Mineral Mining and Institutional Quality: Evidence from sub-Saharan Africa

Aksel Candas

Thesis for Master of Philosophy in Economics

Department of Economics

University of Oslo

October 2013

Mineral Mining and Institutional Quality: Evidence from sub-Saharan Africa

2013

Mineral Mining and Institutional Quality: Evidence from sub-Saharan Africa

Aksel Candas

http://www.duo.uio.no/

Print: Reprosentralen, Universitetet i Oslo

Preface

First and foremost I would like to thank my supervisor Andreas Kotsadam at the University of Oslo for motivating the subject of this thesis, and for allowing me to build on his work in the current working paper “Mineral Mining and Female Employment”. My gratitude extends to Anja Tolonen at the University of Gothenburg with whom he is writing the paper. I would also like to thank Andreas for continued encouragement and guidance throughout the writing process.

A special debt of gratitude goes to my girlfriend Synne - who sat right next to me throughout most of the writing period, working on her own paper – for her patience and invaluable support.

I would like to thank my family and friends for discussions, technical assistance and (mostly unwitting) emotional support.

This thesis represents the culmination of years of studies at the University of Oslo. I would like to thank the Department of Economics, the inspiring lecturers, my fellow students, and the friends I have made here along the way, both for an educational and an enjoyable period at the University.

Contents

List of Figures:

List of Tables:

1 Introduction

Between 2002 and 2012 the average annual GDP growth rate in sub-Saharan Africa (SSA) was 5.6 percent. This is a high figure compared to the developed world, but the region fared worse compared to some other developing regions. In developing Asia the average annual growth rate of GDP was 8.5 percent over the same period. Different trade patterns may explain some of the differences in economic performance. The SSA exports are much less diversified and heavily based on commodities. Many SSA countries are indeed very dependent on their natural resources. Over the period from 2006 to 2010, eight SSA countries had a mineral and oil share of exports exceeding 80 percent of the total. Ten SSA countries had more than one fifth of their entire revenues stemming from natural resource extraction (World Economic Forum, 2013).

Demand for mineral commodities has increased dramatically since the turn of the 21st century and it is largely driven by the expanding Chinese economy (UNECA, 2011).[1] According to United Nations Economic Commission for Africa (UNECA), many market observers believe that metal prices are in an early phase of a "super cycle". Alan Heap defines such a super cycle as "…a prolonged (decades) trend rise in real commodity prices, driven by the urbanization and industrialization of a major economy" (Heap, 2005). SSA nations have significant reserves and production of minerals in global terms, even though parts of the continent is not geologically surveyed, and the continent as a whole is considered underexplored (UNECA, 2011). Bearing the positive market expectations in mind, this wealth holds the potential for great economic and social development.

Intuitively, abundance of natural resources should be positive for any country, but whether this is the case actually turns out to be a controversial issue, and the body of literature on the subject is extensive. "The natural resource curse" refers to the negative relationship some researchers have found between natural resource abundance and economic growth (e.g. Sachs & Warner, 1995; Gylfason, Herbertsson, & Zoega, 1999; Gylfason & Zoega, 2006).[2] Others have found results conflicting the existence of a resource curse (e.g. Alexeev & Conrad, 2009; Doppelhofer, Miller, & Sala-I-Martin, 2004; Sala-I-Martin, 1997). Mehlum, Moene, & Torvik

[1] From 2000 to 2007, China more than doubled their share of global demand for aluminum, copper and zinc, tripled that for lead and quadrupled that of nickel.
[2] The natural resource curse is also known as "the paradox of plenty".

(2006), using the same data as Sachs & Warner (1995), found that whether natural resources turns out to be a curse or a blessing depends on institutional quality.

Usually, it is suggested that natural resources lead to some phenomenon – some transmission mechanism - which in turn affects economic performance. Many such transmission mechanisms have been investigated. Natural resources have been linked with the Dutch disease[3] (e.g. Sachs & Warner, 1995; Ismail, K., 2010), risk of conflict (e.g. Collier & Hoeffler, 2004; Humphreys, M., 2005), corruption (e.g. Leite & Weidmann, 1999; Isham, Woolcock, Pritchett, & Busby, 2005), democracy[4] (Ross, 2001) and female labor participation/patriarchy (Ross, 2008) to name but a few of the cited potential culprits in the resource curse literature (for an overview see Frankel, 2010 or van der Ploeg, 2011).

Common for all aforementioned research is that they are at the national level. Further insight may be gained by studying local area effects of natural resources and, more recently, there has been a surge of such studies. Natural resources have been linked with conflicts in Colombia (Angrist & Kugler, 2008; Dube & Vargas, 2013) and in the Democratic Republic of Congo (De Luca, Matstadt, Sekeris, & Ulimwengu, 2012). Mineral extraction has been linked with localized Dutch disease effects in Peru (Aragón & Rud, 2013) and in SSA it has led to increased female service sector employment (Kotsadam & Tolonen, 2013) and therefore possibly increased gender equality.

The focus in this thesis is on yet another transmission mechanism, namely worsening institutions.[5] Although measuring the quantitative effect of institutional quality on economic performance is very difficult, there is not much doubt in the direction of the effect; better institutions yield greater economic development (Acemoglu, Johnson, & Robinson, 2001). Thus, any positive effect on the economy from an increase in income originating from natural resource extraction, could potentially be offset by a reduction in institutional quality. Studies on the effect of natural resources on institutional quality are also conflicting. For example,

[3] The name «Dutch Disease» was inspired by the experiences of the Netherlands after their natural gas discoveries in the late 1950s. It refers to possible negative side effects of a natural resource boom. Such a boom, due to for example new mineral discoveries or an increased world market price in a commodity, can cause deindustrialization in the manufacturing sector because of real appreciation of the currency and a shift in labor and land because of increased returns in the non-tradable sector (Frankel, 2010).

[4] There are two broad approaches to the question of democracy and economic growth. In the first democracy is the foundation for growth (securing property rights are essential). In the other a democracy can develop only after human- and physical capital accumulation. Property rights are still essential, but they can be upheld by dictatorships as well. In this second approach, democracy would not be that relevant for economic growth. For more on this issue see Glaeser, La Porta, Lopez-de-Silanes, & Shleifer (2004).

[5] For a definition of institutions see section 2.2.2.

Isham, Woolcock, Pritchett, & Busby (2005) and Sachs & Warner (1995) found negative effects, while Alexeev & Conrad (2009), after correcting for what they argue gives a negative bias, find no negative effect. There are numerous studies, both theoretical and empirical, that have found negative effects of natural resources on factors often included in measures of institutional quality. Some of this literature is covered in section 2.3.1.

In my thesis, I study the effect of large scale mining on children's vaccination probabilities in 29 SSA countries between 1990 and 2011. Following Berger (2009), vaccinations may be used as a proxy for institutional quality.[6] As such, this thesis represents a contribution to the already large literature on the relationship between natural resources and institutions. A common factor in the majority of empirical studies on the relationship between natural resources and institutional quality is that they are done at the national level. This study aims to shed some light on what happens at the local level. Geo-coded vaccination data from several rounds of household surveys are combined with geo-coded longitudinal mining data to examine the local effect of mining on vaccinations using a difference-in-difference regression analysis. The analysis is performed using the statistical software STATA. This study shows that children's probability of being fully vaccinated – a measure of the quality of the routine vaccination program - decreased in mining areas once a mine opened. From this we may infer that mining worsened local institutional quality if vaccinations are accepted as a good proxy for institutions. The negative effect diminishes with distance to the mines and is statistically significant up to the point where the mine footprint area is defined as 25 kilometers. This result is robust to all time in-variant differences between the mining and non-mining areas, migration, different geographical definitions of the mining area, and geographically restricting the control area. Unresolved issues related to migration, health provision by mining companies, pre-production activity of mining companies, and unobserved time-varying factors are highlighted as possible problems with the analysis.

[6] The explanation of what a proxy variable is, and the justification for using vaccinations as a proxy for institutions, is covered in section 2.2.2.

2 Background

2.1 Mining in Africa

Mining for metallic and non-metallic minerals has taken place in Africa since long before the colonial period, with considerable production of iron, copper, gold and salts. Desired control over natural resources was one of the main objectives of the colonization and the minerals were largely exported in raw form. Traditional mining dominated up until the 1870s when the patterns of production changed dramatically as foreign mining companies took over much of the production. The indigenous population was restricted from access to mineral rights and high wage jobs as foreign labor was imported. This added even more "enclave industry" features (UNECA, 2011). The term "enclave industry" is commonly used to describe industries that have few or no upstream and downstream linkages with the rest of the local economy. To this day, enclave mining is still very much on the agenda in Africa. According to UNECA (2011), the African mining sector's key characteristics and challenges are those of an enclave industry.

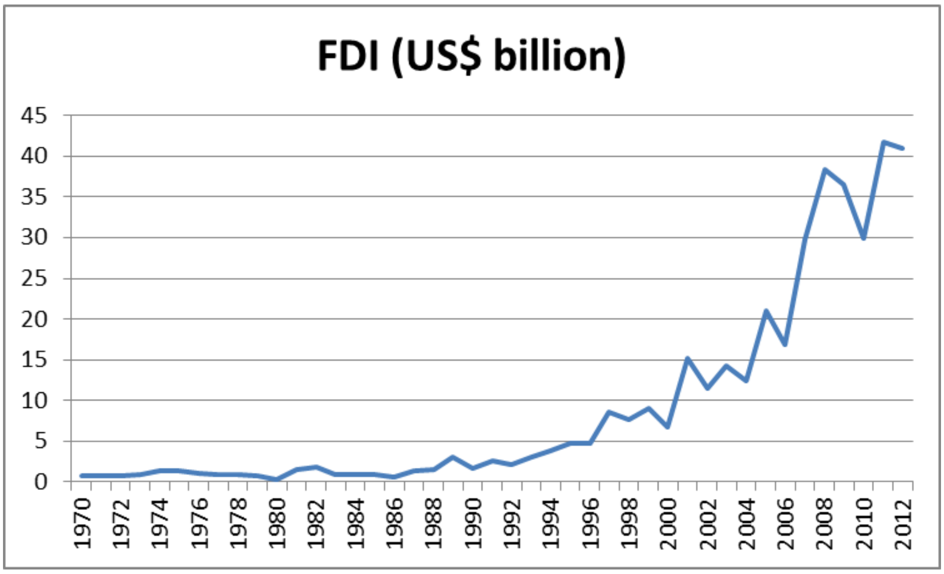
Africa has production and reserves of many minerals that are significant in world terms. Some examples are bauxite, chromium, cobalt, gold, manganese, phosphate, platinum, titanium and diamonds (UNECA, 2011). Many SSA countries are very dependent on their natural resources. Over the period from 2006 to 2010, eight SSA countries had mineral and oil share of exports exceeding 80 percent of the total and ten SSA countries had more than one fifth of their entire revenues stemming from natural resource extraction (World Economic Forum, 2013).

The investment-to-GDP ratio in SSA as a whole has had a positive trend in the last 20 years. In 2012 it was about 22 percent. Although the trend is positive, this is the lowest investment-to-GDP ratio of any developing region in the world (World Economic Forum, 2013). Foreign direct investment (FDI) has also had a positive trend in SSA, with the extractive sector receiving the bulk of investments.[7] In 2012 FDI was at $41.1 billion – above the level before the financial crises. Figure 1 shows the development in FDI in SSA since 1970, based on

[7] Foreign direct investment refers to investments to acquire a lasting management interest in an enterprise operating in an economy outside the country of the investor.

figures from UNCTAD. By 2015 FDI is expected to reach $54 billion (The World Bank, 2013a).

Figure 1. FDI flows to sub-Saharan Africa in billion US$ at current prices and exchange rates (1970-2012)



Source: Authors own. Data from UNCTAD.

A survey performed by the World Bank revealed that mining companies consider mineral potential and existing infrastructure as key decision variables for investments (i.e. opening a new mine site or expanding on an existing one). Other important factors found were a stable legal and fiscal framework, contractual stability, a guaranteed fiscal regime, assured profit repatriation, and easy access to foreign exchange (The World Bank, 1992; UNECA, 2011). The decision variables for mineral exploration are the same by extension. The budget for mineral exploration in Africa accounted for only 13 percent of the total world-wide budget in 2010. Electricity shortages and regional unrest limited exploration activity in some areas (U.S.Geological Survey, 2012). Large parts of Africa have not been geologically surveyed and the continent is considered to be under-explored as a whole (UNECA, 2011). Exploration in Africa is still in early development compared to other regions, with a greater focus on exploring new areas as opposed to expanding on previously identified ones (U.S.Geological Survey, 2012).

Demand for mineral commodities has increased dramatically since the turn of the 21st century and it is largely driven by the expanding Chinese economy. India and Brazil are other populous nations who have had a large growth rate in metal use (UNECA, 2011). According to UNECA many market observers believe that metal prices are in an early phase of a “super cycle”. Alan Heap defines such a super cycle as “…a prolonged (decades) trend rise in real commodity prices, driven by the urbanization and industrialization of a major economy” (Heap, 2005). By 2020 it is expected that only four or five countries in the region are not engaged in mineral resource extraction (The World Bank, 2013a).

The vast mineral resource wealth in SSA, if managed properly, could finance economic and social development in many currently poor, resource-rich nations.

2.2 Vaccination in sub-Saharan Africa

Vaccinations are commonly considered to be the “best buy” for the health sector, so it may seem as a puzzle that financing vaccinations is problematic (Kaddar, Lydon, & Levine, 2004). Arguably, immunization coverage is critical to socio-economic development. Astounding progress has been made in SSA since the birth of WHO’s Expanded Program on Immunization in 1974, but the progress has not been steady. Immunization rates skyrocketed in the 80s only to decline in the 90s. Table 1 shows the development in immunization rates in SSA since 1980. Though there has been great progress, immunization coverage from routine vaccinations is lagging in many SSA nations compared to other developing regions, despite the concerted efforts of the WHO and UNICEF. In the 27th resolution of the United Nations

Table 1. Immunization coverage estimates in percentage from selected antigens in sub-Saharan Africa (1980-2010)

Year	1980	1990	2000	2010
BCG	10	73	67	85
DPT1	<10	76	66	84
DPT3	<10	56	52	74
Polio3	<10	56	53	78
Measles	<10	56	53	75

Source: Brown, Burton, Gacic-Dobo, & Karimov (2012). Data is from WHO and UNICEF. The numbers behind the vaccine names refer to the specific dose of vaccination, i.e., DPT3 is the third (and final) dose of the primary series of the combination vaccine DPT (diphtheria, pertussis and tetanus).

General Assembly, a proclaimed goal was that 90 percent of all children under the age of one year should be fully immunized by 2010 (U.N General Assembly, 2002). This goal is yet to be achieved in SSA.

Africa still relies heavily on external financing of their immunization programs. The simple average of the proportion of government funding in routine vaccination was 52 percent for the continent as a whole in 2010. The share of government funding has increased only slightly in the last decade (Politi & Sagna, 2011).

Central to this thesis, with regard to whether immunization of children can be considered as a proxy for local institutional quality, and for interpreting results, is the degree of involvement by local level governments in immunization. Non-governmental organizations (NGOs) play a significant role in the provision of immunization in SSA, but much less of a role than in financing. The extent of NGOs involvement is not well documented. Neither is how exactly they operate in relation to the national programs or to whom they provide vaccines (Gaulé & Kaddar, 2003). Private for-profit providers also play a role and they operate more independently of the national programs. Based on an e-mail survey of all UNICEF and Pan American Health Organization country offices, DeRoeck & Levine (1998) estimated that in SSA, 26 percent of all immunization was provided by private for-profit operators and NGOs combined.

Since around the time of independence, and from the 1970s and onwards, many African nations have become more decentralized (Mills, Smith, Vaughan, & Tabibzadeh, 1990).[8] Decentralization may be broadly defined as the transfer of public authority, resources and personnel to sub-national levels. The degree and form of decentralization varies across countries (Ndegwa, 2002) and the process has not been linear. Decentralization in the health sector has often been a part of a broader reform and it has been widely advocated by the WHO and other organizations (Mills et al., 1990). Decentralization reforms in general have been funded by USAID, WHO, UNICEF and the World Bank (Beauvais & Bossert, 2002). Between 1993 and 1997, 19 percent of the World Bank projects in Africa had some decentralization component (Junaid, Bird, & Litvack, 1998). Ndegwa (2002) found that 15 out of 30 analyzed African countries exhibited a moderate or high degree of political decentralization and 12 out of 30 countries had moderate or high administrative decentralization. The levels of fiscal decentralization found were lower. Decentralization has been one of the most popular forms of health reform in SSA (Gilson & Mills, 1995), and all of the 46 countries in WHOs Africa Region have reformed their health systems (Lambo & Sambo, 2003).

[8] For an overview of the history of decentralization in Africa see Olowu (2001).

Given the degree of decentralization in general, the amount of reforms in the health sector in particular and the WHO emphasis on decentralization specifically in the health sector, the significance of local governments in immunization provision in SSA is unquestionable, though showing great variation across time and space. It is unfortunately out of the scope of this thesis to gather data to control for whether the local districts in each country at each time of survey had responsibility for immunization.

2.2.1 Corporate Social Responsibility

It is possible to trace business's societal concerns centuries back. The concept of corporate social responsibility (CSR) has been defined in several ways since the formal writings on the subject emerged in the 1950s (Carroll, 1999). However it is defined, and whatever motivates it, what matters is that businesses in SSA engage in activities that do not directly increase profits and that are of benefit to the local communities – health provision included. A survey of 85 companies spread across six SSA countries showed that health projects were the second most common manifestation of CSR after education (GTZ, 2009). Mining companies are no exception to this tendency. A survey of 12 SSA countries revealed a variety of health projects initiated by mining companies (GIZ, 2012).

Despite CSR still being in its infancy in SSA (GTZ, 2009), the evidence suggests that some mining companies are directly providing immunization to the local communities. This potential provision may be negligible in SSA as a whole, or even at the national scale, but locally, in close proximity to the mines, CSR is possibly a significant contributor to children's immunization. Therefore CSR poses a real threat to my identification strategy. Any positive effects on vaccinations from mining found in this thesis must be interpreted with caution. However, any negative effects on vaccination will be in spite of the CSR, adding significance to the results.

2.2.2 Vaccinations as a Proxy for Institutions

In my thesis I analyze the effect of mining on children's probability of being vaccinated. Immunization is important and valuable in and of itself, and it is arguably important for economic performance and social development. Hence, any results found in my analysis are interesting without further interpretation. However, my main interest lies with the effect of mining on institutional quality. In this section I will argue that any effect of mining on vaccinations may be interpreted as an effect on local institutional quality. This relationship cannot be examined directly as there exists no good measure of local institutional quality in SSA. Because institutional quality is unobserved, I exploit the supposed correlation between the observed vaccination and institutional quality. Provided that vaccination fulfills certain criteria discussed more in depth below, it can take the place of institutions in my regression analysis. In that case we can assume that vaccinations are a good proxy for institutions.

The use of vaccinations as a proxy for institutional quality is inspired by a study by Daniel Berger (2009) on the effect of different colonial policies on institutional quality in Nigeria. Comparing households living on either side of the historical North-South border - that does not correspond to any modern state or provincial border, he finds that vaccination rates are lower on the side where the historical taxation system was less developed. His interpretation is that in the areas where the local governments had to collect taxes institutions had to be developed. This increased institutional quality persists to this day as measured by the higher vaccination rates.

Institutions are the profound game rules of society on which all activity is based. North (1994) defines institutions as:

> *... the humanly devised constraints that structure human interaction. They are made up of formal constraints (e.g., rules, laws, constitutions), informal constraints (e.g., norms of behavior, conventions, self-imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies (page 360).*

For vaccination rates to be a good proxy for institutional quality at the local level three criteria must be fulfilled. First, institutions and vaccinations should be strongly correlated. I offer no evidence that this criterion is fulfilled, but a strong positive correlation is reasonable to assume. Section 2.2 shows the significant involvement of local governments in immunization provision in SSA. A successful immunization program would require the willingness and ability of the local government. Corruption, government inefficiency, breech of contracts and security are just a few of the classical measures of institutional quality that should affect these requirements.[9] Second, there should not be much measurement error in the vaccination data. This criterion is fulfilled as the DHS data is highly trustworthy, and because there is no quality/quantity trade-off in vaccination. One is clearly either vaccinated or not. As a robustness test I will restrict the sample to only include children for whom the DHS interviewer has seen a vaccination card. Third, if proximity to mining correlates with factors that affect vaccination, these factors must be controlled for. Non-random mine placement is perhaps the greatest threat to my identification strategy. There is self-selection into being a mining area with infrastructure being of key importance. Better infrastructure is likely to have a positive effect on vaccination. The threat of selection into being a mining area is at least in part dealt with by using a difference-in-difference strategy which removes all unobserved time in-variant characteristics. The empirical issues are discussed in detail in section four. An additional concern is that of CSR as explained in the previous subsection.

Intuitively, institutional change is a gradual process. Institutions are commonly thought to be durable and persistent, hence the use of historical instruments as, for example, in the classical paper by Acemoglu, Johnson, & Robinson (2001). Berger (2009) also emphasises the persistence of institutions. Table 1 shows that immunization coverage in SSA has increased very quickly since the 80s and has shown relatively large swings over time. Glaeser, La Porta, Lopez-de-Silanes, & Shleifer (2004) investigate three different measures of institutional quality used in econometric analysis in several influential papers.[10] They argue that two of the measures are unusable as a measure of institutions as defined by North because they do not capture constraints. A dictator choosing the correct policies can receive the highest evaluations using these measures. All three measures are highly GDP-dependent and show great volatility. This goes against the common notion and our intuition of institutional change as a gradual process. In light of this critisism interpreting changes in immunization rates as institutional change may be misleading. Simply put any effect on vaccination rates from mining found in my analysis may happen too quickly for it to be interpreted as institutional change.

---

[9] See section 2.3.1 for more on measures of institutional quality.

[10] The authors list Knack & Keefer (1995), Hall & Jones (1999) , Acemoglu, Johnson, & Robinson (2001) and Rodrik, Subramanian, & Trebbi (2004).

2.3 The Resource Curse

A seminal paper in this field of studies is "Natural Resource Abundance and Economic Growth" by Sachs & Warner, published first as a working paper in 1995. In a cross-section analysis of 79 developing countries, Sachs & Warner (1995) found that natural resource abundance had a negative effect on GDP growth rates over the period 1971-1989. Several other cross-sectional studies have provided empirical support to this finding (e.g. Gylfason, Herbertsson, & Zoega, 1999; Gylfason & Zoega, 2006).[11] Other cross-sectional analyses have not supported a resource curse unambiguously. For example Sala-I-Martin (1997) and Doppelhofer, Miller, & Sala-I-Martin (2004) found that a higher mining share of GDP affects economic growth positively.

Alexeev & Conrad (2009) dismiss the findings of Sachs & Warner (1995) and other previous literature and find no evidence of a resource curse. On the contrary, they say "the effect of a large endowment of oil and other mineral resources on long-term economic growth of countries has been on balance positive (p. 586)". A problem with most of the previous literature, as pointed out by Alexeev & Conrad (2009), is that its measures of natural resource abundance and natural resource dependence are endogenous and will cause bias in favor of the existence of a resource curse. The reason for this is that, given a level of natural resource output, countries which, for whatever reason are performing poorly economically will be measured as more resource abundant when the natural resource share of GDP is used. The natural resource share of total exports as a measure of natural resource dependence suffers from a similar problem, but in addition, countries that are more industrialized process and consume more of their own natural resources and is therefore measured as less resource dependent. After correcting this they find that natural resources have had a positive effect on economic growth.

In short, the evidence of the natural resource curse's existence is conflicting. While resource abundant countries on average have been growth losers (Mehlum, Moene, & Torvik, 2006), there are examples of nations across time and space with great natural resource abundance that have been growth winners. To name but a few; Norway, USA, Botswana and Chile have all been successful "despite of" natural resource abundance.

[11] Sachs & Warner's (1995) preferred measure of natural resource dependence was the ratio of primary-product exports to GDP. For robustness they test the share of mineral production in GDP, the fraction of primary exports in total exports and the log of land area per person.

Quoting Frankel (2010):

Few would think that a country with oil or other natural resources would be better off destroying them or refraining from developing them. Resource-rich countries can succeed. The question is why does oil lead to success in some cases and failure in others (2010, p. 13)

2.3.1 Institutions and the Resource Curse

Mehlum, Moene & Torvik (2006) divides the literature on the relationship between institutions and the resource curse into three strands. One in which natural resources interacts with institutional quality; another, in which institutions have a neutral/unimportant role; and a third, in which institutions are an intermediate causal link – or transmission mechanism – for the resource curse.

Within the first strand we find Mehlum, Moene & Torvik (2006). They reason that destructive rent-seeking activities depend on institutional quality and illustrate it with a simple model. Entrepreneurs can choose between rent-seeking and producing activities. The profitability of destructive rent-seeking activities on the part on the entrepreneurs depends on institutional quality. If institutions are bad – or "grabber-friendly" – profitability from rent-seeking outside the productive economy is higher than when institutions are good – or "producer-friendly". The model predicts that natural resources increase the entrepreneurs' income and the total production when institutions are producer friendly, but decrease income and total production when institutions are grabber-friendly. The model is tested empirically by using the same data and methodology as Sachs & Warner (1995), but including an interaction term between institutional quality and resource abundance. The interaction term is significantly positive, which supports the model's prediction that there is only a resource curse when the institutions are grabber-friendly. Robinson, Torvik, & Verdier (2006) develop a political economy model that gives a similar conclusion as Mehlum, Moene & Torvik (2006): A resource curse may exist when institutional quality is low. They study an incumbent politician that can influence the probability of being reelected by offering inefficient public sector jobs. In the absence of institutions that limit the power of the incumbent to bias elections by such distribution of patronage, a resource boom may lead to a resource curse. The model also predicts an improved resource extraction path because the discount factor of the incumbent is equal to the probability that he is reelected. Compared to the social optimum, the politician undervalues future income from the natural resources since he only cares about the future resource income if he is reelected. The patronage increases his probability to be reelected which moves resource extraction closer to the socially optimal extraction path. These results hold for permanent or anticipated future resource booms.

Within the second strand we find the previously mentioned Sachs & Warner (1995). They did find a negative association between resource abundance and institutional quality, but deemed it unimportant in explaining the resource curse. Alexeev & Conrad (2009) argue that all previous findings from cross-country analyses on the effect of natural resources on institutional quality suffer the same negative bias. The negative bias arises from the use of "initial GDP" as a control variable in the regressions. Initial GDP was included by Sachs & Warner (1995) because it has been "found to be important for economic growth (1995, p. 1)".[12] The initial year used is usually 1970. However, as Alexeev & Conrad (2009) show, most major resource extracting countries had been doing so since well before 1970 and they have on average higher GDP levels. Because of the positive relationship between natural resources and per capita GDP, and between per capita GDP and institutions, including initial GDP drives down the estimated effect of natural resources. To bypass this problem Alexeev & Conrad (2009) predict initial GDP as of 1970 by using absolute latitude and dummies for European population, Latin America and East Asia. They run the regression analysis of natural resources on institutional quality replacing initial GDP in 1970 with the predicted values, and find no significant effect of natural resources on institutions.

The last strand – institutions as a transmission mechanism - is the focus of this thesis. Measuring the quantitative effect of institutional quality on economic performance is very difficult, but there is not much doubt in the direction of the effect; better institutions yield greater economic development. Thus, any positive effect on the economy from an increase in income originating from natural resource extraction could potentially be offset by a reduction in institutional quality. The measures on institutional quality in the literature vary, but commonly the measure is an index constructed from a range of variables. For example, the Worldwide Governance Indicators (used by Rodrik, Subramanian, & Trebbi (2004) and others), consist of data on 215 countries describing six dimensions of governance: voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption. The data has been gathered from 31

[12] Initial GDP level is important in neo-classical growth models. In the Solow model a country with a lower income level has a higher income growth all else equal.

different sources (The World Bank, 2013b). An effect from natural resources on any or all of these dimensions of governance can be interpreted as an effect on institutional quality. In the following paragraph I introduce a few of a large number of studies relevant to institutions as a transmission mechanism for a resource curse.

Isham, Woolcock, Pritchett, & Busby (2005) found, in a cross-country regression analysis, a negative effect on six out of six measures of institutions from "point source" natural resource extraction.[13] Point source resources are natural resources "extracted from a narrow geographic or economic base (2005, page 143)" like, for example, most minerals and oil. Ross (2001) shows, using time series data from 113 states between 1971 and 1997, that both oil wealth and mineral wealth have impeded democratization in this period. The measures of natural resources used are export values as shares of GDP. The study provides tentative evidence of three mechanisms for the impeded democratization: a "rentier state" effect (resource rich countries can afford to have low taxes and distribute patronage), a repression effect (resource rich countries can afford security) and a modernization effect (resource extraction inhibits social and cultural development). Collier & Hoeffler (2004) study factors that influence the risk of conflict in 123 countries over the period 1960 to 1999. They find that a higher primary commodity dependence, measured as the ratio of the value of primary commodity exports to GDP, significantly increased the risk of conflict. Dube & Vargas (2013) study how price shocks have affected the risk of conflict in Colombian municipalities from 1988 to 2005. They find that a negative price shock to coffee increased the risk of conflict more in municipalities that produce coffee. The result is consistent with the theory of opportunity cost as a mechanism for conflict as coffee is labor intensive, and a negative price shock on coffee leads to decreased wages. On the other hand, a positive price shock in less labor intensive industries, foremost oil, but also non-fuel minerals, led to an increase in conflicts in municipalities that produce them. This result is consistent with rapacity, i.e fighting over resource rents, as a link between resources and conflicts. De Luca, Matstadt, Sekeris, & Ulimwengu (2012) study how mineral mining affected conflicts in Congo in the period 1997-2007. They instrument for mineral mining by using historical mining concession data and the world market mineral prices over the period of 1997-2007. The study finds that in areas close to mining there is no significant increase in conflicts, but it does find an effect using a larger geographical definition of the mining footprint area. Caselli & Michaels (2013) find that oil

[13] The six institutional variables were "rule of law", "political stability", "government efficiency", "absence of corruption", "regulatory framework" and "property rights and rule-based governance".

abundance in Brazilian municipalities - measured by oil output - caused increased reported public spending. However, survey data showed little or no increase in services provided. The authors provide tentative evidence pointing towards corruption as the cause. Brollo, Nannicini, Perotti, & Tabellini (2010) study a model of how windfall income affects corruption and the quality of political candidates. In the model, increased income leads to more corruption on the part of the incumbent politician and a reduction in quality of the pool of political candidates. Corruption increases because the public is assumed to be imperfectly informed. Therefore, the incumbent is able to grab more rents without disappointing the public. The quality of political candidates decreases because politicians of lower quality are assumed to be more concerned about how much rents they can grab. The model also predicts that the probability that the incumbent is reelected increases. The model is tested by means of a regression discontinuity analysis of Brazilian municipalities. Brazilian municipalities receive central funding according to their population size. Comparing municipalities just below and just above the income jumps, the study finds empirical evidence supporting all mentioned model predictions.

3 Data

In order to examine local area effects on vaccination from mining in SSA, geo-coded datasets from Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MeasureDHS or DHS) and Intierra Raw Minerals Group (IntierraRMG) are merged.

Table 2. Descriptive statistics

Variables	Definition	Obs.	Mean	Std. Dev.
Mining Variables				
distancemine1	Distance from respondent to nearest mine in kilometers	277956	241.67	210.83
active25	1 if at least one active mine is within 25 kilometers of respondent	277956	0.021	0.144
inactive25	1 if at least one inactive mine is within 25 kilometers of respondent	273522	0.007	0.082
suspended25	1 if at least one suspended mine is within 25 kilometers of respondent	277956	0.016	0.125
Main Independent Variables				
child1anyvacc	1 if last born child has received any vaccine	277956	0.836	0.369
child1fullvacc	1 if last born child is fully vaccinated	277956	0.379	0.485
child2anyvacc	1 if second last born child has received any vaccine	101613	0.853	0.354
child2fullvacc	1 if second last born child is fully vaccinated	101613	0.479	0.500
anychildvacc	1 if a mother has at least one child that has received a vaccine	277956	0.872	0.334
allchildvacc	1 if a mother has all her children are fully vaccinated	277956	0.356	0.479
Control Variables				
age	Respondent's age in years	277956	28.72	7.243
christian	1 if respondent is Christian	250413	0.557	0.497
muslim	1 if respondent is Muslim	257459	0.375	0.484
Mechanisms				
urban	1 if respondent lives in urban environment	277956	0.267	0.442
schoolyears	Number of years of schooling	277800	3.459	4.086
working	1 f respondent is currently working	277684	0.686	0.464
non_mover	1 if respondent has never moved	212908	0.427	0.495

The longitudinal mining data allows construction of indicators for whether a mine is currently producing (active), not yet producing (inactive) or has stopped producing (suspended). From the mines center points, using GPS-coordinates, concentric circles of different radii are constructed.[14] Then, for each woman in the DHS data using the DHS cluster GPS-coordinates, an indicator variable is generated for whether she lives within the constructed concentric circles around an active mine at the time of the survey. If she is not, the same procedure is done for inactive mines. If the woman does not live within any of the constructed circles around an active or inactive mine, she is labeled as living in a non-mining area. On average the respondents live about 235 kilometers from the closest mine, either active, inactive or suspended. About 2.32 percent of the respondents live within 25 kilometers of an active mine, 0.69 percent live within 25 kilometers of an inactive mine and 1.7 percent live within 25 kilometers of a suspended mine at the time of the survey.

3.1 DHS Data

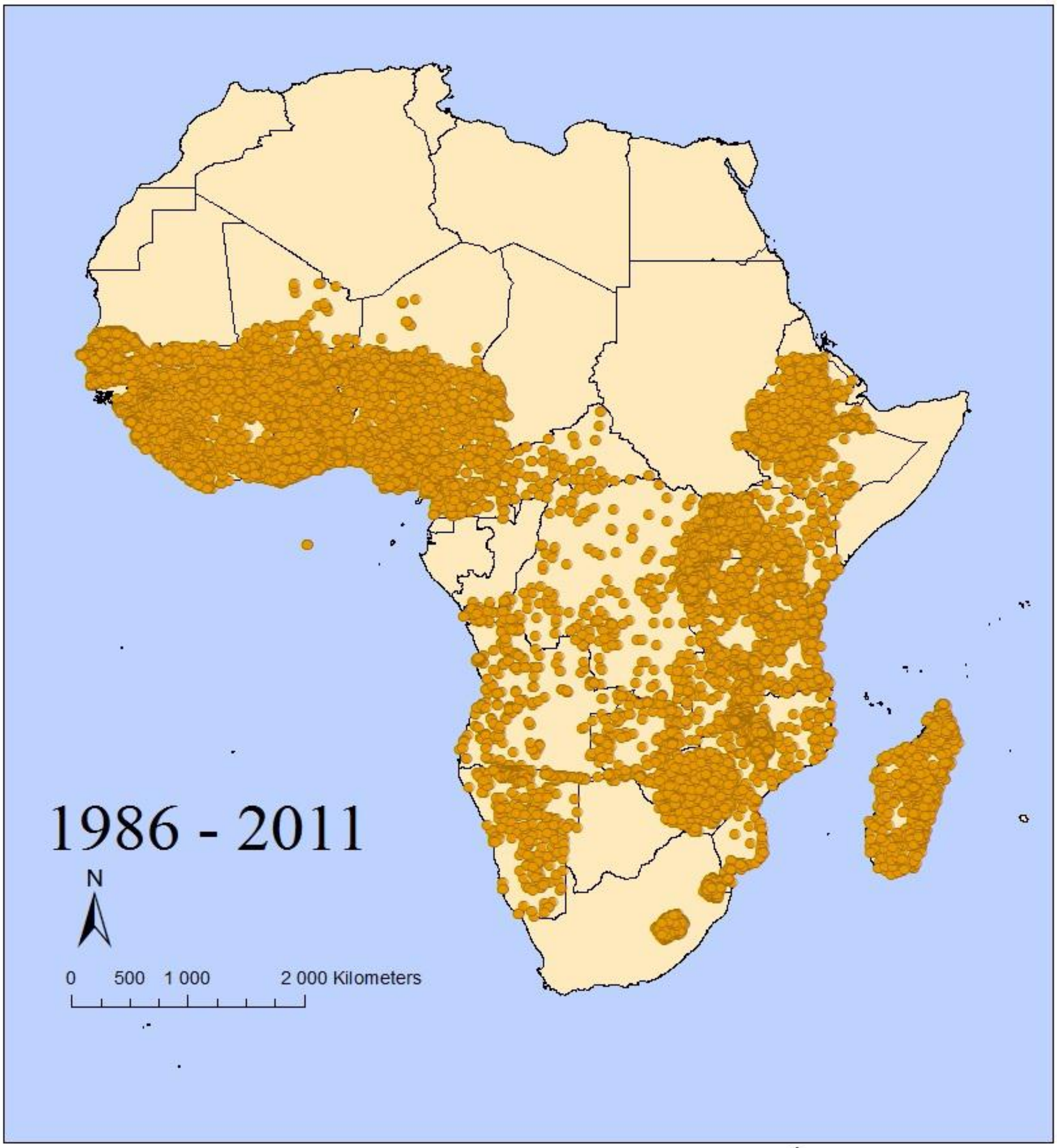
MeasureDHS is a project funded by U.S. Agency for International Development (USAID) and other donors, and implemented by ICF International. They provide technical assistance to surveys performed in the developing world with the goal of advancing global understanding of health and population trends.

The data used is from the Demographic and Health Surveys. These are household surveys of women that are standardized across time and space, and performed by trained interviewers in-person. The participating women are grouped in clusters ranging in size from 1 to 108, spread across 297 sub-national regions.[15] In most surveys the clusters have been geo-coded. Only the surveys that have been geo-coded are used in this research. In order to maintain anonymity a small random error in the GPS-coordinates is introduced.[16] The errors are contained within country and region. Since the errors in the GPS-coordinates are random, they do not pose a threat to the identification strategy.

In total 625 141 women between the ages 15 and 49 have participated in the 59 surveys used in my analysis. The surveys are from 29 countries and were performed between 1990 and 2011.[17] Figure 2 shows the spread of DHS clusters across SSA from 1986 to 2011.

[14] The radii's, in kilometers, are 5, 10, 15, 20, 25, 30, 50, 75, 100 and 200.
[15] The number of women in each sub-national region range from 30 to 23 007.
[16] Urban clusters contain a minimum of 0 and a maximum of 2 kilometers of error. Rural clusters contain a minimum of 0 and a maximum of 5 kilometers of positional error with a further 1% of the rural clusters displaced a minimum of 0 and a maximum of 10 kilometers.
[17] Table A.1 in the appendix shows the list of countries and the corresponding number of survey participants.

Figure 2. DHS clusters in sub-Saharan Africa 1986-2011.



Source: Kotsadam & Tolonen (2013)

The surveys contain vaccination data on children up to five years old with a maximum of six entries per mother. If she has had more than six children in the last five years, the oldest child will not be registered. Due to the way the data is constructed, the vaccination data on the children is split into whether it is last born child, second last born, third last born etc.[18] There are necessarily more observations on the last born children. 277 956 out of the 625 141

[18] This may be unfortunate as the sample is reduced in each regression. Combining all the children in a single regression could potentially produce more significant results.

women sampled have had at least one child for whom I have vaccination data. 101 613 have had two children and 12 404 have had three children. The last born children are one year and four months old on average. The second last born are on average just over three years old. As one would expect, the older children have on average received more vaccines (see table 2).

The dataset contains information on eight different vaccines: measles, BCG, three doses of polio and three doses of DPT.[19] The main independent variables in this thesis are constructed from this data. They are indicators for whether a child has received at least one vaccine and for whether the child is fully vaccinated. In addition, in order to use as large a sample as possible, an indicator variable is constructed for whether a mother has at least one child that has at least one vaccine and for whether all her children are fully vaccinated.

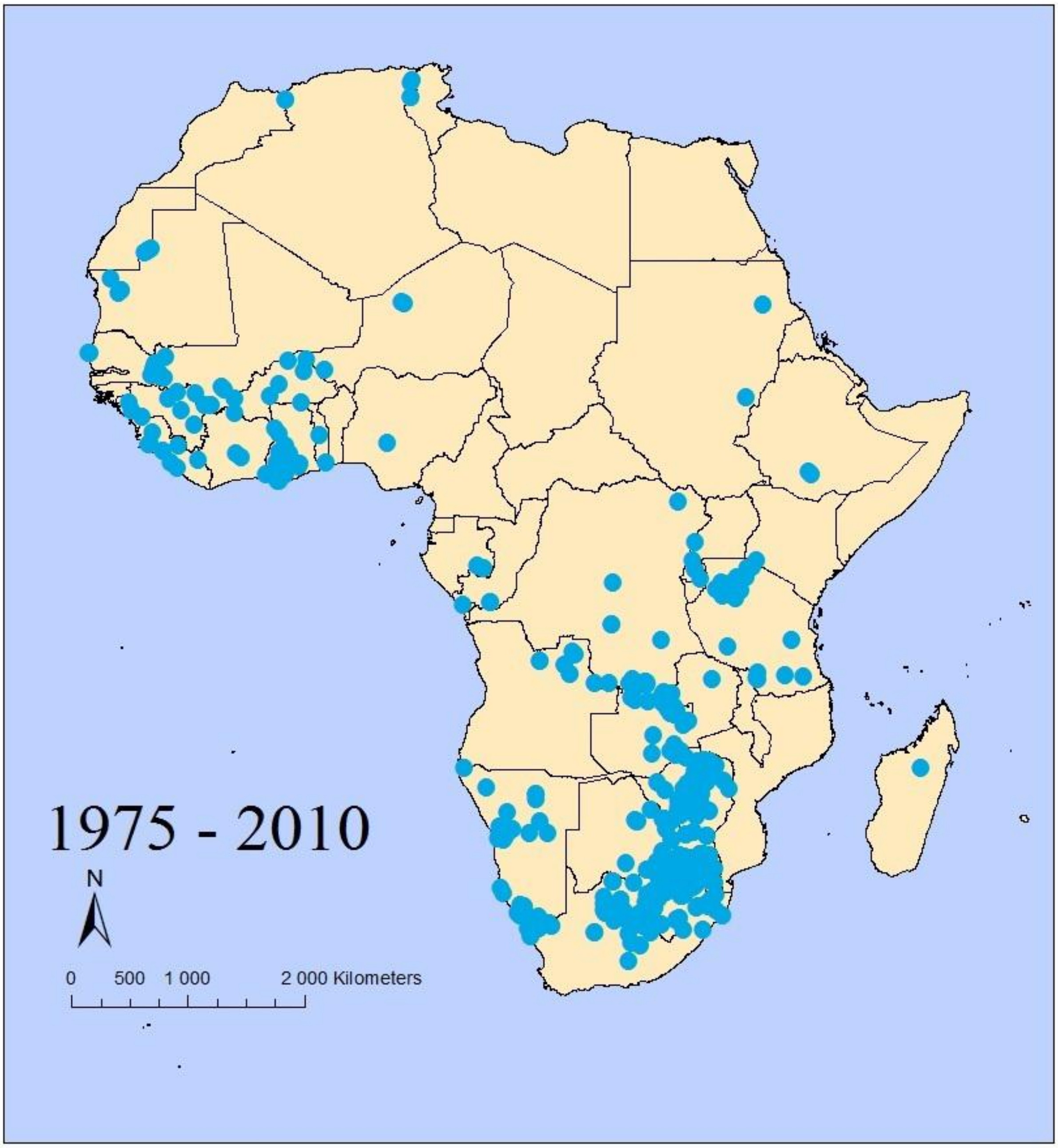
3.2 Resource Data

The mining data is from IntierraRMG. It contains information on large scale production of 31 different minerals in 1975 and from 1984 to 2010. The information consists of production levels, the type of mineral, the name of the producer and geographical placement by GPS-coordinates. In total there is information on 874 industrial size mines across Africa. 277 of which are matched to a DHS cluster. All DHS clusters are matched to a mine, but not all mines are matched to a DHS cluster. This is because some mines are in remote areas and because DHS data from a few countries – unfortunately including South Africa – is missing. Figure 3 plots RMG mines in Africa from 1975 to 2010.

Artisanal and small scale mining (ASM) is widespread in SSA. More than 100 000 people are employed directly in ASM and associated services in 21 countries (UNECA, 2011). The IntierraRMG data is for large scale mining so ASM is not covered. While ASM is definitely important for many SSA economies, this thesis is on the connection between mining and institutions. Given the nature of ASM it is likely to be of less relevance in this regard, though it is possibly important for risk of conflict in certain areas. As an example the FDLR group in eastern Congo has been heavily linked with trade in minerals (United Nations Group of Experts, 2009).

Figure 3. RMG mines in Africa 1975-2010.

[19] BCG is short for “Bacillus Calmette–Guérin” – a vaccine against tuberculosis. DPT is a combination vaccine. It is an abbreviation of the three diseases for which it provides immunization: diphtheria, pertussis and tetanus.



Source: Kotsadam & Tolonen (2013)

4 Methodology

In this thesis I analyze the local area effect of mineral extraction on institutional quality. I proxy for institutional quality by using different vaccination measures. One way to perform such an analysis would be to run a plain ordinary least square (OLS) regression of the form:

$$Y_i = \beta_0 + \beta_1 Active + \varepsilon_i$$

The dependent variable Y (e.g. the probability of last born children being fully vaccinated) for individual i, is a function of an indicator for whether the individual lives near an active mine or not (Active). If the only thing that matters to mining investment and mineral extraction is geology, and geology is random and geological surveying is uncorrelated with everything that affects vaccination, then this identification strategy would be sufficient. If this were the case we could say that there is no selection into being a mining area. The problem is that these conditions are definitely not met. As stated earlier, mining companies make other considerations when investing besides geological ones. Consider the other key decision variable identified besides geology; existing infrastructure. Existing infrastructure, e.g., roads and electricity, is likely to have a positive effect on vaccination directly. Roads are needed for outreach-programs and for the population to get to the health centers and hospitals. Electricity is needed for the cold chain and for alerting the public about vaccination dates through radio broadcasts.[20] Because mines are placed where the existing infrastructure is good, and infrastructure affects vaccination positively, we will get a positive omitted variable bias (OVB) on our mining estimate β_1. In addition, the quality of the infrastructure is likely to be associated with other things that may affect vaccination, like, for example, corruption. We could potentially control for infrastructure by adding some measure of it to our regression. The OLS regression model would be:

$$Vaccination_i = \beta_0 + \beta_1 Active + \beta_2 Infrastructure_i + \varepsilon_i$$

Under this model specification, OVB from infrastructure is gone, but there are further problems. In reality we may not have good measures of infrastructure at the local level in SSA. But more importantly, in addition to infrastructure, the mining areas may differ from the

[20] Vaccines are very sensitive to temperature. The cold chain refers to the need for vaccines to be kept cool (commonly 2°C to 8°C) at all times from production until administration.

non-mining areas in a whole range of different ways that have an impact on vaccination. There are many potential sources of OVB and we are unable to control for all of them.

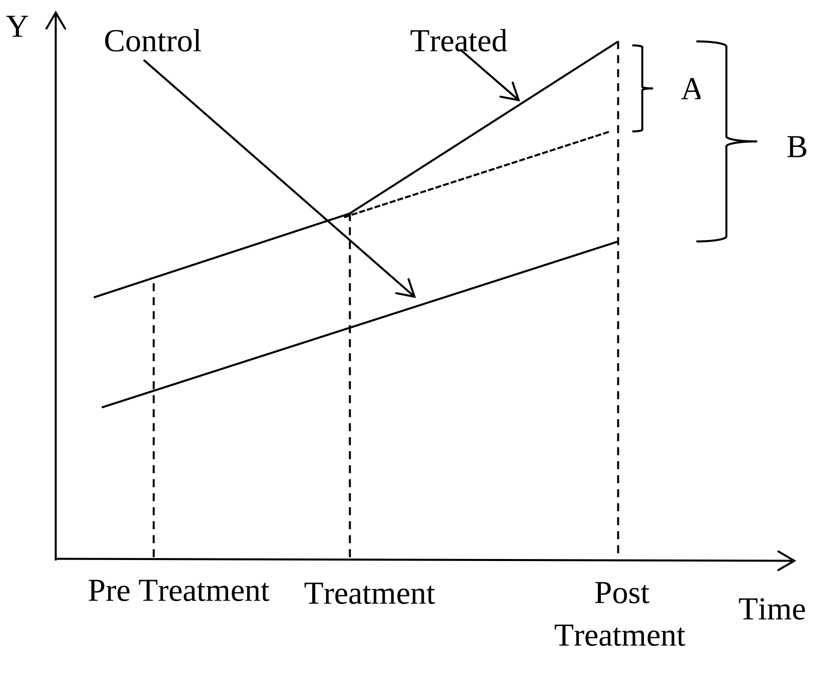
To mediate the overwhelmingly likely OVB, I exploit the longitudinal mining data and the different waves of household surveys to do a difference-in-difference regression analysis. The temporal variation allows me to examine the impact on vaccination before and after "treatment" - treatment in this analysis is mine openings. This is a type of "fixed effects" model. The general idea is to exploit variation in vaccination rates within areas over time, instead of only exploiting variation in vaccination rates across space. Taking differences removes all OVB from unobservable factors (i.e. factors left out of our model) that are constant over time.

The regression model used in this thesis takes the form:

$$Y_{irvt} = \beta_1 Active + \beta_2 Inactive + \alpha_r + g_t + \delta_{rt} + \gamma X_i + \varepsilon_{irvt}$$

The dependent variable Y for individual i, in region r, in cluster v, at time t, is regressed on indicators for whether the individual lives in an active or inactive mining area at the time of the survey, region and year fixed effects, region specific linear time trends and a set of individual specific control variables. Each individual will fall in one of three categories: She lives either within an area defined as being close to active mining (Active), within an area defined as being close to where a mine is yet to be active (Inactive) or she will live outside these areas. In that case she belongs to the control group.

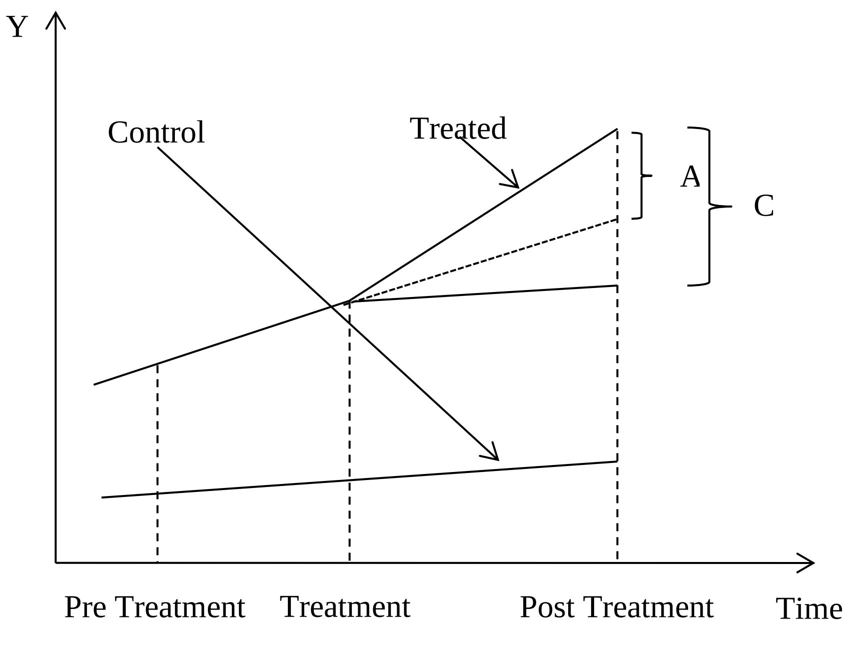
Figure 4. Difference-in-difference with equal trends.



β_1 is the difference between the treated and the control group. This estimate is represented by the bracket "B" in figure 4. β_2 is the difference between the treated group and the control group before treatment. Subtracting the β_2 estimate from β_1 yields a difference-in-difference estimate of the effect of mineral extraction on the outcome variable. This estimate corresponds to bracket A in figure 4. The hypothesis that $\beta_1 - \beta_2 = 0$ is tested after each regression. The figure represents a case where the mining areas have higher vaccination levels than the non-mining areas, but identical trends over time. Interpreting the β_1-estimate of "Active" as the effect of mining without taking differences would yield the estimate "B" in figure 4 as the treatment effect. This would be an overestimation if relevant variables are omitted from the regression.

The difference-in-difference method relies on the assumption that the trends in the outcome variable in the mining- and non-mining areas would have been the same absent the mining. The method controls for all unobserved fixed effects, but factors that vary over time and affect the outcome variable can still cause biased estimates if they vary differently in the treatment and control groups. Consider the case of figure 5 below. The trend in the outcome variable is greater in the mining areas compared to the control group also absent the mining. The difference-in-difference method would fail to take account of the different trends in the two groups and would overestimate the treatment effect to be "C" in the figure. The actual treatment effect of mining would be "A".

Figure 5. Difference-in-difference with unequal trends.



4.1 Empirical Issues and Robustness tests

Both for robustness and interpretation, the analysis relies on different definitions of the mining area and different restrictions on the control group. In the baseline regression, the mining area is defined up to a cut-off of 25 kilometers from a mine, but different distance measures ranging from 5 kilometers to 75 kilometers are analyzed. One would expect a diminishing impact from mining on the outcome variables as the cut-off distance is increased. In a similar way to mine openings, mine closings will also be analyzed to see if any results from mine openings are reversed.

All regressions include controls for the mother's age and religious beliefs. The mother's degree of urbanization, her education and her employment status are all affected by mining. Kotsadam & Tolonen (2013) found that mine openings in SSA between 1990 and 2011 have had a negative effect on the likelihood that a woman is working. This decrease in overall employment was driven by a decrease in agricultural employment, while employment in services partially counteracted the overall negative effect. In the same study they also found that mine openings have had a positive effect on women's length of education. Mining is also likely to cause an increased degree of urbanization. Because these three factors may influence the mother's opportunities and choices for immunization of her children, including them in the regression may remove some of the effect of mining on vaccinations. Therefore these variables are included separately from the other controls as possible mechanisms through which mining affects vaccinations.

Different vaccination measures are used in the analysis. The DPT3 coverage is widely regarded as a good measure of the quality of the routine vaccination services (Arevshatian et al., 2007). DPT3 is the third dose of the primary series of the DPT vaccination that is recommended by WHO to be finished by the age of 6 months. It is used as a measure/indicator as it reflects completeness of the routine vaccination to a larger degree than any single vaccination shot like for example the BCG. Using the DHS data, an indicator variable is constructed that takes the value one if a child has had all eight vaccinations on which there is data. DPT3 is included in these eight vaccinations. This measure is certainly superior to using the DPT3 vaccination rate alone to judge the quality of the routine vaccination program. The indicator variable constructed for whether a child has received at least one vaccine may be a better measure of breadth of vaccinations.

4.1.1 Unobservable Time-Variant Factors

The difference-in-difference method employed in this thesis eliminates any OVB from unobservable time-invariant factors, but time-varying factors still pose a problem. The assumption that the trends in the outcome variable in the mining- and non-mining areas would have been the same, absent the mining, cannot be confirmed. It can never be ruled out that something unobserved varies differently over time in the treatment and control groups, and that this is driving any results found in a difference-in-difference model. Several measures are taken to reduce the danger of any bias that might arise from such factors.

Migration may be such an unobserved factor and it poses a real threat. The household survey data on vaccination is not panel data. Implicitly I am assuming that the population before and after treatment is the same. However, a mine opening may induce work migration en masse. These migrants, and the places from which they come, may have different characteristics that are unobserved and affect vaccination of children. To control for this the sample will be restricted to those who have never moved in their life. About 42,7 percent of the mothers in my sample have never moved. Restricting the sample to non-movers should largely remove the danger of bias from migration, but there are further problems. First, moving requires the need or want to move and the ability to overcome obstacles such as a lack of information about places to move to, monetary costs and family attachments (Parnwell, 1993). Non-movers may therefore share certain characteristics so that the results from this sub-population cannot be generalized. Second, the people who comprise the community around the non-movers may change dramatically if there is large inward or outward migration, and this may affect the non-mover's vaccination choices. As an example of such community effects on individual's choices; Kravdal (2002) showed, using DHS data from SSA, that the average educational level of a community had a significant negative effect on a woman's birth rate net of her own education and degree of urbanization.

Regional time trends are included in each regression. This allows for the trends in the outcome variables to be different across regions, thus reducing the danger of unequal trends from unobserved factors.

Despite of taking these measures, a fear still exists that the treatment and control groups are too dissimilar and therefore have different trends. Therefore the control group will be restricted to living within 200 kilometers of a mine whereby reducing any dissimilarity.

5 Results

This section describes the results of my analysis using the empirical strategy outlined in section four. The main results of the baseline regressions are shown in table 3 and table 4. The baseline regressions have mining areas defined to a cut-off of 25 kilometers. In the following subsections possible mechanisms are investigated and different robustness tests are performed.

Table 3 and 4 show the relationship between the explanatory variables – active25 and inactive25 being those of main interest - and the probability that last born and second last born children respectively have received at least one vaccine and for them to have been fully vaccinated. The explanatory variables are organized by rows and the explained variables – under different regression specifications - by columns. In all regressions controls are added for the mother's age and religious beliefs. Results are shown with and without geographically restricting the control group to living within 200 kilometers of a mine. This restriction is done to reduce potential dissimilarity in the trends between the two groups at the cost of losing about half of the sample. The estimated effect of mining is the difference between the coefficients for the variables active25 and inactive25. The coefficients for these variables are the estimated difference in vaccination probabilities associated with living within 25 kilometers of an active/producing mine or an inactive/future mine compared to living further away. The result of the F-test of whether this difference is statistically significant is provided after each regression along with the associated p-value. The p-value is the probability that the null hypothesis $active25 - inactive25 = 0$ is true given the estimates found in the analysis. Thus a low p-value means that there is a high probability that there is an effect of mining.

The first regression in each table examines the effect of the explanatory variables on the probability of having received at least one vaccine, without geographical restrictions on the control group. There is a significant positive correlation between living in an active mining area and the probability of having received at least one vaccine. Last born children in active mining areas had an estimated 3.2 percentage points higher probability while the estimate for the second last born is 4.3 percentage points higher. However we cannot tell whether this is because of actual mining or of mining areas being different from non-mining areas. The correlation between living in inactive mining areas and having received at least one vaccine is positive, but insignificant. The estimated effect of mining (which here and henceforth refers

Table 3: Effect of mining on the last born children's vaccination probabilities. Within 25 kilometers with and without geographical restrictions on the control group.

Geographical restriction	None	<200km	None	<200km
	(1)	(2)	(3)	(4)
VARIABLES	Any Vaccine	Any Vaccine	Fully Vaccinated	Full Vaccinated
active25	0.032***	0.030***	0.018*	0.018*
	(0.008)	(0.008)	(0.010)	(0.010)
inactive25	0.021	0.018	0.054***	0.050***
	(0.023)	(0.023)	(0.019)	(0.019)
age	0.001***	0.001***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.094***	0.076***	0.095***	0.088***
	(0.005)	(0.005)	(0.005)	(0.006)
muslim	0.069***	0.054***	0.042***	0.037***
	(0.006)	(0.007)	(0.006)	(0.008)
Observations	243,846	127,008	243,846	127,008
F test: act25-inact25=0	0.224	0.230	2.985	2.374
p value	0.636	0.631	0.0841	0.123

Region and year fixed effects and regional linear time trends are not displayed.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Effect of mining on the second last born children's vaccination probabilities. Within 25 kilometers with and without geographical restrictions on the control group.

Geographical restriction	None	<200km	None	<200km
	(1)	(2)	(3)	(4)
VARIABLES	Any Vaccine	Any Vaccine	Fully Vaccinated	Fully Vaccinated
active25	0.043***	0.039***	0.014	0.011
	(0.011)	(0.011)	(0.017)	(0.018)
inactive25	0.018	0.018	0.081**	0.071**
	(0.025)	(0.025)	(0.032)	(0.033)
age	0.000	-0.000	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.079***	0.054***	0.086***	0.087***
	(0.007)	(0.008)	(0.008)	(0.011)
muslim	0.059***	0.046***	0.046***	0.049***
	(0.008)	(0.011)	(0.009)	(0.013)
Observations	89,012	42,796	89,012	42,796
F test: act25-inact25=0	0.831	0.585	3.467	2.766
p value	0.362	0.444	0.0626	0.0963

Region and year fixed effects and regional linear time trends are not displayed.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

to the difference between active and inactive) is not significantly different from zero at any conventional significance level. The second regression shows the same analysis when the control group is restricted to living within 200 kilometers of a mine. This restriction reduces the correlations between living in mining areas and the probability of having received at least one vaccine only slightly. In other words there is little difference in vaccination probability between children living 25-200 kilometers from a mine and children living further away.

The third regression in each table examines the effect of the explanatory variables on the probability of being *fully vaccinated,* without geographical restrictions on the control group. Last born children in active mining areas had an estimated 1.8 percentage points higher probability of being fully vaccinated. The estimate is significant at the ten percent level. There is no significant difference in the second last born. However, the correlation between living in a mining area that is not yet active and being fully vaccinated is highly positive and highly significant. This difference in vaccination between the mining areas before mining takes place and areas further away means that there indeed is selection into being a mining area that is not picked up by the regional fixed effects. Last born children in inactive mining areas had an estimated 5.4 percentage points higher probability while the estimate for the second last born is 8.1 percentage points. The estimated effect of mining is a decline of 3.6 and 6.7 percentage points for the last and second last born respectively. These estimates are significant at the ten percent level. The fourth regression shows the same analysis when restricting the control groups geographically. The correlations are slightly reduced and for the last born children the negative effect of mining loses significance at the ten percent level (p-value 0,123).

The estimated negative effect of mining on the children's probability of being fully vaccinated is driven by the non-infants. Tables A.7 and A.8 in the appendix show the effect of mining when separating children younger than one year old (infants) from children one to five years old (non-infants). Most infants are actually not supposed to be fully vaccinated. The WHO recommendations are that the (first) measles vaccine is administered either at the age of nine months or at the age of twelve months, depending on the mortality level in the country. The first polio and DPT vaccines are recommended for administration at the age of six to eight weeks, with the subsequent doses at intervals of four to eight weeks. The BCG vaccine is recommended for administration as soon as possible after birth (WHO, 2013).

The vaccination data used so far includes mother's self-reported vaccinations of their children. The DHS data contains information on whether or not the interviewer has confirmed a child's vaccinations in their vaccination card. It is clear from the data that children receive their vaccination cards only upon vaccination. More than 99 percent of the children with vaccination cards had received at least one vaccine. Therefore, for this sub-sample, the effect of mining on the probability of children having received at least one vaccine is not investigated. Including the mothers' self-reported vaccinations would bias the estimates if women in mining areas over- or underestimate their children's vaccinations or if they are more or less likely to lie about them compared to the women living further away. Including self-reported vaccinations would also bias the results if the women who obtain vaccination cards are different in the mining and non-mining areas. Table A.2 in the appendix shows the effect of mining on the probability that children were fully vaccinated for the sub-sample of children whose mothers could show vaccination cards. The second last born children living in inactive areas have a significantly higher probability of being fully vaccinated in this sub-sample. The estimated effect of mining is negative, but is not significantly different from zero at any conventional significance level. The loss of significance is most likely because of the reduced sample size. Nevertheless, the estimated negative effect of mining unfortunately fails the robustness test of confirmed vaccinations.

Two additional vaccination measures are analyzed. Table 5 shows the effect of the explanatory variables on a mother's probability of having at least one child that had received at least one vaccine and on the probability of all her children being fully vaccinated. The control group is restricted to living within 200 kilometers of a mine. Mothers in active mining areas had an estimated 1.9 percentage points higher probability to have at least one child that had received at least one vaccine. This estimate is significant at the one percent level. There is no significant difference between mothers in inactive mining areas compared to those further away. The estimated effect of mining is an increase of 1.6 percentage points, but it is insignificant. Mothers in active mining areas had an estimated 1.8 percentage points higher probability of having all their children fully vaccinated. This estimate is significant at the ten percent level. Mothers in inactive mining areas had an estimated 5.5 percentage points higher probability of having all their children fully vaccinated. The estimated effect of mining is a decline of 3.8 percentage points. This estimate is significant at the ten percent level.

Table 5: Effect of mining on the probability that a mother has at least one child with at least one vaccine and on the probability that all her children are fully vaccinated. Within 25 kilometers.

	(1)	(2)
VARIABLES	At least one vaccine	All Children Fully Vaccinated
active25	0.019***	0.018*
	(0.007)	(0.010)
inactive25	0.003	0.055***
	(0.022)	(0.018)
age	0.000***	0.005***
	(0.000)	(0.000)
christian	0.066***	0.091***
	(0.005)	(0.006)
muslim	0.049***	0.040***
	(0.007)	(0.008)
Observations	127,008	127,008
F test: active25-inactive25=0	0.500	3.179
p value	0.480	0.0746

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.1 Mechanisms

In the previous subsection the analysis showed statistically significant relationships between living in mining areas and vaccination probabilities of children. These relationships may have been found because of the effect of mining on the mother's degree of urbanization, her length of education or her employment status which may all influence vaccinations.[21] In this subsection these three possible mechanisms for the relationships are investigated.

Tables 6 and 7 show the results of this analysis for the last and second last born children respectively. The control group is restricted to living within 200 kilometers of a mine in all regressions. When urbanization is included in the regression, the positive correlations between living in mining areas and vaccination probabilities are reduced. The positive correlations are reduced more in active mining areas which implies that urbanization was stronger when there was active mining. Urbanization in inactive mining areas may be related to mining.

[21] See section 4.1.

Including education reduces the estimated impact of urbanization which means that they are positively correlated. Its inclusion reduces the correlation between living in active mining areas and vaccination probabilities, while it increases the correlation between living in inactive mining areas and vaccination. Controlling for women's employment status has negligible impact on the analysis.

After including the mechanisms, the estimated negative effect of mining on the probability of being fully vaccinated increases both in magnitude and significance. The estimated negative effect of a mine opening is a decline in probability of 4.3 and 7.6 percentage points for the last born and second last born respectively. Both estimates are significant at the five percent level. Given the causal relationship between mining and the mechanisms, this is an overestimation of the negative effect of mining on vaccination probability.

Table 6: Effect of mining on last born children's vaccination probabilities including the mechanisms. Within 25 kilometers.

VARIABLES	(1) Any Vaccine	(2) Any Vaccine	(3) Any Vaccine	(4) Any Vaccine	(5) Fully Vaccinated	(6) Fully Vaccinated	(7) Fully Vaccinated	(8) Fully Vaccinated
active25	0.030***	0.013*	0.012	0.012	0.018*	0.003	0.001	0.000
	(0.008)	(0.008)	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)
inactive25	0.018	0.009	0.011	0.010	0.050***	0.041**	0.045**	0.043**
	(0.023)	(0.022)	(0.022)	(0.022)	(0.019)	(0.018)	(0.018)	(0.018)
age	0.001***	0.001***	0.001***	0.001***	0.005***	0.005***	0.006***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.076***	0.067***	0.056***	0.056***	0.088***	0.080***	0.064***	0.064***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
muslim	0.054***	0.041***	0.041***	0.041***	0.037***	0.025***	0.025***	0.025***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
urban		0.085***	0.070***	0.071***		0.074***	0.051***	0.053***
		(0.004)	(0.004)	(0.004)		(0.005)	(0.005)	(0.005)
schoolyears			0.007***	0.007***			0.011***	0.011***
			(0.000)	(0.000)			(0.000)	(0.000)
working				0.017***				0.030***
				(0.003)				(0.004)
Observations	127,008	127,008	126,929	126,827	127,008	127,008	126,929	126,827
F test: ac25-inac25=0	0.230	0.0439	0.00325	0.00717	2.374	3.484	4.604	4.361
p value	0.631	0.834	0.955	0.933	0.123	0.0620	0.0319	0.0368

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Effect of mining on second last born children's vaccination probabilities including the mechanisms. Within 25 kilometers.

VARIABLES	(1) Any Vaccine	(2) Any Vaccine	(3) Any Vaccine	(4) Any Vaccine	(5) Fully Vaccinated	(6) Fully Vaccinated	(7) Fully Vaccinated	(8) Fully Vaccinated
active25	0.039***	0.026**	0.024**	0.024**	0.011	-0.002	-0.006	-0.006
	(0.011)	(0.011)	(0.011)	(0.011)	(0.018)	(0.017)	(0.017)	(0.017)
inactive25	0.018	0.014	0.017	0.015	0.071**	0.068**	0.072**	0.070**
	(0.025)	(0.025)	(0.025)	(0.025)	(0.033)	(0.033)	(0.032)	(0.032)
age	-0.000	-0.000	0.000	-0.000	0.001***	0.001***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.054***	0.049***	0.042***	0.042***	0.087***	0.082***	0.066***	0.066***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
muslim	0.046***	0.038***	0.037***	0.038***	0.049***	0.041***	0.038***	0.039***
	(0.011)	(0.011)	(0.011)	(0.010)	(0.013)	(0.013)	(0.013)	(0.013)
urban		0.057***	0.044***	0.046***		0.061***	0.035***	0.037***
		(0.005)	(0.005)	(0.005)		(0.008)	(0.008)	(0.008)
schoolyears			0.006***	0.006***			0.013***	0.013***
			(0.000)	(0.000)			(0.001)	(0.001)
working				0.028***				0.033***
				(0.004)				(0.006)
Observations	42,796	42,796	42,768	42,726	42,796	42,796	42,768	42,726
F test: ac25-inac25=0	0.585	0.198	0.0815	0.122	2.766	3.655	4.679	4.480
p value	0.444	0.656	0.775	0.727	0.0963	0.0559	0.0306	0.0343

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.3 in the appendix shows the effect of mining on the probability that a mother has at least one child that has received at least one vaccine and on the probability that all her children are fully vaccinated with the mechanisms included. Mothers in active mining areas are no longer more likely to have at least one child that has received a vaccine. The estimated effect of mining on the probability that a mother has all her children fully vaccinated is a decline of 4.8 percentage points. This estimate is significant at the five percent level.

Tables A.4 and A.5 in the appendix show the effect of mining on the probability that the last born and second last born children have received the individual vaccines. The control group is restricted to living within 200 kilometers of a mine in all regressions. The numbers after the variable names refer to the dose of the vaccine, i.e. "Polio3" is the third and final recommended dose of polio vaccination. The analysis suggests that the results are driven mainly by the final rounds of the polio and DPT vaccination.

5.2 Migration

A major threat to my identification strategy is that of selective migration. Table 8 shows the results when the sample is restricted to women who have never moved. Only looking at those who have never moved eliminates most problems associated with migration. In all regressions the control group is restricted to living within 200 kilometers of a mine.

Table 8: Effect of mining on children's vaccination probabilities for the sub-sample of children whose mothers have never moved. Within 25 kilometers.

	Last Born Children				Second Last Born Children			
Restricted to non-movers	No	No	Yes	Yes	No	No	Yes	Yes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated
active25	0.012	0.000	0.045***	0.035**	0.024**	-0.006	0.079***	0.033
	(0.008)	(0.010)	(0.012)	(0.016)	(0.011)	(0.017)	(0.018)	(0.030)
inactive25	0.010	0.043**	0.016	0.069***	0.015	0.070**	0.016	0.138***
	(0.022)	(0.018)	(0.027)	(0.023)	(0.025)	(0.032)	(0.038)	(0.047)
age	0.001***	0.005***	0.001***	0.004***	-0.000	0.001***	0.000	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
christian	0.056***	0.064***	0.073***	0.078***	0.042***	0.066***	0.056***	0.067***
	(0.005)	(0.006)	(0.009)	(0.010)	(0.008)	(0.011)	(0.015)	(0.018)
muslim	0.041***	0.025***	0.060***	0.055***	0.038***	0.039***	0.071***	0.064***
	(0.007)	(0.008)	(0.011)	(0.012)	(0.010)	(0.013)	(0.019)	(0.021)
urban	0.071***	0.053***	0.094***	0.058***	0.046***	0.037***	0.062***	0.033**
	(0.004)	(0.005)	(0.006)	(0.008)	(0.005)	(0.008)	(0.011)	(0.015)
schoolyears	0.007***	0.011***	0.009***	0.012***	0.006***	0.013***	0.008***	0.015***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)
working	0.017***	0.030***	0.018***	0.033***	0.028***	0.033***	0.023**	0.032***
	(0.003)	(0.004)	(0.005)	(0.006)	(0.004)	(0.006)	(0.009)	(0.011)
Observations	126,827	126,827	39,111	39,111	42,726	42,726	12,494	12,494
F test: act25-inact25=0	0.00717	4.361	1.046	1.553	0.122	4.480	2.257	3.642
p value	0.933	0.0368	0.306	0.213	0.727	0.0343	0.133	0.0564

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Controlling for migration leads to a substantial increase in the correlation between living in mining areas and the probability that children are fully vaccinated. The changes in the estimates imply that there is selective inward migration to both active and inactive mining areas of women who are less likely to fully vaccinate their children and/or selective outward migration of women who are more likely to fully vaccinate their children. Last born children in active mining areas are an estimated 3.5 percentage points more likely to be fully vaccinated compared to those living further away. This estimate is significant at the five percent level. There is no significant difference found in the second last born children. Last born children living in areas where mines are yet to open are an estimated 6.9 percentage points more likely to be fully vaccinated while the second last born are 13.8 percentage points more likely. The estimated effect of mining is a decline of 3.4 percentage points for the last born children, but it is not statistically significant. For the second last born children the estimated effect of mining is a decline of 10.5 percentage points. This estimate is almost significant at the five percent level.

The correlation between living in an active mining area and the probability that children have received at least one vaccine increases substantially when migration is controlled for. Last born children in active mining areas are an estimated 4.5 percentage points more likely to have received at least one vaccine compared to those living further away while second last born are 7.9 percentage points more likely. Both estimates are significant at the one percent level. However the effect of mining fails the F-test at any conventional significance level.

Table 9 shows the effect of mining on the probability of a mother having at least one child that has received at least one vaccine and on the probability that all her children are fully vaccinated, for a sub-sample of women who have ever moved. In this sub-sample mothers in active mining areas have a significantly higher probability of having at least one child that has received at least vaccine. Mothers in active and inactive mining areas have a significantly higher probability of having all their children fully vaccinated. The estimated effect of mining is an increase of 4.2 percentage points in the probability of a mother having at least one child that has received at least one vaccine, and a decline of 3.9 percentage points in the probability of her having all her children fully vaccinated. The estimates are not statistically significant at conventional significance levels with p-values of 0,116 and 0,148.

Table 9: Effect of mining on the probability that a mother has at least one child with at least one vaccine and on the probability that all her children are fully vaccinated. Within 25 kilometers.

VARIABLES	(1) At Least One Vaccine	(2) All Children Fully Vaccinated
active25	0.040***	0.037**
	(0.011)	(0.016)
inactive25	-0.002	0.076***
	(0.025)	(0.023)
age	0.001***	0.005***
	(0.000)	(0.000)
christian	0.062***	0.079***
	(0.008)	(0.010)
muslim	0.055***	0.058***
	(0.011)	(0.012)
urban	0.078***	0.054***
	(0.006)	(0.008)
schoolyears	0.007***	0.013***
	(0.001)	(0.001)
working	0.014***	0.032***
	(0.005)	(0.006)
Observations	39,111	39,111
F test: active25-inactive25=0	2.466	2.096
p value	0.116	0.148

Control group restricted to living within 200 kilometers of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.3 Different Cutoffs

The baseline regressions are performed with the mining area defined as a concentric circle around a mine of radius 25 kilometers. The narrower the definition of the mining area, the larger is the potential difference between the mining and non-mining areas. A narrow definition is presumably more likely to capture CSR. The number of women defined as living in mining areas decreases rapidly as the geographical restrictions become stricter.

Table 10 shows the analysis using different cut-offs for the mining area for a sub-sample of women who have never moved. The cut-off distances are identified by the different numbers after the variables active and inactive. In all regressions the control group is restricted to living within 200 kilometers of a mine.

Table 10: Effect of mining on children's vaccination probabilities using different cut-offs for the mining area. Sub-sample of non-movers.

	Last Born Child		Second Last Born Child	
	(1)	(2)	(3)	(4)
VARIABLES	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated
active5	0.043	0.038	0.034	0.002
	(0.038)	(0.056)	(0.051)	(0.067)
inactive5	0.026	0.110**	0.014	0.375***
	(0.038)	(0.049)	(0.088)	(0.102)
Observations	39,731	39,731	12,687	12,687
p-value act-inact=0	0.748	0.330	0.848	0.00213
active10	0.055***	0.043	0.076**	-0.040
	(0.021)	(0.028)	(0.037)	(0.046)
inactive10	0.014	0.092**	0.035	0.327***
	(0.034)	(0.040)	(0.052)	(0.067)
Observations	39,538	39,538	12,632	12,632
p value act-inact=0	0.305	0.316	0.530	5.24e-06
active15	0.055***	0.022	0.078***	0.018
	(0.016)	(0.024)	(0.024)	(0.035)
inactive15	-0.021	0.039	0.010	0.148**
	(0.042)	(0.034)	(0.046)	(0.066)
Observations	39,474	39,474	12,605	12,605
p value act-inact=0	0.0880	0.672	0.191	0.0795
active20	0.043***	0.033*	0.076***	0.016
	(0.014)	(0.019)	(0.021)	(0.031)
inactive20	-0.011	0.065**	-0.011	0.129**
	(0.032)	(0.026)	(0.044)	(0.053)
Observations	39,360	39,360	12,580	12,580
p value act-inact=0	0.113	0.312	0.0701	0.0660
active25	0.045***	0.035**	0.079***	0.033
	(0.012)	(0.016)	(0.018)	(0.030)
inactive25	0.016	0.069***	0.016	0.138***
	(0.032)	(0.026)	(0.044)	(0.053)
Observations	39,111	39,111	12,494	12,494
p value act-inact=0	0.306	0.213	0.133	0.0564
Active30	0.041***	0.026*	0.075***	0.031
	(0.011)	(0.015)	(0.017)	(0.027)
Inactive30	0.022	0.055***	0.011	0.083**
	(0.024)	(0.021)	(0.031)	(0.039)
Observations	38,905	38,905	12,420	12,420
p value act-inact=0	0.468	0.255	0.0707	0.267
Active50	0.028***	-0.003	0.061***	0.033
	(0.010)	(0.013)	(0.015)	(0.022)
Inactive50	0.015	0.030	-0.016	0.058*
	(0.019)	(0.018)	(0.023)	(0.030)
Observations	37,783	37,783	12,064	12,064
p value act-inact=0	0.533	0.129	0.00366	0.480
Active75	0.035***	0.023*	0.031**	0.026
	(0.011)	(0.012)	(0.015)	(0.019)
Inactive75	0.042**	0.034**	-0.000	0.035
	(0.018)	(0.015)	(0.020)	(0.025)
Observations	36,808	36,808	11,664	11,664
p value act-inact=0	0.734	0.537	0.188	0.760

Control group restricted to living within 200 kilometers of a mine. Region and years fixed effects, regional linear time trends and individual specific controls are not shown. Robust standard errors in parentheses

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

The analysis reveals a statistically significant negative effect of mining on the second last born children's probability of being fully vaccinated up to a cut-off of 25 kilometers. The negative effect diminishes with distance from the mines. The same tendency is found in the last born children, but the effect is not significant at conventional significance levels.

The estimated effect of mining on children's probability of having received at least one vaccine is consistently positive, i.e. in the opposite direction to the estimated effect on the probability that they are fully vaccinated. While the estimated effect is positive, it does not seem to be larger in close proximity to mines. The most significant result is found using a cut-off of 50 kilometers for the mining area, in which case mining has led to an estimated 7.7 percentage points increase in the probability of that the second last born children having received at least one vaccine. The estimate is significant at the one percent level.

Table A.9 in the appendix shows the results of this analysis without restrictions on the sample and only including controls for the mothers' age and religious beliefs.

5.4 Mine Closings

Table 11 shows the results from an analogous analysis on mine closings when there is no control on migration. The second last born children in closed mining areas have a 3.5 percentage point higher probability of being fully vaccinated. This estimate is significant at the five percent level. The estimated effect of a mine closing is an increase of 4.2 percentage points in the probability for the second last born to be fully vaccinated. The effect is significant at the ten percent level. Table A.6 in the appendix shows the results for the sub-sample of non-movers. For this sub-sample there are no significant effects from mine closings. The most significant effect (p-value of 0.138) is a decline of five percentage points in the probability of the second last born children to have received at least one vaccine.

Table 11: Effect of mine closings on children's vaccination probabilities. Within 25 kilometers.

	Last Born Children		Second Last Born Children		All Mothers	
VARIABLES	(1) Any Vaccine	(2) Fully Vaccinated	(3) Any Vaccine	(4) Fully Vaccinated	(5) At Least One Vaccine	(6) All Children Fully Vaccinated
suspended25	0.011	0.013	0.006	0.035**	0.008	0.013
	(0.007)	(0.011)	(0.012)	(0.016)	(0.006)	(0.011)
active25	0.012	-0.002	0.023**	-0.007	0.005	-0.002
	(0.007)	(0.010)	(0.011)	(0.017)	(0.007)	(0.010)
age	0.001***	0.005***	-0.000	0.001***	0.001***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.055***	0.061***	0.040***	0.065***	0.049***	0.064***
	(0.005)	(0.006)	(0.008)	(0.011)	(0.005)	(0.006)
muslim	0.040***	0.024***	0.037***	0.038***	0.038***	0.027***
	(0.007)	(0.008)	(0.010)	(0.013)	(0.007)	(0.007)
urban	0.070***	0.052***	0.045***	0.039***	0.053***	0.055***
	(0.004)	(0.005)	(0.005)	(0.008)	(0.003)	(0.005)
schoolyears	0.007***	0.011***	0.006***	0.013***	0.005***	0.012***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
working	0.016***	0.031***	0.029***	0.033***	0.013***	0.031***
	(0.003)	(0.003)	(0.004)	(0.006)	(0.003)	(0.003)
Observations	131,006	131,006	44,064	44,064	131,006	131,006
F test: suspended25-active25=0	0.00399	1.160	1.218	3.328	0.140	1.231
p value	0.950	0.281	0.270	0.0681	0.709	0.267

Control group restricted to living within 200 kilometers of a mine. Region and years fixed effects, regional linear time trends and individual specific controls are not shown. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

6 Discussions and Concluding Remarks

The African continent is considered geologically underexplored (UNECA, 2011), yet many African countries are economically dependent on mineral resources today (World Economic Forum, 2013) and many market observers believe that metal prices are in an early phase of a super cycle (UNECA, 2011). The mineral wealth of the African continent holds the potential for vast economic and social progress, but whether natural resources are a curse or a blessing is debated. There is empirical evidence both supporting and opposing the existence of a natural resource curse.

Using geo-coded data and a difference-in-difference regression analysis, this thesis provides empirical evidence of negative local area effects from large scale mining in sub-Saharan Africa between 1990 and 2011. Children in mining areas where mines had yet to open had a significantly higher probability to be fully vaccinated compared to children living further away. After mineral extraction had begun the relative vaccination advantage decreased. In other words large scale mining had a negative local area effect on the quality of the routine vaccination program. The negative effect was larger close to mining sites and is statistically significant up to the point where the mining footprint area is defined as 25 kilometers. This negative effect was partially counteracted by increased urbanization and educational levels among women in the mining areas.

This result is robust to migration, restricting the control group geographically and using different geographical definitions of the mining areas. Using the alternative vaccination measure of the mother's probability of having all her children fully vaccinated yields the same qualitative results. There is some weaker evidence found of an improvement in the routine vaccination program once the mines closed, but this may be because of selective migration. The results are not robust to only considering confirmed vaccinations. This is however most likely due to sample size issues.

The reduction in the quality of the routine vaccination program can be interpreted as a negative effect on local institutional quality if vaccinations are accepted as a good proxy. As such, this thesis represents a contribution to the existing literature on the connection between natural resources and institutions. Which dimensions of institutions have been negatively affected by mining is a question that remains unanswered by this study, but related studies, both theoretical and empirical, suggests that increased corruption, reduced quality of political candidates, government inefficiency, and threatened security may follow mineral extraction or windfall income.

Interestingly, the analysis reveals that the probability that children have received at least one vaccine increased as a result of mining. This seemingly conflicting result may be explained by what is known as corporate social responsibility (CSR). Mining companies themselves may provide vaccinations locally and it is not controlled for in my analysis. CSR may explain the results if, instead of just adding to immunization locally, the additional provider in an area causes confusion on either the user or the provider side. It is conceivable that the local government relies on the mining companies' health provision for immunization of children in the areas where it is in fact in place. If the mining companies' health provision is, for example, less focused on immunization, less well organized or efficient, or if it lacks funding, CSR could explain both the reduction in the full vaccination probability and the increase in the probability for children to have received at least one vaccine; two providers may encompass more children, but the effectiveness and "depth" of immunization is lower. There is however an inconsistency in this story. The probability of children having received at least one vaccine did not increase nearer mining sites, which suggests that something other than CSR is driving the results.

There are alternative explanations for the results obtained in the analysis. First, migration may drive the results also for the non-movers through community effects or a strained local health system. Second, the estimated negative effect of mining is largely driven by a disappearing advantage in vaccination probability when mines opened. If the increased probability of children being fully vaccinated in mining areas before mines opened was caused by pre-production activity from mining companies, the claim that mining had a negative effect is not valid. Instead the interpretation would be that mining caused a temporary local advantage in vaccinations. The analysis has revealed selective migration to "inactive" mining areas, which suggests that these areas are in fact not so inactive after all. Third, there will always be a worry when doing a difference-in-difference analysis that unobserved factors, which have an impact on the outcome variables, vary differently over time in the treatment and control group. Infrastructure has been identified as a main decision variable for mining companies' investments, it may impact vaccination, and it is not controlled for in my analysis. Regional specific time trends included in my analysis reduce the concern for bias by such unobserved factors.

7 References

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *The American Economic Review, 91*(5), 1369-1401. Retrieved from http://www.jstor.org/stable/2677930

Alexeev, M. V., & Conrad, R. F. (2009). The Elusive Curse of Oil. *The Review of Economics and Statistics, 91*(3), 586-598. doi:10.1162/rest.91.3.586

Angrist, J. D., & Kugler, A. D. (2008). Rural Windfall or a New Resource Curse? Coca, Income, and Civil Conflict in Colombia. *Review of Economics and Statistics, 90*(2), 191-215. doi:10.1162/rest.90.2.191

Aragón, F. M., & Rud, J. P. (2013). Natural Resources and Local Communities: Evidence from a Peruvian Gold Mine. *American Economic Journal: Economic Policy, 5*(2), 1-25. doi:10.1257/pol.5.2.1

Arevshatian, L., Clements, C., Lwanga, S., Misore, A., Ndumbe, P., & Seward, J. (2007). An evaluation of infant immunization in Africa: is a transformation in progress? *Bulletin of the World Health Organization, 58*(6), 449-457. Retrieved from http://www.who.int/bulletin/volumes/85/6/06-031526.pdf

Beauvais, J. C., & Bossert, T. J. (2002). Decentralization of health systems in Ghana, Zambia, Uganda and the Phillippines: a comparative analysis of decision space. *Health Policy and Planning, 17*(1), 14-31. doi:10.1093/heapol/17.1.14

Berger, D. (2009). *Taxes, Institutions and Local Governance: Evidence from a Natural Experiment in Colonial Nigeria*., Manuscript, Department of Politics, New York University. Retrieved from http://www.yale.edu/leitner/resources/PMF-papers/NigeriaPaper.pdf

Brollo, F., Nannicini, T., Perotti, R., & Tabellini, G. (2010). The political resource curse (NBER Working Paper No. 15705). Retrieved from http://www.nber.org/papers/w15705.pdf?

Brown, D. W., Burton, A. H., Gacic-Dobo, M., & Karimov, R. I. (2012). Data Update: A Summary of Global Immunization Coverage Through 2011. *The Open Infectious Diseases Journal, 6,* 71-75. doi:10.2174/1874279301206010071

Carroll, A. B. (1999). Corporate Social Responsibility Evolution of a Definitional Construct. *Business & Society, 38*(3), 268-295. doi:10.1177/000765039903800303

Caselli, F., & Michaels, G. (2013). Do Oil Windfalls Improve Living Standards? Evidence from Brazil. *American Economic Journal: Applied Economics, 5*(1), 208-238. doi:10.1257/app.5.1.208

Collier, P., & Hoeffler, A. (2004). Greed and Grievance in Civil War. *Oxford Economic Papers, 56*(4), 563-595. doi:10.1093/oep/gpf064

De Luca, G., Matstadt, J.-F., Sekeris, P. G., & Ulimwengu, J. (2012). Mineral Resources and Conflicts in DRC: A Case of Ecological Fallacy (Working Paper No. 1207). Retrieved from http://www.unamur.be/eco/economie/recherche/wpseries/wp/1207.pdf

DeRoeck, D., & Levin, A. (1998). *Review of Financing of Immunization Programs in Developing and Transitional Countries* (Special Initiatives Report No. 12). Bethesda, MD: Partnerships for Health Reform Project, Abt Associates Inc. Retrieved from www.healthsystems2020.org/files/1292_file_Sir12.pdf

Doppelhofer, G., Miller, R. I., & Sala-I-Martin, X. (2004). Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach. *The American Economic Review, 94*(4), 813-835. Retrieved from http://www.jstor.org/stable/3592794

Dube, O., & Vargas, J. F. (2013). Commodity Price Shocks and Civil Conflict: Evidence from Colombia. *The Review of Economic Studies*. doi:10.1093/restud/rdt009

Frankel, J. A. (2010). The Natural Resource Curse: A Survey (NBER Working Paper No. 15836). Retrieved from http://www.nber.org/papers/w15836.pdf

Gaulé, P., & Kaddar, M. (2003). *Economics of immunization:a guide to the literature and other resources* Geneva, Switzerland: World Health Organization, Department of Immunization, Vaccines and Biologicals. Retrieved from http://whqlibdoc.who.int/hq/2004/WHO_V&B_04.02.pdf

Gilson, L., & Mills, A. (1995). Health sector reforms in sub-Saharan Africa: lessons of the last 10 years. *Health Policy, 32*(1-3), 215-243. doi: 10.1016/0168-8510(95)00737-D

GIZ. (2012). *Shaping Corporate Social Responsibility in sub-Saharan Africa Guidance Notes from a Mapping Survey* GIZ. Retrieved from: http://ccps-africa.org.winhost.wa.co.za/dnn7/Portals/0/Downloads/121203_bmz_csr_rz_web_LoRes.pdf. Last accessed October 4. 2013.

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2004). Do Institutions Cause Growth? *Journal of Economic Growth, 9*(3), 271-303. doi:10.1023/B:JOEG.0000038933.16398.ed

GTZ. (2009). *Built-in or bolted-on Corporate Social Responsibility in sub-Saharan Africa A survey on promoting and hindering factors* GTZ. Retrieved from: http://commdev.org/files/2489_file_CSR_GTZ_Publication_Report_low_res_12_06_09k.pdf. Last accessed October 4. 2013.

Gylfason, T., Herbertsson, T. T., & Zoega, G. (1999). A Mixed Blessing - Natural Resources and Economic Growth. *Dynamic Macroeconomics, 3*(2), 204-225. doi:10.1017/S1365100599011049

Gylfason, T., & Zoega, G. (2006). Natural Resources and Economic Growth: The Role of Investment. *The World Economy, 29*(8), 1091-1115. doi:10.1111/j.1467-9701.2006.00807.x

Hall, R. E., & Jones, C. I. (1999). Why do Some Countries Produce So Much More Output Per Worker than Others? *The Quarterly Journal of Economics, 114*(1), 83-116. doi:10.1162/003355399555954

Heap, A. (2005). *China - The Engine of a Commodities Super Cycle* New York: Citigroup Smith Barney.

Humphreys, M. (2005). Natural Resources, Conflict, and Conflict Resolution: Uncovering the Mechanisms. *Journal of Conflict Resolution, 49*(4), 508-537. doi:10.1177/0022002705277545

IntierraRMG. (2013). http://www.rmg.se/Products/RawMineralsData.aspx

Isham, J., Woolcock, M., Pritchett, L., & Busby, G. (2005). The Varieties of Resource Experience: Natural Resource Export Structures and the Political Economy of Economic Growth. *The World Bank Economic Review, 19*(2), 141-174. doi:10.1093/wber/lhi010

Ismail, K. (2010). The Structural Manifestation of the `Dutch Disease': The Case of Oil Exporting Countries (IMF Working Paper No.10/103). Retrieved from http://ssrn.com/abstract=1594548

Junaid, A., Bird, R., & Litvack, J. (1998). Rethinking Decentralization in Developing Countries. *Sector Series Studies*. Retrieved from http://www1.worldbank.org/publicsector/decentralization/Rethinking%20Decentralization.pdf. Last accessed October 4. 2013.

Kaddar, M., Lydon, P., & Levine, R. (2004). Financial Challenges of immunization: a look at GAVI. Bulletin of the World Health Organization, 82(9), 697-702. Retrieved from http://apps.who.int/iris/bitstream/10665/72703/1/bulletin_2004_82%289%29_697-702.pdf. Last accessed October 4. 2013.

Knack, S., & Keefer, P. (1995). Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures. *Economics & Politics, 7*(3), 207-227. doi:10.1111/j.1468-0343.1995.tb00111.x

Kotsadam, A., & Tolonen, A. (2013). Mineral Mining and Female Employment (OxCarre Research Paper 114). Retrieved from http://www.oxcarre.ox.ac.uk/files/OxCarreRP2013114.pdf

Kravdal, Ø. (2002). Education and fertility in sub-Saharan africa: Individual and community effects. *Demography, 39*(2), 233-250. doi:10.1353/dem.2002.0017

Lambo, E., & Sambo, L. G. (2003). Health Sector Reform in Sub-Saharan Africa: A Synthesis of Country Experiences. *East African Medical Journal, 80*(6), 1-20. doi:10.4314/eamj.v80i6.9308

Leite, C., & Weidmann, J. (1999). Does Mother Nature Corrupt? Natural Resources, Corruption, and Economic Growth (IMF Working Paper No. 99/85). *IMF Working Papers*. Retrieved from http://www.imf.org/external/pubs/ft/wp/1999/wp9985.pdf. Last accessed October 4. 2013.

Mehlum, H., Moene, K., & Torvik, R. (2006). Cursed by Resources or Institutions? *The World Economy, 29*(8), 1117-1131. doi:10.1111/j.1467-9701.2006.00808.x

Mills, A., Smith, D. L., Vaughan, J. P., & Tabibzadeh, I. (1990). *Health system decentralization : concepts, issues and country experience* Geneva: World Health Organization. Retrieved from http://whqlibdoc.who.int/publications/9241561378.pdf. Last accessed October 4. 2013.

Ndegwa, S. N. (2002). Decentralization in Africa: A Stocktaking Survey (Africa Region Working Paper Series No. 40). Retrieved from http://www.worldbank.org/afr/wps/wp40.pdf. Last accessed October 4. 2013.

North, D. C. (1994). Economic Performance Through Time. *The American Economic Review, 84*(3), 359-368. Retrieved from http://www.jstor.org/stable/2118057

Olowu, D. (2001). *Decentralization Policies and Practices under Structural Adjustment and Democratization in Africa* Geneva: United Nations Research Institute for Social Development. Retrieved from: http://www.unrisd.org/80257BA40032154E%2F(httpAuxPages)%2F543FFCD9808693FD80256B5E003B4E1E%2F$file%2Folowu.pdf. Last accessed October 4. 2013.

Parnwell, M. (1993). Why people move. In *Population Movements and the Third World* (pp. 71-99). New York: Routledge.

Politi, C., & Sagna, O. (2011). *Analysis of Immunization Financing Indicators from the WHO-UNICEF Joint Reporting Form (JRF), 2008-2010*. Retrieved from: http://www.who.int/immunization_financing/analyses/JRF_Analysis_2008_2010.pdf. Last accessed October 4. 2013.

Robinson, J. A., Torvik, R., & Verdier, T. (2006). Political foundations of the resource curse. *Journal of Development Economics*, *79*(2), 447-468. doi:10.1016/j.jdeveco.2006.01.008

Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development. *Journal of Economic Growth, 9*(2), 131-165. Retrieved from http://www.jstor.org/stable/40212696

Ross, M. L. (2001). Does Oil Hinder Democracy? *World Politics, 53*(03), 325-361. doi:10.1353/wp.2001.0011

Ross, M. L. (2008). Oil, Islam, and Women. *American Political Science Review, 102*(1), 107-123. doi:10.1017/S0003055408080040

Sachs, J. D., & Warner, A. M. (1995). Natural resource abundance and economic growth (NBER Working Paper No. 5398). Retrieved from The National Bureau of Economic Research website: http://www.nber.org/papers/w5398.pdf?

Sala-I-Martin, X. (1997). I Just Ran Two Million Regressions. *The American Economic Review, 87*(2), 178-183. Retrieved from http://www.jstor.org/stable/2950909

The World Bank. (1992). Strategy for African Mining. Mining Unit, Industry and Energy Division. *World Bank Technical Paper Number 181*. Washington, D.C. Retrieved from http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/10/21/000178830_98101904142281/Rendered/PDF/multi_page.pdf. Last accessed October 11. 2013.

The World Bank. (2013a). *Africa's Pulse* (7). Washington, D.C: The World Bank.

The World Bank. (2013b). Worldwide Governance Indicators. Retrieved from http://info.worldbank.org/governance/wgi/index.aspx#home. Last accessed October 11. 2013.

UN General Assembly. (2002). *27. Special session: resolution adopted by the General Assembly*, 11 October 2002, A/RES/S-27/2. Available at: http://www.unicef.org/specialsession/docs_new/documents/A-RES-S27-2E.pdf

U.S.Geological Survey. (2012). *2010 Minerals Yearbook AFRICA [ADVANCE RELEASE]* U.S Geological Survey. Retrieved from: http://minerals.usgs.gov/minerals/pubs/country/2010/myb3-sum-2010-africa.pdf. Last accessed August 5. 2013.

UNCTAD. (2013). *Foreign direct investment flows statistics*. Retrieved from: http://unctadstat.unctad.org/TableViewer/tableView.aspx?ReportId=88. Last accessed October 8. 2013.

UNECA. (2011). *Minerals and Africa's Development* Addis Ababa, Ethiopia: Publications and Conference Management Section (PCMS), Economic Commission for Africa. Retrieved from: http://www.uneca.org/sites/default/files/publications/mineral_africa_development_report_eng.pdf. Last accessed October 4. 2013.

United Nations Group of Experts. (2009). *Final report of the Group of Experts on the Democratic Republic of the Congo* (603). United Nations. Retrieved from: http://www.un.org/ga/search/view_doc.asp?symbol=S/2009/603. Last accessed October 4. 2013.

van der Ploeg, F. (2011). Natural Resources: Curse or Blessing? *Journal of Economic Literature*, *49*(2), 366-420. doi:10.1257/jel.49.2.366

WHO. (2013). *Table 2: Summary of WHO Position Papers - Recommended Routine Immunizations for Children*. Retrieved from http://www.who.int/immunization/policy/Immunization_routine_table2.pdf. Last accessed October 4. 2013.

World Economic Forum. (2013). *The Africa Competitiveness Report 2013*. Retrieved from: http://www3.weforum.org/docs/WEF_Africa_Competitiveness_Report_2013.pdf. Last accessed October 4. 2013.

Appendix

Table A.1. List of countries and the number of survey participants.

Country	Number of Women
Benin	11,710
Burkina Faso	41,361
Burundi	9,389
Cameroon	29,939
Central African Republic	5,884
Congo DR	9,773
Cote d’Ivoire	11,139
Ethiopia	45,088
Ghana	19,917
Guinea	14,592
Kenya	16,594
Lesotho	14,262
Liberia	6,902
Madagascar	24,143
Malawi	47,398
Mali	37,059
Mozambique	6,405
Namibia	16,391
Niger	14,080
Nigeria	49,748
Rwanda	24,956
Senegal	44,569
Sierra Leone	7,320
Swaziland	4,908
Tanzania	29,775
Togo	11,920
Uganda	39,100
Zambia	7,146
Zimbabwe	23,673
Total	625,141

Table A.2: Effect of mining on the probability for children to be fully vaccinated for a sub-sample of children whose mothers could show vaccination cards. Within 25 kilometers.

	Last Born	Second Last Born
	(1)	(2)
VARIABLES	Fully Vaccinated	Fully Vaccinated
active25	0.015	0.024
	(0.011)	(0.020)
inactive25	0.028	0.077**
	(0.021)	(0.036)
age	0.007***	0.000
	(0.000)	(0.000)
christian	0.066***	0.052***
	(0.008)	(0.014)
muslim	0.017*	0.023
	(0.010)	(0.018)
Observations	77,199	19,998
F test: active25-inactive25=0	0.314	1.700
p value	0.575	0.192

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.3: Effect of mining on the probability that a mother has at least one child with at least one vaccine and on the probability that all her children are fully vaccinated including mechanisms. Within 25 kilometers.

	(1)	(2)
VARIABLES	At Least One Vaccine	All Children Fully Vaccinated
active25	0.005	0.000
	(0.007)	(0.010)
inactive25	-0.003	0.048***
	(0.022)	(0.018)
age	0.001***	0.005***
	(0.000)	(0.000)
christian	0.051***	0.065***
	(0.005)	(0.006)
muslim	0.038***	0.028***
	(0.007)	(0.007)
urban	0.055***	0.055***
	(0.004)	(0.005)
schoolyears	0.006***	0.012***
	(0.000)	(0.000)
working	0.014***	0.031***
	(0.003)	(0.003)
Observations	126,827	126,827
F test: active25-inactive25=0	0.159	5.752
p value	0.690	0.0165

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.4: Effect of mining on the individual vaccine probabilities for the last born children. Within 25 kilometers.

VARIABLES	(1) Measles	(2) BCG	(3) Polio1	(4) Polio2	(5) Polio3	(6) DPT1	(7) DPT2	(8) DPT3
active25	0.008	0.012	0.010	0.010	0.008	0.011	0.014	0.017*
	(0.009)	(0.009)	(0.008)	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)
inactive25	0.014	0.012	0.017	0.038*	0.050**	0.022	0.031	0.052**
	(0.018)	(0.022)	(0.020)	(0.020)	(0.021)	(0.021)	(0.020)	(0.021)
age	0.007***	0.001***	0.002***	0.004***	0.004***	0.002***	0.003***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.065***	0.067***	0.060***	0.072***	0.075***	0.067***	0.078***	0.084***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)
muslim	0.035***	0.047***	0.038***	0.044***	0.034***	0.044***	0.043***	0.038***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
urban	0.075***	0.093***	0.067***	0.079***	0.060***	0.080***	0.091***	0.093***
	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
schoolyears	0.012***	0.009***	0.008***	0.011***	0.012***	0.010***	0.012***	0.014***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
working	0.039***	0.014***	0.025***	0.025***	0.024***	0.025***	0.025***	0.020***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
Observations	127,817	128,852	129,003	128,853	128,852	128,608	128,446	128,445
F test: active25-inactive25=0	0.0818	0.000257	0.0999	1.645	3.363	0.225	0.637	2.433
p value	0.775	0.987	0.752	0.200	0.0667	0.635	0.425	0.119

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.5. Effect of mining on the individual vaccine probabilities for the second last born children. Within 25 kilometers.

VARIABLES	(1) Measles	(2) BCG	(3) Polio1	(4) Polio2	(5) Polio3	(6) DPT1	(7) DPT2	(8) DPT3
active25	0.023	0.034***	0.017	0.010	0.000	0.025*	0.016	0.023
	(0.015)	(0.013)	(0.012)	(0.014)	(0.016)	(0.015)	(0.016)	(0.017)
inactive25	0.040	0.014	0.026	0.048	0.071**	0.023	0.043	0.056*
	(0.030)	(0.027)	(0.026)	(0.029)	(0.032)	(0.031)	(0.032)	(0.033)
age	0.001*	0.000	0.000	0.001**	0.001***	0.000	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.060***	0.055***	0.041***	0.060***	0.064***	0.063***	0.071***	0.081***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.011)	(0.009)	(0.010)	(0.011)
muslim	0.043***	0.048***	0.039***	0.055***	0.044***	0.054***	0.057***	0.053***
	(0.012)	(0.012)	(0.011)	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)
urban	0.052***	0.067***	0.049***	0.049***	0.029***	0.062***	0.068***	0.074***
	(0.007)	(0.006)	(0.005)	(0.007)	(0.008)	(0.006)	(0.007)	(0.008)
schoolyears	0.013***	0.009***	0.007***	0.010***	0.011***	0.009***	0.011***	0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
working	0.023***	0.032***	0.031***	0.031***	0.035***	0.027***	0.022***	0.021***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)
Observations	43,256	43,904	43,993	43,900	43,900	43,747	43,661	43,661
F test: active25-inactive25=0	0.271	0.461	0.0979	1.390	3.884	0.00502	0.539	0.805
p value	0.603	0.497	0.754	0.238	0.0488	0.943	0.463	0.370

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional

linear time trends are not displayed. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.6: Effect of mine closings on outcome variables for a sub-sample of non-movers. Within 25 kilometers.

	Last Born Children		Second Last Born Children		Mothers	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated	At Least One Vaccine	All Children Fully Vaccinated
suspended25	0.028*	0.031	0.027	0.036	0.022	0.037
	(0.017)	(0.024)	(0.029)	(0.037)	(0.015)	(0.023)
active25	0.046***	0.033**	0.077***	0.028	0.041***	0.034**
	(0.012)	(0.016)	(0.018)	(0.030)	(0.011)	(0.016)
age	0.001***	0.004***	0.000	0.003***	0.001***	0.005***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
christian	0.071***	0.074***	0.053***	0.064***	0.060***	0.075***
	(0.009)	(0.010)	(0.015)	(0.018)	(0.008)	(0.010)
muslim	0.060***	0.053***	0.067***	0.060***	0.054***	0.055***
	(0.011)	(0.012)	(0.018)	(0.021)	(0.011)	(0.011)
urban	0.093***	0.059***	0.063***	0.036**	0.077***	0.055***
	(0.006)	(0.008)	(0.011)	(0.015)	(0.006)	(0.008)
schoolyears	0.009***	0.012***	0.008***	0.015***	0.007***	0.013***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
working	0.019***	0.034***	0.025***	0.033***	0.015***	0.033***
	(0.005)	(0.006)	(0.009)	(0.011)	(0.005)	(0.006)
Observations	39,796	39,796	12,714	12,714	39,796	39,796
F test: suspended25-active25=0	0.814	0.00441	2.265	0.0345	1.037	0.0133
p value	0.367	0.947	0.132	0.853	0.309	0.908

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.7. Effect of mining of vaccinations for last born children. By Age.

	All	Infants	Non-infants	All	Infants	Non-infants
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Any Vaccine	Any Vaccine	Any Vaccine	Fully Vaccinated	Fully Vaccinated	Fully Vaccinated
active25	0.030***	0.048***	0.021***	0.018*	0.012	0.008
	(0.008)	(0.014)	(0.008)	(0.010)	(0.010)	(0.012)
inactive25	0.018	0.027	0.013	0.050***	0.002	0.059**
	(0.023)	(0.035)	(0.022)	(0.019)	(0.014)	(0.025)
age	0.001***	-0.001***	-0.000*	0.005***	0.000**	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
christian	0.076***	0.107***	0.059***	0.088***	0.021***	0.108***
	(0.005)	(0.010)	(0.006)	(0.006)	(0.006)	(0.008)
muslim	0.054***	0.081***	0.039***	0.037***	0.009	0.045***
	(0.007)	(0.012)	(0.007)	(0.008)	(0.006)	(0.010)
Observations	127,008	40,864	86,144	127,008	40,864	86,144
F test: active25-inactive25=0	0.230	0.354	0.118	2.374	0.322	3.545
p value	0.631	0.552	0.731	0.123	0.571	0.0598

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed Infants are under age of one. Non-infants are one year and up. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.8. Effect of mining of vaccinations for second last born children. By Age.

	All	Infants	Non-infants	All	Infants	Non-infants
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Any Vaccine	Any Vaccine	Any Vaccine	Fully Vaccinated	Fully Vaccinated	Fully Vaccinated
active25	0.039***	0.259***	0.037***	0.011	0.097	0.010
	(0.011)	(0.078)	(0.011)	(0.018)	(0.128)	(0.018)
inactive25	0.018	-0.141	0.016	0.071**	-0.155	0.074**
	(0.025)	(0.296)	(0.025)	(0.033)	(0.109)	(0.033)
age	-0.000	-0.003	-0.000	0.001***	0.001	0.001***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.002)	(0.000)
christian	0.054***	0.060	0.054***	0.087***	0.024	0.090***
	(0.008)	(0.075)	(0.008)	(0.011)	(0.069)	(0.011)
muslim	0.046***	0.031	0.046***	0.049***	-0.055	0.054***
	(0.011)	(0.095)	(0.011)	(0.013)	(0.069)	(0.013)
Observations	42,796	647	42,149	42,796	647	42,149
F test: active25-inactive25=0	0.585	1.692	0.553	2.766	2.104	3.071
p value	0.444	0.194	0.457	0.0963	0.147	0.0797

The control group is restricted to living within 200 km of a mine. Region and year fixed effects and regional linear time trends are not displayed Infants are under age of one. Non-infants are one year and up. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.9: Effect of mining on children's vaccination probabilities using different cut-offs for the mining area. No restrictions.

	Last Born Child		Second Last Born Child	
	(1)	(2)	(3)	(4)
VARIABLES	Any Vaccine	Fully Vaccinated	Any Vaccine	Fully Vaccinated
active5	0.042	0.030	0.056	-0.010
	(0.027)	(0.034)	(0.039)	(0.046)
inactive5	0.097***	0.148***	-0.000	0.138
	(0.030)	(0.045)	(0.084)	(0.094)
Observations	247,614	247,614	90,225	90,225
p-value act-inact=0	0.170	0.0367	0.543	0.156
active10	0.055***	0.042**	0.042*	-0.012
	(0.015)	(0.018)	(0.023)	(0.031)
inactive10	0.077***	0.123***	0.015	0.198***
	(0.027)	(0.039)	(0.046)	(0.058)
Observations	246,452	246,452	89,865	89,865
p value act-inact=0	0.463	0.0558	0.595	0.00142
active15	0.046***	0.038***	0.050***	0.037*
	(0.011)	(0.013)	(0.015)	(0.022)
inactive15	0.014	0.036	-0.016	0.062
	(0.031)	(0.034)	(0.034)	(0.049)
Observations	245,835	245,835	89,652	89,652
p value act-inact=0	0.324	0.964	0.0771	0.637
active20	0.035***	0.027**	0.040***	0.020
	(0.009)	(0.011)	(0.013)	(0.019)
inactive20	0.004	0.042*	-0.003	0.066*
	(0.026)	(0.022)	(0.030)	(0.037)
Observations	245,186	245,186	89,449	89,449
p value act-inact=0	0.268	0.531	0.182	0.263
active25	0.032***	0.018*	0.043***	0.014
	(0.008)	(0.010)	(0.011)	(0.017)
inactive25	0.021	0.054***	0.018	0.081**
	(0.023)	(0.019)	(0.025)	(0.032)
Observations	243,846	243,846	89,012	89,012
p value act-inact=0	0.636	0.0841	0.362	0.0626
Active30	0.035***	0.021**	0.049***	0.031**
	(0.007)	(0.009)	(0.010)	(0.016)
Inactive30	0.016	0.046***	0.001	0.052*
	(0.020)	(0.017)	(0.024)	(0.027)
Observations	242,701	242,701	88,632	88,632
p value act-inact=0	0.357	0.180	0.0615	0.490
Active50	0.022***	0.011	0.033***	0.030**
	(0.007)	(0.008)	(0.009)	(0.014)
Inactive50	0.012	0.033**	-0.021	0.033
	(0.015)	(0.014)	(0.018)	(0.021)
Observations	236,423	236,423	86,664	86,664
p value act-inact=0	0.543	0.173	0.00605	0.876
Active75	0.024***	0.022***	0.019**	0.031**
	(0.007)	(0.008)	(0.010)	(0.012)
	0.026*	0.034***	-0.000	0.038**
Inactive75	(0.013)	(0.012)	(0.015)	(0.017)
Observations	232,090	232,090	84,799	84,799
p value act-inact=0	0.937	0.371	0.244	0.725

Region and years fixed effects, regional linear time trends and individual specific controls are not shown. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1