her district (termed *ethnic homeland*). As before, we find that gold mines have a negative effect on educational attainment. Interestingly, we also observe that natives are relatively less educated than respondents who are not natives to a district. In model (II), we include an interaction of the dummy for gold mines with the one for ethnic homeland. This allows us to explore whether gold mines have a larger effect on the eduction of non-natives. Such a larger effect would be consistent with endogenous migration of less educated non-natives to mining districts. However, we observe the opposite. While the interaction effect is insignificant, it is negative. This suggest that gold mines, if at all, affect the educational attainment of natives more adversely than that of non-natives.

Model (IV) and (V) re-estimate the baseline model with subsamples of natives and non-natives. The idea is to explore whether the adverse effect of mines are higher among natives or non-natives. We find that mines reduce educational attainment by 0.315 points for natives but by only 0.129 points for non-natives. These results are consistent with those of model (II): mines affect the educational attainment of natives more adversely. Overall, these findings indicate that endogenous migration is likely not responsible for the negative effect of mining on educational attainment.

[25]We rely on shapefile data provided by Nunn and Wantchekon (2011) and match ethnic group names in Murdock (1959) to the in Afrobarometer using data provided by Deconinck and Verpoorten (2013).

[26]We acknowledge that this strategy does not rule out endogenous migration at very low levels of geography, i. e. that relatively uneducated natives migrate within their homeland from non-mining to mining districts.

7.3 Mineral resources, conflicts, and education

As discussed previously, a large literature argues that mineral resources facilitate civil wars and other forms of violent conflicts (Collier and Hoeffler, 2004, 2005; Berman et al., 2014). Resources may be a tempting target for predatory political groups. They may also enable rebels or the state to fund violent campaigns. In turn, it is likely that violent conflicts cause disruptions to the education of children. Hence, any negative relationship between gold mining and educational attainment may not come about because children prefer to work in sectors related to mining, but because the presence of gold deposits facilitates conflicts.

To explore this channel, we match geocoded data on violent conflicts to the Afrobarometer data. We use the 6th version of the ACLED (Armed Conflict Location and Event Data Project) dataset. This dataset provides information on "the dates and locations of all reported political violence and protest events in over 60 developing countries" from 1997 to 2015. We project all battles and the number of fatalities recorded in the dataset on a district-level shapefile covering the countries in our sample.[27] We then note whether the district of a given respondent experienced at least one battle when she was in adolescence (aged 12) as well as the total number of fatalities in that year.

We then explore the relationship between gold mining, conflicts, and educational attainment by estimating variants of Equation 1 in Table 1. The results are collected in Table 8. Since the ACLED data begins only in 1997, we have no information on conflicts for respondent who were in adolescence before this year. Hence, older respondents are dropped in the regressions reported in Table 8 and the final sample is substantially smaller than in the baseline regressions.

[27] As noted in the description of the dataset, the ACLED also collects information on conflict-related events other than battles, for example protests, the setting up of bases by warring parties, etc. We omit these non-battle related events when defining the conflict variable.

In model (I), we explore whether respondents where more likely to experience a conflict in their district during their adolescence when there was a gold mine in the same district. The purpose of this model is to establish whether conflicts are more likely in districts with gold mines. In model (II), we explore, as in the baseline regressions, the relationship between gold mines during adolescence and educational attainment, but additionally control for any conflicts in the year of adolescence. If the negative effect of gold mines on educational attainment is in effect due to the higher propensity of conflicts in mining districts, the effect of gold mines on education should become insignificant once we explicitly control for conflicts. In model (III), we extend model (II) and additionally control for the intensity of a conflict by including the number of fatalities in a respondent's year of adolescence.

The results indicate that there is no significant relationship between gold mines and the incidence of conflicts (model I). In line with this result, we find that the negative effect of gold mines on educational attainment remains negative if we control for conflicts (model II) and their intensity (model III). We also observe a negative but insignificant effect of conflicts on educational attainment. Overall, these results imply that the negative effect of gold mines found in the baseline regressions is not due a higher incidence of conflicts.

8 Long-run effect of gold mines on economic outcomes

To complement our previous findings regarding educational attainment, we explore in this section whether respondents in mining-districts are at least economically better off in the long-run than respondents in non-mining districts even if they have lower educational attainment. That is, if the income from gold mining is sufficiently large or persistent, working in the mining sector or related sectors rather than acquiring further education may be the financially dominant strategy even in the long-run.

In order to explore this issue, we relate the dummy for gold mines during adolescence to contemporaneous economic conditions of a respondent. Specifically, we explore how an Afrobarometer respondent who had gold mines in her district during adolescence (i) assesses her current living conditions relative to other co-nationals, (ii) how she assesses her living conditions as such, and (iii) how she assesses the present economic conditions in her country. The results are collected in Table 9. We find that respondents with mines during adolescence do not view their living conditions as worse than that of other co-nationals (model I). However, it is likely that respondents think of their immediate neighborhood, i. e. other inhabitants of their district, when asked to compare their living conditions to co-nationals. Hence, their assessment of their absolute living conditions is more informative. Indeed, we find in model (II) that respondents with mines during adolescence are more likely to assess their current living conditions as unsatisfactory; the estimate is negative and almost significant.

In line with this result, we also find that respondents who had mines in their districts during their adolescence perceive the current economic conditions in their country as worse than other respondents in the same country (model III). While the Afrobarometer question explored in model (III) relates to country-level developments, the response is presumably informed by what respondents experience in their immediate neighborhood. Overall, these results suggest that in the long-run, respondents with gold mines in their youth do not fare better economically than generic respondents. In fact, the long-run effects of gold mines seems to be negative. The lower level of educational attainment and any broader long-run costs that insufficient education may have is not compensated by better economic conditions during adulthood.

9 Conclusion

There is a ongoing debate on whether mineral resources help or hinder development. Skeptics tend to point toward adverse terms of trade effects and heightened political instability as potentially negative effects. More optimistic observers emphasize the ability of the mineral resource sector to generate income and thereby to lift some of the poorest countries out of poverty. This paper contributes to this debate by documenting that mineral resources, specifically gold mines, have adverse effects on educational attainment and, even if they may increase incomes in the short-run, do not persistently improve economic conditions.

These results suggest that while mineral resource booms may very well be a boon for Africa, there are definitely some costs as well. Governments should thus adopt policies that mitigate the negative consequences on educational attainment (and possibly also on other socio-demographic outcomes). It appears that child labor in the mining sector, even if it may appear to children and their parents as more useful than going to school, does not pay off in the long-run. Besides the obvious humanitarian arguments against child labor, this economic rationale should provide further incentives to outlaw this practice.

Our results indicate furthermore that especially small-scale and artisinal mining, which is prevalent in gold production, is not an economic activity that can provide poor households with sustainable income. This is an important results given that some observers view it as a particularly promising form of mining, one that is decentralized and can ensure subsistence for low income households in developing countries (Economist, 2016; Hilson, 2016). Indeed, many African governments have recently adopted measures to discourage this type of mining. While these measures have provoked criticism and more often than not were adopted for suspect reasons, our findings indicate that such policies may have some, even if unintended, merits.

One important limitation of our study is the available data. For example, the evidence we provide for the main transmission channel, that the employment opportunities offered by gold mines incentivize parents to neglect the education of their children, is mostly indirect and circumstantial, i. e. by ruling out competing channels. The reason why we cannot provide more direct evidence is that there is no detailed data available on educational and employment histories for Africa. One avenue for future research in this area would be to address such data limitations. In particular, collecting survey data data on how individuals progress through the various educational stages and transition to employment may lead to further important insights.

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Table 1: Gold mines during adolescence and educational outcomes, baseline results

	(I)	(II)	(III)	(VI)
Gold mine	-0.133***	-0.083*	-0.119**	-0.213***
	(0.045)	(0.048)	(0.047)	(0.072)
Estimation method	Ordered probit	Ordered probit	Ordered probit	OLS
Cohort FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Region FE	No	Yes	Yes	Yes
Ethnic group FE	No	No	Yes	Yes
Countries	18	18	18	18
Districts	1669	1669	1669	1669
N	24866	24866	24866	24866

Notes: This table shows ordered probit and OLS regression results that relate a categorical variable measuring educational outcomes of an Afrobarometer respondent against a dummy for whether there was a gold mine in the respondent's district when she was in adolescence (at age 12). Education is classified from no formal or informal education (0) to post-graduate (9). Model (I)-(III) are estimated with ordered probit. Model (IV) is estimated with OLS. Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 2: GOLD MINES DURING ADOLESCENCE AND EDUCATIONAL OUTCOMES, HETEROGENEOUS EFFECTS

	(I)	(II)	(III)
Gold mine	-0.219***		-0.264
	(0.082)		(0.170)
Female	-0.598***		
	(0.022)		
Gold mine × Female	0.022		
	(0.096)		
Small mine		-0.328***	
		(0.107)	
At least major mine		-0.102	
		(0.073)	
Gold mine × Price			0.010
			(0.040)
Estimation method			
Cohort FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes
Countries	18	18	18
Regions	1669	1669	1669
N	24866	24866	23188

Notes: This table shows OLS regressions that relate a categorical variable measuring educational outcomes of an Afrobarometer respondent to a dummy variable for whether there was a gold mine in the respondent's district when she was in adolescence (at age 12). We allow for heterogeneous effects of mines according to whether a respondent is a woman or a man (model I), according to the size of a mine (model II), and according to the price of gold (model III). Education is classified from no formal or informal education (0) to post-graduate (9). Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 3: Gold mines during adolescence and educational outcomes, mineral resources other than gold

	(I)	(II)	(III)
Only non-gold mines	0.110		
	(0.093)		
At least one non-gold mine		0.108	
		(0.084)	
Exclusively gold mine			-0.261***
			(0.077)
Estimation method	OLS	OLS	OLS
Cohort FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes
Countries	18	18	18
Districts	1669	1669	1669
N	24866	24866	24866

Notes: This table shows OLS regression results that relate a categorical variable measuring educational outcomes of an Afrobarometer respondent against a dummy for whether there was a mine for a mineral resource other than gold in the respondent's district when she was in adolescence (at age 12). Education is classified from no formal or informal education (0) to post-graduate (9). Model (I) include. Model (IV) uses a mining dummy that is one for districts where gold and other minerals may be produced at the same time. Model (II) uses a mining dummy that is one only for mining districts where gold is not produced at the same time. Model (III) uses a dummy that is one only for mining districts where gold but no other minerals are produced. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 4: Gold mines during adolescence and educational outcomes, Placebo tests

	Gold mine neighboring district		Current gold mines	
	(I)	(II)	(III)	(IV)
Gold mine		-0.220***		-0.221***
		(0.078)		(0.076)
Gold mine in neighboring district	-0.009	-0.014		
	(0.067)	(0.065)		
Current gold mine			-0.040	-0.044
			(0.097)	(0.090)
Sample	Restricted	Full	Restricted	Full
Estimation method	OLS	OLS	OLS	OLS
Cohort FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes	Yes
Countries	18	18	18	18
Regions	1631	1669	1631	1669
N	23912	24866	23912	24866

Notes: This table shows two sets of placebo regressions. All models are estimated with OLS. The dependent variable is always educational attainment of an Afrobarometer respondent. Model (I)-(II) include dummies that are one if there was no gold mine in the respondent's own district but in a neighboring district during her adolesence. Model (III)-(IV) include a dummy that is one if there is in 2007 a mine in a respondent's district but not during adolescence. Model (I) and (III) omit observations that had mines in their districts during adolesence. Model (II) and (IV) are estimated with the full sample and additionally include the dummy for whether there was a gold mine in a respondent's district during her adolecence. Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 5: Gold mines during adolescence and educational outcomes, results with Development and Health Surveys data

	(I)	(II)	(III)	(VI)	(V)
Gold mine	-0.064**	-0.056*	-0.083**	-0.092**	-0.132***
	(0.027)	(0.029)	(0.038)	(0.037)	(0.045)
Estimation method	Ordered probit	Ordered probit	Ordered probit	OLS	OLS
Cohort FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Region FE	No	Yes	Yes	Yes	Yes
Ethnic group FE	No	No	Yes	No	Yes
Countries	16	16	12	16	12
Districts	9975	9975	7950	9975	7950
N	320391	320391	259790	320391	259790

Notes: This table shows ordered probit and OLS regression results that relate a categorical variable measuring educational outcomes of a Development and Health Surveys (DHS) respondent against a dummy for whether there was a gold mine within a radius of 30 km of a respondent's sampling cluster when she was in adolescence (at age 12). We use data from the DHS surveys covering 16 sub-Saharan African countries. Respondents below 18 year are dropped. Education is classifed from no education (0) to higher education (5). Model (I)-(III) are estimated with ordered probit. Model (IV) is estimated with OLS. Standard errors in parentheses. Standard errors are clustered at the level of sampling clusters and are robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 6: GOLD MINES DURING ADOLESCENCE AND PUBLIC GOODS

	Public good as outcomes					Control for public goods	
Dep. Var.:	School	Health clinic	Sewage system	Electricity grid	Post office	Education	Education
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Gold mine in 2007	-0.025	-0.001	-0.024	-0.015	-0.010		
	(0.024)	(0.039)	(0.030)	(0.033)	(0.037)		
Gold mine						-0.227***	-0.260**
						(0.070)	(0.119)
School						0.144***	0.249***
						(0.048)	(0.084)
Health clinic						0.071**	0.129**
						(0.034)	(0.058)
Sewage system						0.489***	0.362***
						(0.054)	(0.067)
Electricity grid						0.675***	0.634***
						(0.048)	(0.069)
Post office						0.133***	0.100
						(0.046)	(0.070)
Cohort FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Countries	18	18	18	18	18	18	18
Regions	1669	1653	1651	1667	1652	1624	1338
N	24877	24635	24613	24843	24630	24099	4877

Notes: This table shows two sets of OLS regressions. First, we relate dummy variables for various public goods against a dummy for whether there is a gold mine in the respondent's district when the Afrobarometer survey was taken (model I-V). Second, we relate the educational outcomes of a respondent against the standard gold mines dummy and dummies for the presence of the various public goods (model VI-VII). Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 7: Gold mines during adolescence and educational outcomes, ethnic homelands

	Full sample		Native group sample	Non-native group sample
	(I)	(II)	(III)	(VI)
Gold mine	-0.243***	-0.200**	-0.325***	-0.179*
	(0.073)	(0.094)	(0.099)	(0.098)
Ethnic homeland	-0.246***	-0.244***		
	(0.043)	(0.043)		
Ethnic homeland × Gold mine		-0.075		
		(0.127)		
Estimation method	OLS	OLS	OLS	OLS
Cohort FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes	Yes
Countries	18	18	18	18
Regions	1639	1639	1311	1183
N	22946	22946	13863	9083

Notes: This table shows ordered probit and OLS regression results that relate a categorical variable measuring educational outcomes of an Afrobarometer respondent against a dummy for whether there was a gold mine in the respondent's district when she was in adolescence (at age 12). We account for whether a respondent lives within the traditional homeland of her ethnic group (and thus has likely not migrated due to the precence of a mine) in these regressions. Education is classifed from no formal or informal education (0) to post-graduate (9). Model (I)-(III) are estimated with ordered probit. Model (IV) is estimated with OLS. Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 8: GOLD MINES DURING ADOLESCENCE AND EDUCATIONAL OUTCOMES, CONFLICTS AS AN ALTERNATIVE TRANSMISSION CHANNEL

Dep. Var.:	Conflict	Education	Education
	(I)	(II)	(III)
Gold mine	0.026	-0.246*	-0.246*
	(0.022)	(0.135)	(0.135)
Conflict		-0.085	-0.084
		(0.080)	(0.080)
Fatalities			-0.108
			(1.066)
Estimation method	OLS	OLS	OLS
Cohort FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes
Countries	18	18	18
Districts	1380	1380	1380
N	5091	5087	5087

Notes: This table shows OLS regression results that relate the incidence of conflicts (model I) and educational attainment of an Afrobarometer respondent (model II-III) against a dummy for whether there was a gold mine in the respondent's district when she was in adolescence (at age 12). Model (II) controls for the incidence of conflicts and model (III) additionally for fatalities. Education is classified from no formal or informal education (0) to post-graduate (9). Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

Table 9: MINERAL RESOURCES DURING ADOLESCENCE AND CONTEMPORANEOUS ECONOMIC OUTCOMES

	Own Living conditions (relative)	Own Living conditions (absolute)	Country-level economic conditions
	(I)	(II)	(III)
Gold mine	0.012	-0.075	-0.113*
	(0.053)	(0.055)	(0.058)
Cohort FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Ethnic group FE	Yes	Yes	Yes
Countries	18	18	18
Districts	1669	1669	1669
N	24096	24791	24457

Notes: This table shows OLS regressions that relate binary variables for the economic conditions of a respondent against a dummy for whether there was a gold mine in the respondent's district when she was in adolescence (at age 12). Specifically, we explore how a respondent perceives her own living conditions relative to other co-nationals, her own living conditions as such, and the present economic conditions in the country if she had a mine during her adolescence. how she perceives her own current economic conditions. We Standard errors in parentheses. Standard errors are clustered at the district level and robust to heteroscedasticity. Stars indicate significance levels at 10% (*), 5% (**) and 1%(***).

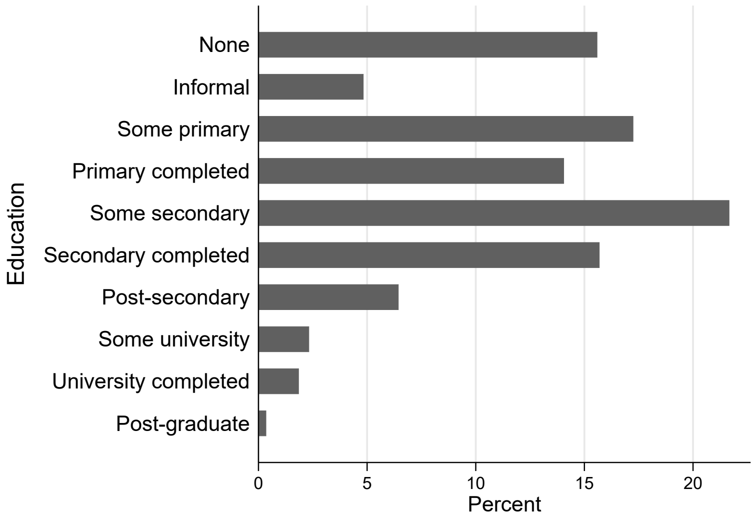


Figure 1: Educational attainment of Afrobarometer respondents

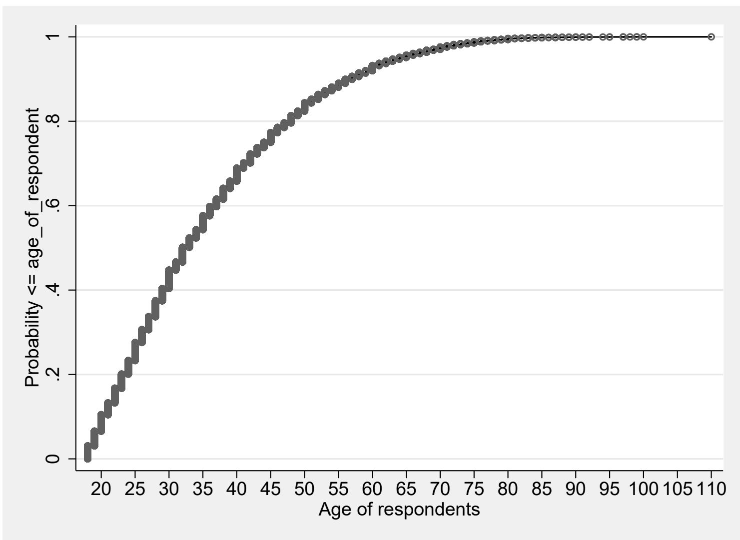
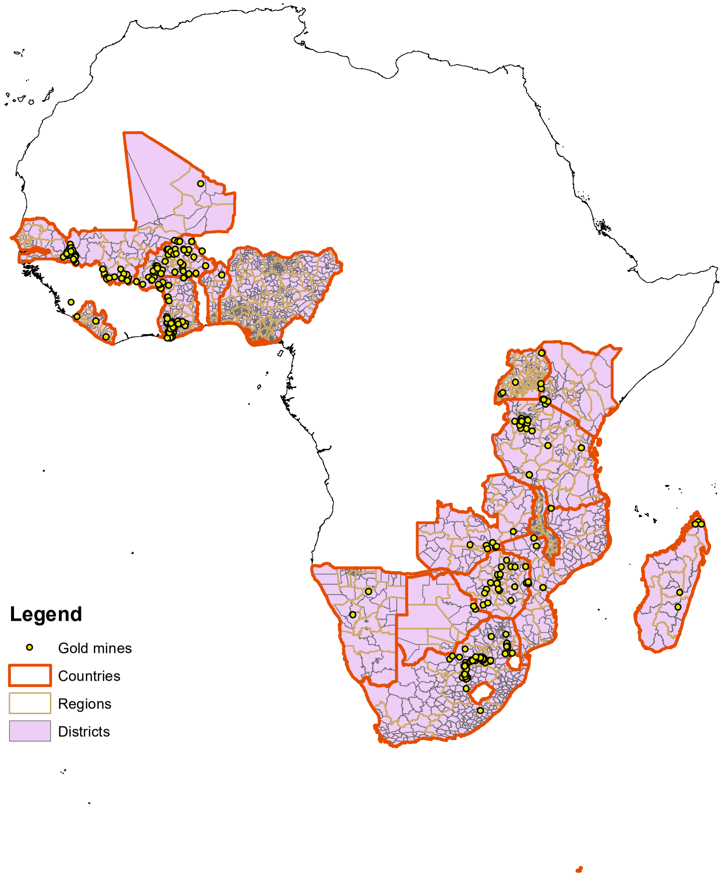
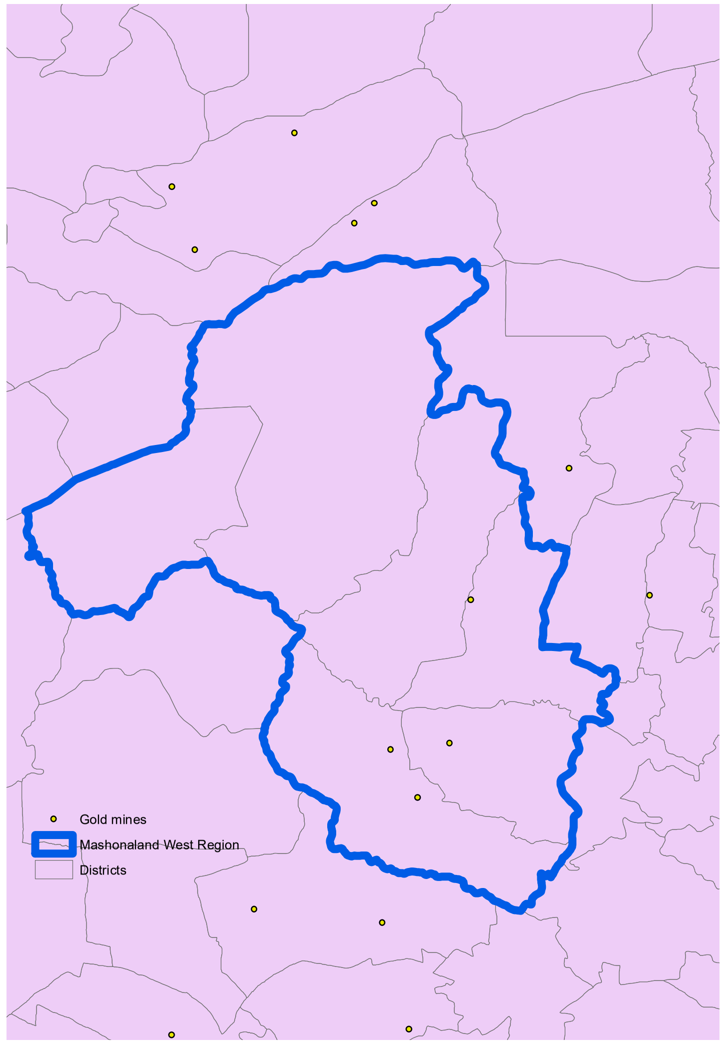


Figure 2: Age distribution of Afrobarometer respondents



(a) Africa



(b) Mashonaland West Region, Zimbabwe

Figure 3: Location of mines in the countries included in the sample and in a particular region. This figure shows the location of (historical and current) mines in the countries included in our sample (subfigure a) and in Mashonaland West Region, Zimbabwe (subfigure b).

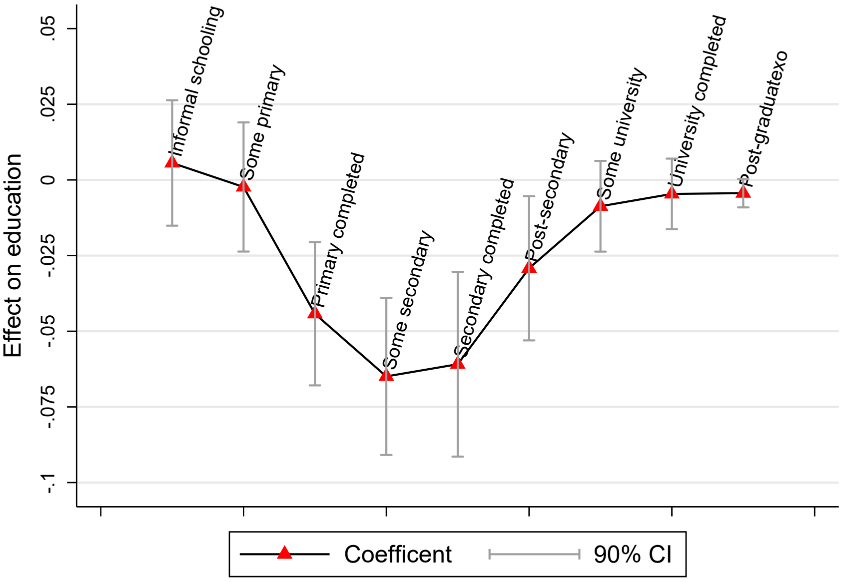


Figure 4: Effect on different educational stages. This figure shows coefficient estimates for the effect of gold mines on the probability of transition from one educational stage on the next.

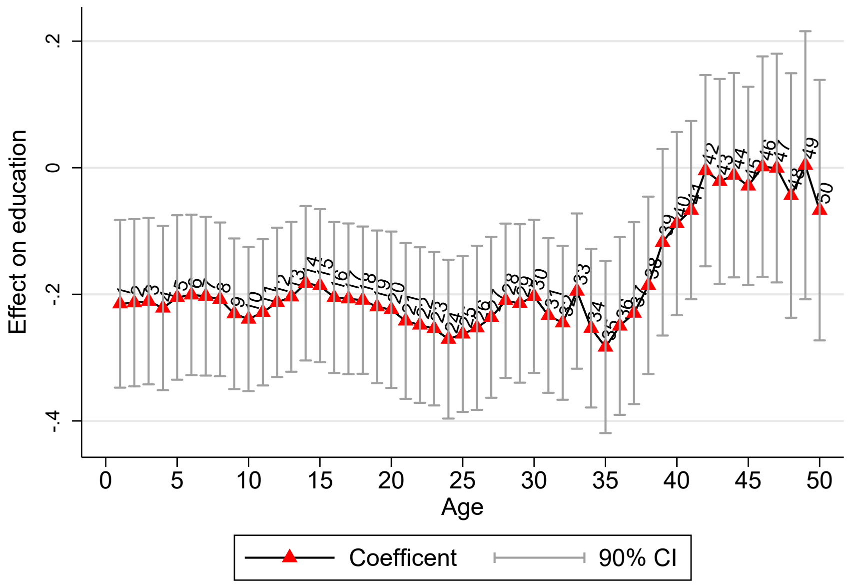


Figure 5: Coefficients at different adolescence years. This figure shows coefficient estimates for different ages as thresholds for adolescence.

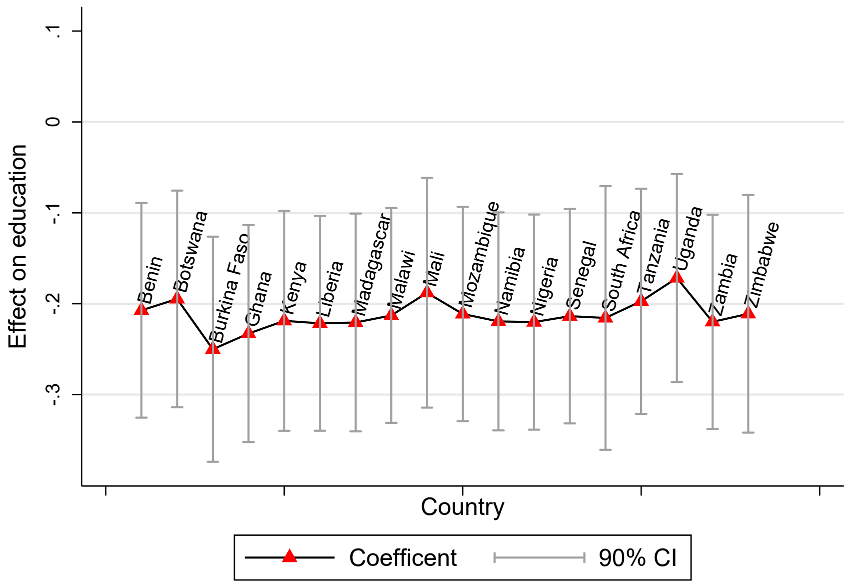


Figure 6: Coefficients without individual countries. This figure shows coefficient estimates after dropping individual countries

Table A.1: Definition of Variables

Label	Description	Source
Education	Educational attainment, 9 distinct stages, ranges from none to post-graduate.	Afrobarometer 4th wave.
Gold mine	Dummy = 1 if least one gold mine in one's district at age 12.	Own construction based on data from MinEx.
Gold mine in neighboring district	Dummy = 1 if gold mine in at least one neighboring district at age 12 & no gold mine in one's own district.	Own construction based on data from MinEx.
Only non-gold mines	Dummy = 1 if only non-gold mines in one's district at age 12	Own construction based on data from MinEx.
At least one non-gold mine	Dummy = 1 if at least one non-gold mine in one's district at age 12	Own construction based on data from MinEx.
Exclusively gold mine	Dummy = 1 if only gold mines one's district at age 12	Own construction based on data from MinEx.
Current gold mine	Gold mine in 2007 (shortly before the 4th wave of the Afrobarometer survey was conducted).	Own construction based on data from MinEx.
Female	Dummy=1 if female respondent.	Afrobarometer 4th wave.
Ethnic homeland	Dummy=1 if district of a respondent overlaps with the traditional settlement area of the respondent's ethnic group.	Own construction using data from Afrobarometer 4th wave, Murdock (1959), Nunn and Wantchekon (2011), and Deconinck and Verpoorten (2013).
Small mine	Dummy=1 if gold mine is classified either as minor ($\geq$ 0.03 Moz Au) or moderate ($\geq$ 0.32 Moz Au & $<$2.24 Moz Au)	Own construction based on data form MinEx.
At least major mine	Dummy=1 if mine is at least classified as major ($\geq$ 2.24 Moz Au)	Own construction based on data form MinEx.
Gold Price	Price of gold in year t.	World Bank commodity price data (The Pink Sheet, February 2016).
School	Dummy=1 if there is a school in the sampling unit / enumeration area of a respondent.	Afrobarometer 4th wave.
Health clinic	Dummy=1 if there is access to a health clinic in the sampling unit / enumeration area of a respondent.	Afrobarometer 4th wave.
Sewage system	Dummy=1 if there is access to a sewage system in the sampling unit / enumeration area of a respondent.	Afrobarometer 4th wave.
Electricity grid	Dummy=1 if there is access to a electricity grid in the sampling unit / enumeration area.	Afrobarometer 4th wave.
Cell phone service	Dummy=1 if there is cell phone service in the sampling unit / enumeration area.	Afrobarometer 4th wave.

Table A.2: Summary statistics

Variable	**Obs**	**Mean**	**SD**	**Min**	**Max**
Education	24866	3.193	2.028	0.000	9.000
Gold mine	24866	0.038	0.192	0.000	1.000
Gold mine in neighboring district	24866	0.124	0.330	0.000	1.000
Current gold mine	24866	0.036	0.185	0.000	1.000
Only non-gold mines	24866	0.061	0.240	0.000	1.000
At least one non-gold mine	24866	0.070	0.255	0.000	1.000
Exclusively gold mine	24866	0.030	0.169	0.000	1.000
Female	24866	0.497	0.500	0.000	1.000
Ethnic homeland	24866	0.558	0.497	0.000	1.000
Small mine	24866	0.016	0.127	0.000	1.000
At least major mine	24866	0.026	0.158	0.000	1.000
Gold Price	23188	0.158	0.843	0.000	9.320
School	24839	0.894	0.308	0.000	1.000
Health clinic	24599	0.644	0.479	0.000	1.000
Sewage system	24576	0.242	0.428	0.000	1.000
Electricity grid	24805	0.550	0.498	0.000	1.000
Post office	24593	0.265	0.441	0.000	1.000

This table provixodes summary statistics on the Afrobarometer respondents included in the sample.