University of the Witwatersrand

Department of International Relations

Estimating the impact of large-scale mining on local communities in sub-Saharan Africa

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Abstract

The proliferation of large-scale mining in sub-Saharan Africa and its impact on local communities living conditions has been a matter of considerable debate amongst stakeholders. Thus far, there has been little consensus as to whether a local resources curse exists, with both quantitative and qualitative research yielding contradictory results.

This dissertation aims to provide a reliable and replicable methodology to measure the social impact of large-scale mining on local communities. It does so by constructing three living condition indices measuring access to infrastructure and levels of lived poverty using Round 6 Afrobarometer surveys. Making use of the recently geocoded survey data, it links 4 796 individuals to 148 large-scale mines in 19 sub-Saharan African countries within a 100km radius of a PSU [1]. Using a linear mixed model with a random intercept and common slope, this dissertation finds that when country and urbanisation effects are controlled for, the proximity of a large-scale mine to a local community has a negligible impact on living condition outcomes.

The case studies reveal that while large-scale mining has contributed to development infrastructure provision and improved living conditions, the disruption to social fabrics and land alienation often nullify these benefits – particularly when government investments do not extend beyond mining.

In short, this paper finds no substantive evidence for a local resource "curse" or "blessing".

1. Replication data and code available on request

Statement of authorship

I Lauren Kendra Veckranges (Student number: 315567) am a student registered for the degree of MA in International Relations in the academic year 2019.

I hereby declare the following:

- I completed this dissertation on my own and that information which has been directly or indirectly taken from other sources has been noted as such. Neither this nor a similar work has been presented to an examination committee.
- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Johannesburg, March 4, 2020 ....

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Abbreviations

DII Development Infrastructure Index

EARP Electricity Access Roll-Out Program

EJOT Environmental Justice Organizations, Liabilities and Trade

GDPPC gross domestic product per capita

GDP gross domestic product

HDI Human Development Index

HII Household Infrastructure Index

ICIJ International Consortium of Investigative Journalists

IFC International Finance Corporation

ICMM International Council on Mining and Metals

LME linear mixed-effects

LPI Lived Poverty Index

MCI mining contribution index

MPI Multidimensional Poverty Index

NGO non-governmental organization

PSU primary sampling unit

QMM QIT Minerals Madagascar

UNDP United Nations Development Programme

WBG The World Bank Group

1 Introduction

1.1 Introduction

The ongoing development of the mineral extraction industry in sub-Saharan Africa in recent years has been met with both optimism and wariness. While developing countries with extractive industries have on average higher gross domestic product per capita (GDPPC) and Human Development Index (HDI) scores, conflicts between mining firms and local communities have brought the question of the local impact of large-scale mining under scrutiny (Kirsch 2014; McMahon and Moreira 2014; Hatcher 2010).

International organisations such as The World Bank Group (WBG) maintain that exploiting Africa's vast mineral wealth is central to developing these economies and lifting millions out of poverty. The WBG's commitment to mineral extraction as a mechanism for development is reflected in its continued investment in large-scale mining projects throughout the developing world (International Finance Corporation 2014). Similarly, many African governments remain committed to exploiting its mineral wealth as a mechanism for socioeconomic development. The African Mining Vision notes that through the "transparent, equitable and optimal exploitation of mineral resources" mining can be "socially responsible and appreciated by surrounding communities" (African Union 2009, v).

However, many have raised concerns that economic growth spurred on by the mining sector may come at the expense of local populations. The Bretton Woods Project and the International Consortium of Investigative Journalists (ICIJ) have highlighted the negative impacts large-scale mining has on local communities, even in the presence of international governing bodies such as the WBG. Violent conflicts between WBG-backed mining firms and local populations have occurred in Peru, where opposition to a new gold mine led to five deaths and in South Africa, where 34 miners were killed and a further 78 injured by police forces following wage disputes (Bretton Woods Project 2012; Herskovitz 2012).

Both international organisations and national governments make substantial investments into developing Africa's extractive industry in the hopes of boosting the economy and in turn improving the living conditions of the African population (International Finance Corporation 2014; African Union 2009). However, research investigating the impact of these interventions have been mixed. Furthermore, little is known about the impact of large-scale mining in local communities, particularly in under-serviced rural areas.

Given the level of investment and the potential for benefits and harm to local communities, it is imperative to establish an accurate assessment of the impact of large-scale mining on living conditions. This study seeks to contribute to this area of study by measuring the impact of large-scale mining on local communities using spatial analysis. If the impact on local communities is not in line with expectations, human and fiscal resources may be better off diverted into alternative programmes that yields more equitable and satisfactory results, such as in the infrastructure, energy, and technology sectors (Lalor et al. 2017). In short, given the potential risks and opportunities, is the current level of investment in the extractive industry justified?

1.2 Statement of the Problem

Although governments and international organisations continue to pursue the extractive industry as a mechanism for improving living conditions, research regarding the effects of large-scale mining on local communities that surround these mines are limited, and results are mixed. Despite this ambiguity, 17 of the top 25 countries in 2018 the mining contribution index (MCI), developed by the International Council on Mining and Metals (ICMM) are African countries (ICMM 2018).

The presumption that that large-scale mining has positive benefits for local communities is based on research indicating socioeconomic benefits at a national level (Badeeb, Lean, and Clark 2017; McMahon and Moreira 2014). African countries like Botswana and South Africa have enjoyed strong economies and relative political stability despite mining respectively contributing to 18% and 8.1% of GDP in 2018 (Statistics Botswana 2018; Statistics South Africa 2019).

However, economic gains at a national level do not necessarily translate to socioeconomic benefits locally. National governments may choose to divert funds away from local economies to address concerns in other regions, and the presence of a large-scale mine does not guarantee the development of backward linkages or adequate job creation.

In light of this dissonance, this study will quantitatively assess the extent to which large-scale mines improve or worsen the living conditions of local populations. The total population is limited to within a 100km radius of an active mine in African countries where data is available. The treatment group is limited to those individuals who reside within 50km of a mine. The study will examine three measures of living conditions; the experience of lived poverty, access to development infrastructure, and access to household infrastructure. These measures are discussed in detail in Chapter 3.

To fully exploit the development potential of the extractive industry in local economies, a better understanding of the mechanisms involved is required. This paper seeks to provide a quantitative analysis to illuminate this problem further, thereby contributing to the discourse around local impacts of the extractive industry.

1.3 Purpose of the Study

The study focuses on local African communities surrounding large-scale mines and their access to infrastructure and levels of lived poverty when compared to similar communities in non-mining areas. Its methodology makes use of a spatial strategy that geographically links 4 796 Afrobarometer Round 6 survey respondents to 121 large-scale mines in 19 African countries (Afrobarometer 2016; Arroyo 2014).

Given the limited quantitative research regarding the impact of large-scale mines on local African communities, the aim of this research is to provide a more robust means of measuring living conditions by incorporating several indicators into one analysis, including the Lived Poverty Index (LPI), Development Infrastructure Index (DII), and Household Infrastructure Index (HII). This study seeks to systematically measure and analyse the living conditions of local communities near large-scale mines versus similar non-mining communities.

1.4 Research Question

This thesis investigates the following questions:

1. To what extent are the living conditions of local communities improved or harmed by large-scale mines, when compared to similar non-mining areas?
2. How does the proximity to a large-scale mine affect the following:
   - Poverty levels of an individual?
   - Access to household infrastructure of an individual?
   - Development infrastructure within an enumeration area?
3. To what extent is investment and development of the extractive industry in Africa justified?

1.5 Statement of Hypothesis

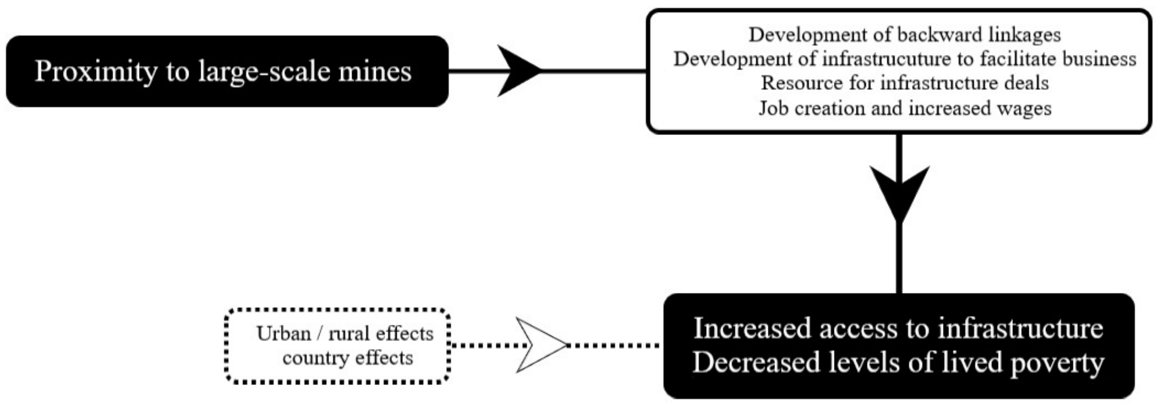

Figure 1: Proposed causal relationship between living condition outcomes and large-scale mining

Given the mixed results of current research, it is reasonable to assume that the impact of large-scale mining on local communities will likewise be mixed. The study hypothesises that controlling for country and urban/rural, we can expect to see benefits in specific measures of living conditions including the development of infrastructure that assists the day to day running of the mine (such as improved road systems) but a negligible impact on other measures that do not impact the mine (Chuhan-Pole, Dabalen, and Land

2017).

This thesis hypothesises the following:

H_{1_1}: Overall, proximity to a large-scale mine has a positive benefit to an individual's living conditions.

H_{1_2}: Communities that are located near a large-scale mine enjoy greater access to development infrastructure when compared to similar communities without a local mine in proximity.

H_{1_3}: Proximity to large-scale mines reduce poverty levels in surrounding communities; this effect weakens as we move away from a mine.

H_{1_4}: The presence of a mine in an area makes no impact on access to household infrastructure.

1.6 Significance of Study

This study contributes to the limited but growing literature quantitatively assessing the local impacts of proximity to large-scale mines on local populations in Africa. It does so by drawing on the work and spatial strategy of Kostadam and Tolonen (2016), Knutsen et al. (2017), Wegenast et al. (2017) and Benshaul-Tolonen (2018). It focuses specifically on general living conditions by expanding on the LPI pioneered by Mattes et al.(2003). It introduces two additional measurements of living conditions including access to household infrastructure and presence of development infrastructure within an enumeration area.

By providing a replicable methodology to measure the impact of mining on local living conditions quantitatively, insights gained by this research may guide future research and policy decisions regarding investment in the extractive industry in Africa.

1.7 Assumptions

This study makes the following assumptions:

- Mining and labour policies are made at the national level and are not affected by local governments.
- For the purpose of investigating the impact on local communities, non-lootable mineral resources are comparable.
- People seek employment opportunities within a radius of their residence, after which, travel costs become prohibitive.

1.8 Limitations and Delimitations

The following limitations and delimitations are specified:

- **Data availability**

  This study provides a modest sample size than previous research due to limited data availability. The Raw Materials Data (RMD) compiled by IntierraRMG is currently the most robust dataset of industrial mines; however, the cost is prohibitive. Instead, this study makes use of the freely available World Bank PowerMining Projects Database. Although extensive, this dataset only contains information that is publicly available and therefore does not provide a complete list of all mining projects in Africa. Because mining data is linked to individual Afrobarometer data within a country, this has narrowed the sample down to 19 African countries.

- **Limits study to one round of Afrobarometer surveys.**

  This thesis presents a preliminary study of the impact of large-scale mines on local communities when compared to similar areas with a future mine scheduled to open. It does not consider effects over time and instead focuses on one round of Afrobarometer surveys.

- **Does not measure government quality**

  Quality of governance at both national and local levels affects how communities benefit or are harmed by large-scale mining. This factor is beyond the scope of this thesis.

- **Excludes conflict from model**

  The presence of conflict effects living conditions. Although the presence of large-scale mines has been linked with conflict among actors, in the interest of simplicity and time, the impact of mining on levels of conflict has been excluded from this study.

- **Does not investigate the impact of commodity type or mining type**

  Although a limitation of this research, the current literature suggests that the type of mine, such as underground and surface, and the commodity type is not a good predictor of social outcomes. Instead, this study limits commodities to non-lootable resources because they are less likely to cause civil unrest (Ross 2003; Collier and Hoeffler 2004; Lujala, Gleditsch, and Gilmore 2005).

- **Catchment area specification**

  The catchment areas used in this study is based on previous research completed by Aragón and Rud (2016) and Benshaul-Tolonen (2018). However, a more reasoned methodology would be to employ k-means clustering (Hamfelt et al. 2011).

1.9 Structure of the Study

This thesis is organised into five chapters. Chapter 1 provided an overview of the research problem and topic. Chapter 2 critically discusses relevant literature which has influenced this study. Namely, it discusses the literature surrounding methodology employed to quantify local impacts of mines, especially spatial-temporal analysis. Chapter 2 concludes with the justification for the study apropos the literature reviewed. Chapter 3 provides a detailed outline of the research design and methodology employed during this study, including a discussion of the construction of indices and data collection. Chapter 4 presents a general description of the data and presents the study's main findings. Chapter 5 discusses the countries that perform unexpectedly well on the infrastructure measures. The study concludes with a discussion of the implications of the results, and suggestions for further studies.

2 Theoretical Foundation

This chapter provides an overview of the literature that informs this paper. It begins by reviewing arguments and evidence which supports the hypothesis that resource abundance is a blessing in local communities, followed by evidence supporting the inverse.

It then moves on to a discussion of the literature that informed the theoretical foundation and the measurements used to evaluate living conditions. The chapter concludes with a summary of the arguments discussed.

2.1 The Local Resource Curse

The impact of large-scale mining on local communities is rooted in resource curse literature. The resource curse thesis posits that developing countries rich in mineral wealth experience worsened political, economic and development outcomes (Ross 2015). Mining-dependent countries have been found to spend less on education (Gylfason 2001), are more vulnerable to political instability and corruption, have higher rates of economic inequality, and slower economic growth (Ross 2001; Pegg 2006). Likewise, mining economies are purported to have negative environmental impacts, including water and soil contamination, soil erosion and air pollution (Kirsch 2014).

However, further research reveals a more nuanced reality, with studies suggesting that mineral wealth can be a blessing. McMahon and Moreira (2014) note that low to middle-income mining dependent countries, especially in sub-Saharan Africa, have experienced steady economic growth. Furthermore, they analyse the impact of large-scale mining on gross domestic product (GDP) growth and Human Development Index scores in Chile, Ghana, Indonesia, Peru and South Africa and find a strong correlation between mining-dependent economies and economic growth, and in turn, improved HDI outcomes and economic equality over ten years. This phenomenon is reflected in the relatively high HDI scores of mineral dependent Botswana (African Development Bank (AfDB) 2016). Furthermore, Pegg (2006) notes that despite large-scale mining's poor track record of poverty reduction, in the presence of civil society participation and transparent governance in both government and the private sector, countries with high mineral deposits outperform their mineral-poor neighbours on development indicators. In other words, under the correct conditions, the mining industry can contribute positively to development including poverty reduction.

Additionally, meta-analyses of quantitative evidence examining the impact of natural resources on economic development find that although evidence exists to confirm the presence of a resource curse, the methods employed in analyses are plagued by issues of endogeneity, data availability and variable selection (Havranek, Horvath, and Zeynalov 2016; Van Der Ploeg and Poelhekke 2016). Despite the concerns regarding methodology, the volume of disagreement within academia and contradictory findings is not enough to confirm or invalidate the resource curse thesis (Badeeb, Lean, and Clark 2017).

While the impact of mining at the national level is well documented, literature exploring the benefits of large-scale mining in local communities are limited. The role of large-scale mineral resource extraction as a blessing or curse within the local context is discussed below.

2.1.1 Mineral resource abundance as a blessing in local communities

The argument in favour of resource abundance as a blessing rather than a curse is best exemplified by the WBG's policies regarding investment in the extractive sector. Fostering the extractive industry in developing nations is a priority for the WBG as it supports its principal goal of "ending extreme poverty and promoting shared prosperity" (World Bank 2013). In other words, the World Bank argues that the extractive industry in general and large-scale mining, in particular, can act as a catalyst for income growth among a country's more impoverished citizens and contribute to poverty reduction, thereby improving living standards and decreasing economic inequality (United Nations Development Programme 2017, 3-4). This argument assumes that large-scale mining not only attracts foreign direct investment to stimulate the economy but also creates jobs and develops infrastructure. Figure 2 (adapted from de Sa's (2015, 6) presentation at the World Bank) describes the proposed causal relationship between the extractive industry and socioeconmic development.

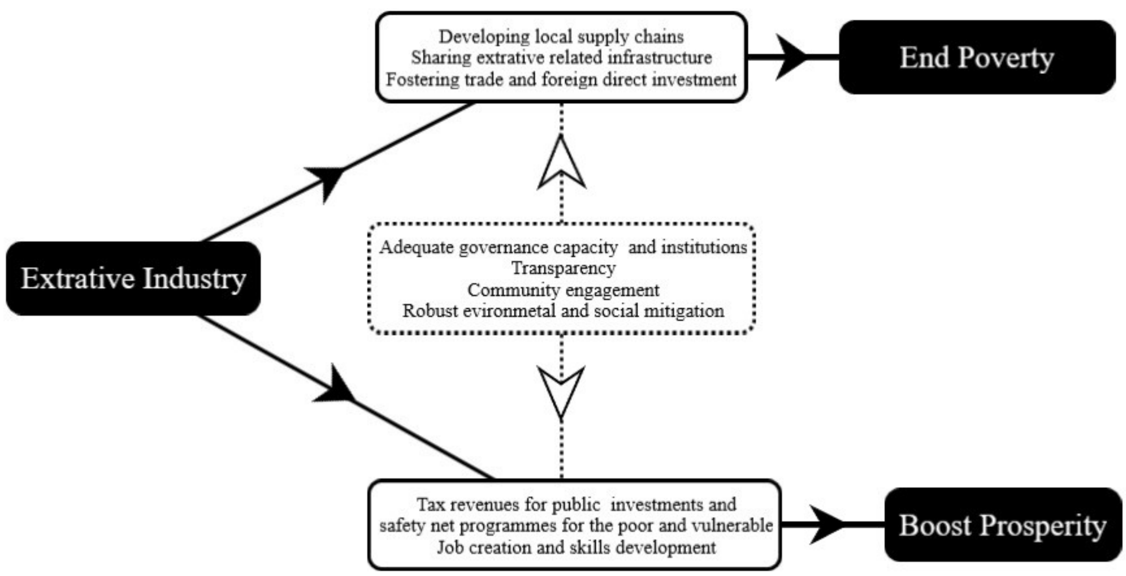

Figure 2: Relationship between the extractive industry and the WBG's twin goals

Natural resource abundance affects local communities via three channels; market, fiscal and environmental (Aragon, Chuhan-Pole, and Land, 2015). Using these three channels as a framework for a quantitative assessment, Chuhan-Pole, Dabalen and Land (2017) find limited positive gains for local mining communities in Ghana, Mali and Tanzania. Likewise, they find inadequate evidence to suggest a deterioration of socioeconomic conditions. The establishment of a mine does lead to an uptick in economic growth; however, these areas do not outperform other areas over time. Mining also appears to have a negligible impact on the agricultural productivity of an area.

Market channels are the most significant driver of positive benefits to local mining communities. This is primarily achieved through the development of a local supply chain and the creation of backward linkages. Backward linkages in this context refer to the local supply chain developed to support mine production. In South Africa, home of Africa's largest gold mining economy, 1.8 jobs are created through backward linkages for every one gold mining job. Likewise, they find a significant positive relationship between service sector employment and proximity to an active mine (Chuhan-Pole, Dabalen, and Land 2017, 15).

Zambian copper output is positively associated with living standards of surrounding communities, regardless of if individuals are directly employed by the mining sector (Lippert 2014). Similarly, in a study investigating the impact of the Yanacocha gold mine in Peru, Aragón and Rud (2013) find positive spillovers in local communities. In particular, they find that an increase in demand for local inputs from Yanacocha is positively correlated with an increase in income, and in turn, an increase in household spending and a reduction in poverty levels. This effect holds for 17 production districts that fare better in measures of consumption, literacy, and poverty levels, although this effect dissipates the further away from the mining centres (Loayza and Rigolini 2016). However, this may be due to the local procurement guidelines established by its shareholder, the International Finance Corporation (IFC), a branch of the WBG. This suggests that while resource abundance can be parlayed into positive outcomes in local communities, it requires sufficient policies and oversight.

Several studies have linked the presence of large-scale mines with improved development infrastructure within its immediate surrounds. Large-scale mines require a well-established infrastructure network to run the site from day to day. In areas where infrastructure is lacking, mining companies are forced to develop supporting infrastructure, which can lead to spillover effects in its surrounding areas (McMahon and Moreira 2014; Lippert 2014). Wegenast et al. (2017) find that the presence of Chinese-owned mines results in an improved road and piped water infrastructure near the mine. "Resource for infrastructure" (Venables 2016, 179) deals are favoured by Chinese companies and often form part of broader trade and investment agreements or are direct barter deals. This payment structure has the benefit of providing an incentive to transform natural resources into development infrastructure, as seen in Angola where loans to build schools and hospitals were paid back in quantities of oil (rather than in value terms). However, due to the emerging nature of such agreements, there lacks sufficient procedural checks and balances to ensure the host economy is getting a fair deal.

Besharati (2014) notes that Anglo American has invested $14 million in an education programme in South Africa’s platinum belt, suggesting that the presence of large-scale mines may contribute to education infrastructure. Lippert (2014) found a positive relationship between copper production in Zambia and improved access to tap water and electricity. A legacy of colonialism means that the bulk of existing infrastructure like roads and railways run from mines to coasts for export, with new infrastructure development continuing this pattern (Bonfatti and Poelhekke 2017). Infrastructure improvements are designed to facilitate production, and this does not necessitate development within local communities (Pegg 2006, 381). This suggests that mining may do little to improve local communities and citizens at large's access to development infrastructure. Also, Chuhan-Pole, Dabalen and Land (2017) find no significant link to improved access to infrastructure in local mining communities.

2.1.2 Mineral resource abundance as a curse

In contrast, several studies report negative impacts on poverty levels, pollution levels, access to education, and corruption in local communities. Rawashdeh, Campbell and Titi (2016) note that while mining has had a positive impact on macroeconomic development in Jordan, local communities remain marginalised, benefiting little yet burdening most of the environmental and social costs. Mining territories perform worse than their non-mining counterparts on several indicators, including unemployment, poverty levels and education. The authors posit that this is because mining revenues are distributed at the national level, rather than through local government. They further note that for local communities to benefit from local mines, mining companies must commit to local infrastructure as a matter of company policy.

Mining-based development has a poor record of poverty reduction (Pegg 2006). A meta-analysis of fifty-two empirical studies reviewing the relationship between mining and poverty find that large-scale mining worsens poverty, while artisanal mining improves poverty levels (Gamu, Billon, and Spiegel 2015). Specifically, mining-dependent economies tend to worsen inequality and living conditions (Ross 2001; Loayza and Rigolini 2016).

In a study examining the social impact of large-scale gold mines in Ghana, Wan (2014) finds that inequality within local communities persists despite the revenue generated by mines. The author suggests that this is due to the underlying political and economic structures which are unable to hold mines accountable and redistribute the mine generated wealth. Increased inequality may also be due to labour participation decreases and skewed income due to the limited access greater society has to mineral resources (Bulte, Damania, and Deacon 2005). Madibeng, South Africa illustrates this well. Referred to as the platinum belt, Madibeng is home to 80% of the world's known platinum reserves, with the region reporting around USD4.5billion in profits in 2011. Despite this, its population is impoverished, lacking access to fundamental human rights including access to clean water and sewage removal, and are subjected to unfair labour practices and low wages (Bond 2014).

Local mining communities tend to have mixed outcomes for women and children, with Benshaul-Tolonen (2018) finding a significant positive correlation between large-scale mining and female empowerment in communities surrounding. Women are also most likely to benefit from the economic transition from agriculture to services and sales within these communities (Chuhan-Pole, Dabalen, and Land 2017). However, once a mine closes, men return to previous employment while women's labour participation lowers when compared to before the mine opening (Kotsadam and Tolonen 2016). Likewise, while some studies find that mining areas experience reduced infant-mortality rates (Benshaul-Tolonen 2018), other studies suggest increased rates of child mortality (Ross 2001). Furthermore, children whose parents are employed in mining are less likely to attend school due to economic hardship, further entrenching households in the poverty trap (Carter et al. 2007; Jensen, Yang, and Muñoz 2011).

Additionally, due to the boom-bust nature of the mining industry, the influx of migrant workers has the potential to disrupt existing local communities. The rapid growth of the local population due to the economic opportunities presented by the establishment of a mine may outstrip the capacity to provide adequate infrastructure. The consequences of which may increase the risk of communicable diseases and increase the demand for local resources such as water and housing. The increase in population may also increase the cost of living as demand for basic goods outstrip supply (Pegg 2006, 378-381). The rapid growth of informal settlements also has worsened health outcomes for individuals including a more significant risk of illness, disability, and premature death due to the lack of essential services (Sverdlik 2011).

Environmental channels play a pivotal role in affecting welfare outcomes in local communities, namely through its effects on health and the local economy (Aragón and Rud 2016). Labour is an indispensable input for economic growth, yet high pollution levels impact labour-intensive growth. Higher pollution levels have been linked to decreased agricultural productivity (Zivin and Neidell 2012; Aragón and Rud 2016) and a decrease in work hours per week (Hanna and Oliva 2015). Aragón and Rud (2016) find that gold mining in Ghana harms local communities within 20km of a mine and that the increase in pollution levels due to mining reduces agricultural productivity, worsens poverty levels, and decreases child nutrition indicators. Failure to safely dispose of cyanide waste products at the Ok Tedi copper and gold mine in Papua New Guinea damaged 40km of the nearby river's downstream ecosystem, killing animal and plant food sources and severely impacting the health of the local population (Kirsch 2014). In

Madibeng, local mines failure to adequately handle mine run-off has contaminated local water sources, resulting in civil unrest (Bond 2014).

The question of whether a local resource curse exists remains a great matter of debate. The effects of large-scale mining on local communities have been investigated from different angles and have yielded inconsistent results. This paper seeks to shed light on this question by quantitatively assessing the impact of large-scale mines on living conditions with regards to experienced lived poverty and access to infrastructure. It theorises that large-scale mining has a net positive impact on living conditions in local communities but this effect is small when compared to the cost of attracting multinational mining firms to invest in a country.

2.2 Measuring Living Conditions

This paper aims to estimate the social impact of large-scale mines on local communities by measuring the quality of life or living conditions of individual survey respondents. Article 25 of the Universal Declaration of Human Rights (UN General Assembly 1948) states that "Everyone has the right to a standard of living adequate for the health and wellbeing of himself and of his family, including food, clothing, housing and medical care and necessary social services". The Multidimensional Poverty Index (MPI) developed by the United Nations Development Programme (UNDP) comprises of ten indicators across three dimensions; health, education and living standards (Moss and Goldstein 2011). Furthermore, the presence of state infrastructure is correlated with access to social services and reduced poverty (Straub 2008; United Nations 2016). This section focuses on the literature surrounding three social indicators of living conditions; development infrastructure, household infrastructure or amenities, and lived poverty.

2.2.1 Poverty and Human Development

Much of the literature regarding the positive social impact of mining focuses on the relationship between economic development and human development, however, how to go about measuring poverty is a contentious issue. The debate centres primarily on whether poverty should be measured economically, using indicators such as income, or as a multidimensional needs-based metric. While the most accepted way to measure economic growth is through measuring GDP and individual or house household income, in recent years there has been a shift away from this definition and towards a multidimensional view of poverty. This section outlines current discussions about these differing poverty measures and makes a case for the Lived Poverty Index as the most appropriate living conditions measurement for Africa.

Income is the preferred measurement of economists, as this is viewed as the most objective and accurate measure of poverty (O'Donnell et al. 2008; Mattes, Bratton, and Davids 2003). This method relies on the assumption that income allows access to goods and amenities one needs to survive (Scott 2002; Maltzahn and Durrheim 2008). While income is an attractive method of measurement because of its simplicity, some argue that it fails to capture the complexity of the lived experience because it fails to account for essential contributors to their wellbeing, such as barriers to public services or institutionalised discrimination. However, in a study looking at five African countries, von Maltzahn and Durrheim (2008) find that different measures of poverty mostly yield the same result at both national and household levels. This suggests that income-based measures are reliable, although it does sacrifice more granular analysis.

Income-related data is particularly challenging to measure in developing countries.

Along with the issues of self-reported inaccuracies inherent in income-based survey questions, this approach fails to account for the informal nature of many African economies. Income of individuals is often sporadic, resulting in inaccurate recollection. This approach also does not account for bartering and access to public goods. Because of these issues, consumption-based measures, which measure the actual use of goods and services and asset-based measures are suggested (O'Donnell et al. 2008; Maltzahn and Durrheim 2008). However, because surveys of African countries mainly focus on issues of health, mortality, and education, they rarely have resources to accommodate these methodologies (Montgomery et al. 2000). This leads researchers with little choice but to turn to proxy indicators that are readily available in cross country surveys.

The Lived Poverty Index, created by Mattes, Bratton, and Davids (2003), aims to address the issues of data availability and accuracy by using five questions asked in the Afrobarometer surveys. LPI has been used to measure access to basic necessities since 1999 (Meyer and Keyser 2016) and is widely used and consistent with cross-country opinion surveys conducted in Africa. The questions used to construct LPI measures access to the following; food, cooking fuel, clean water, cash income, and medical care. This method is based on what O'Donnell et al. (2008, 71) refer to as the "arbitrary approach", in which the sum of an indicator or dummy variable is used as a proxy measure for poverty.

LPI provides the benefit of readily accessible data that is easy to collate and available across African countries across several years. Although this measure does not have external validity when compared to alternative measures like HDI, it is internally valid and reliable, making LPI an appropriate measure of poverty in cross-country and cross-national studies. Similarly, in a study using an expanded LPI scale which includes three additional measures, Meyer and Keyes (2016) find that LPI is a reliable and valid measure of poverty.

2.2.2 Infrastructure as a measure of living conditions

Access to basic infrastructure is necessary to improve living conditions. Several studies find that improving infrastructure increases human development indicators such as poverty and inequality reduction. Development infrastructure refers to infrastructure used in public spaces, like electrical grids, sanitation systems and paved roads. Household infrastructure refers to infrastructure found within the home, including running water and electric mains. Although governments generally provide development and household infrastructure, international development policies have encouraged privatisation to accelerate growth since the 1980s (Parker, Kirkpatrick, and Figueira-Theodorakopoulou 2008, 178). Similarly, the IFC incentivises mining companies to build infrastructure in surrounding communities which otherwise might not have been serviced by the government (International Finance Corporation 2019).

Mattes, Dulani, and Gyimah-Boadi (2016, 10) demonstrate that the Afrobarometer Round 6 data indicates a strong link between development infrastructure and a reduction in lived poverty. In a survey of sixty-four empirical studies assessing the relationship between infrastructure and economic growth in developing countries, Straub (2008) finds that two-thirds of the literature find a positive and significant correlation. Similarly, Akakaiye and Ncube (2010) analyse 136 countries and find a positive relationship between development infrastructure, increased economic growth and lowered economic inequality.

Improving the quality of roads and other modes of transportation is linked to poverty reduction and increased productivity outputs (Straub 2008; Gibson and Rozelle 2003). The distance a household is from public transportation also improves household income

(Fan, Nyange, and Rao 2005). Perhaps the best illustration of the impact of improved transportation infrastructure on human development at a local level is the case of the metro-cable upgrades in Medellín, Colombia. Following the expansion of the metro-cable system (a necessary mode of transport given the mountainous terrain of the city) to link poorer neighbourhoods in the outskirts of the city to the economic hub, the city experienced a marked decrease in levels of violence and poverty (Coupé 2013).

Limited quantitative research exists assessing the impact of electricity on living standards in sub-Saharan Africa. Lenz et al.'s (2017) assessment of Rwanda's Electricity Access Roll-Out Program (EARP) demonstrates that electrification does yield positive effects on household income, although impacts on income generation and local business are limited. In particular, the study found that connecting households to the electrical grid reduced total household energy expenditure, thereby improving health outcomes due to increased use of appliances in clinics and decreased indoor pollution attributed to cooking fuels. Further studies in Bangladesh, Vietnam and India find that electrification improves household income and education outcomes, with more children attending school post-electrification (Khandker, Barnes, and Samad 2013; Walle et al. 2013). Because access to amenities that improve living standards like running water and stoves require electricity, electrification can free up women's labour which would otherwise be spent cooking over non-electric stoves (Rao and Pachauri 2017).

Water and sanitation infrastructure have well-established positive health and development outcomes due to improved hygiene, a reduction in water-borne diseases, and a decrease in labour dedicated to water procurement (Sverdlik 2011). Using child height as a proxy for child health, Thomas and Strauss (1992) find that access to piped water, a sewage system and electricity has a significant positive effect on the height of children in Brazil. Comparable results have been found by Galiani, Gertler, and Schargrodsky (2005) who find that improved water services decrease child mortality. Furthermore, improved water infrastructure allows women to engage in income-generating activities rather than spending that time collecting water (Ilahi and Grimard 2000), thereby improving the living conditions of the household. Central to improving living conditions is to provide individuals and households access to "safe, secure and healthy shelter" (United Nations 1996, 109). Low-quality housing increases the prevalence of communicable diseases and exasperates non-communicable diseases (Sverdlik 2011). Housing stability is significantly linked to improved health outcomes for HIV positive patients (Leaver et al. 2007) - a critical concern for development policy in southern Africa (Moss and Goldstein 2011). Providing access to necessities like water, sanitation and waste removal is challenging in the absence of adequate housing. Inadequate housing also leaves households vulnerable to extreme heat, cold, and increasingly devastating natural disasters due to climate change (Sverdlik 2011). Specifically, inadequate shelters are poorly equipped to protect its inhabitants from natural elements and are more likely to located in disaster-prone areas (Confalonieri et al. 2007, 372). Therefore, measuring an individual's access to both development and household infrastructure access is vital to assessing living condition outcomes.

2.3 Conclusion

This chapter reviewed the arguments for and against large-scale mining as a catalyst for economic and human development at a local level. It outlines the findings that large-scale mining is advantageous to local communities – they create local economic booms with spill-over effects including improved infrastructure creation of backward linkages and improved labour participation of women. It then outlines evidence to the contrary, including examples of worsening living conditions and inequality, and environmental degradation. It notes that the positive macroeconomic benefits of large-scale mining are often at the expense of local communities.

This paper also provided a theoretical overview of measuring living conditions. Using the UN's Multidimensional Poverty Index as a foundation of living condition considerations, it argues that Mattes et al.'s LPI, as well as two additional indices, are the most appropriate indicators to measure living conditions in local African communities.

The next chapter discusses the construction of these indices and provides an overview of the methodology used in the analysis.

3 Research Design and Methodology

3.1 Introduction

The research design of this study is informed by previous research employing spatial analysis, as outlined in Chapter 2. However, the quantitative strategy employed in this paper differs in several important ways. The sample is limited to one round of Afrobarometer surveys and does not employ a difference in difference strategy. Instead, this study utilises a linear mixed-effects model to estimate the impact of large-scale mining on local communities. Furthermore, the regression includes the distance in kilometres of the individual from a mine, as well as a dummy variable indicating if the individual lives within 50km of an active or future mine (a mine in the feasibility, advanced exploration, or development stage).

This study uses a quasi-experimental spatial estimation. It employs a linear mixed-effects regression model to measure the impact of large-scale mines on communities' living conditions. Responses to Round 6 Afrobarometer data is used to construct three separate indices measuring various aspects of living conditions. These are lived poverty (LPI), access to household infrastructure (HII), and access to development infrastructure (DII). Large-scale mines are defined as ones whose ore reserves are higher than $250m, and local communities are defined as Afrobarometer respondents who live within 50km of mine.

The regression specification is as follows:

$$\begin{aligned}
Y_{ijk} &= \beta_0 + \beta_1 \cdot distance + \beta_2 \cdot active + C_k + U_{jk} + \varepsilon_{ijk} \\
C_k &\sim N(0, {\tau_{00}}^2) \\
U_{jk} &\sim N(0, {\tau_{00}}^2) \\
\varepsilon_{ijk} &\sim N(0, \sigma^2)
\end{aligned} \tag{1}$$

Where outcome Y, the index score, is regressed on the distance in kilometres from a mine and an indicator for if an individual is within 50km of mine in production (*active*). The random effects are country C and a dummy variable for urban area U. The regression controls for country and urbanisation effects by making use of a country-specific random intercept and country-urban specific intercept. The subscript $_i$ indicates an individual respondent, $_j$ a dummy variable indicating an urban area, and $_k$ country.

This chapter outlines the methodological approach of the study. It begins with an introduction to the research design, including a background of the spatial estimation strategy and regression model used. The chapter goes on to discuss the population of the study and the sampling procedure, as well as an explanation of the data sources and data preparation. Chapter 3 concludes with the procedure for testing the hypotheses.

3.2 Research Design

3.2.1 Spatial Estimation Strategy

This study estimates whether the proximity to an active mine effects living condition outcomes. It does so by measuring the distance between an individual and the closest active or future legal large-scale mine within a 100km radius. Radius is used because it is assumed that people seek employment opportunities within a certain distance, after which the cost of travel negates potential earnings (Aragón and Rud 2013; Benshaul-Tolonen 2018). Individuals within 50km of at least one mine in production are the treatment group, while those who are $\geq$ 50km from an active or future mine is the control group (future).

The location of a mine is influenced by not only mineral deposits but also the cost of doing business (such as transportation costs). Likewise, the location of mining areas may have unique features, including geographic and demographic characteristics. By comparing only individuals within 100km of an active or future mine, rather than with all people within a country, these differences are controlled. Mining firms tend to favour locations with good infrastructure, institutional quality, and business practices (Tole and Koop 2011). Institutional quality and business practices differ from country to country. Likewise, urban areas tend to have better transport networks and a larger labour force. Thus, urban/rural effects are nested within country random-effects to control for this variation.

3.2.2 Linear Mixed-Effects Model

Linear mixed-effects(LME) models allow for the modelling of both fixed- and random-effects terms. linear mixed-effects (LME) regressions have several advantages when compared to conventional linear-fixed effects regressions when working with hierarchical survey data, including modelling for variance, and controlling for non-independence (Eager and Roy 2017).

Quality of governance and institutions within a country is a good predictor of whether a resource is a curse or a blessing. In this vein, the magnitude of variation among countries, and within the urban and rural observations of each country, is of interest. LME is selected over other models for this study because it not only controls for these factors but allows for the observation of differences among countries and between urban and rural areas within those countries. Furthermore, respondents from the same country may be more like each other than respondents from other countries, and mixed models account for this non-independence.

The selected regression model has a random intercept and common slope, allowing a varied group means. While sharing a common slope can increase Type 1 and Type 2 errors when compared to the random intercept and slope model, the latter's accuracy hinges on a larger and more balanced sample size than is available for this study. Thus, this is the most appropriate mixed-model given the size of the data-set (Harrison et al. 2018).

3.3 Population of Study

Table 1 refers to the summary statistics for the Afrobarometer respondents. In total, the study includes 4 796 respondents, 4 133 of which live within 50km of an active mine. The average participant is around 38 years old, is unemployed, with 61% residing in a formal or non-traditional house. Just over half the respondents have some primary school education. 26% of the respondents work in agriculture, followed by individuals who have never had a job (12%) and unskilled labour at 10%. This study consists of 591 primary sampling unit (PSU)'s. Most PSU's have a school within easy walking distance (89%) as well as a piped water system that most people can access (62%). For additional graphs detailing the population sample, including further information on the mines included in the sample, please see the Appendix.

Table 1: Demographic Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
electrical grid	4,796	0.64	0.48	0	0	1	1
piped water	4,792	0.66	0.48	0	0	1	1
sewage system	4,784	0.40	0.49	0	0	1	1
school	4,780	0.85	0.36	0	1	1	1
clinic	4,776	0.53	0.50	0	0	1	1
paved road	4,796	0.61	0.49	0	0	1	1
impassible road	4,796	0.11	0.31	0	0	0	1
age	4,767	38.08	14.91	18	26	47	100
living conditions	4,764	2.58	1.27	1	1	4	5
w.food	4,789	3.17	1.10	0	2	4	4
w.water	4,790	3.12	1.25	0	2	4	4
w.health	4,786	3.17	1.14	0	2	4	4
w.cooking fuel	4,785	3.36	1.04	0	3	4	4
w.cash	4,783	2.18	1.41	0	1	4	4
water source	4,789	1.75	0.86	1	1	3	3
toilet location	4,791	1.94	0.87	0	1	3	3
electricity	4,781	2.09	2.02	0	0	4	5
employed	4,779	0.41	0.49	0	0	1	1
closest mine (km)	4,796	33.44	21.32	0.0004	17.24	45.84	98.76
DII	4,796	0.61	0.29	0	0.33	0.83	1
HII	4,795	0.61	0.26	0.06	0.44	0.87	1
LPI	4,793	0.75	0.21	0	0.60	0.95	1

3.4 Sampling Procedure

4 796 Afrobarometer round 6 survey respondents (Afrobarometer 2016) are linked to 121 active or future mines within a 100km radius of their recorded GPS location. The sample includes nineteen sub-Saharan African countries;Botswana, Burkina Faso, Gabon, Ghana, Guinea, Ivory Coast, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Sierra Leone, South Africa, Tanzania, Zambia, and Zimbabwe.

The distance between an individual observation (a single respondent from Afrobarometer) and the closest active mine location is measured using the GPS coordinates provided in each dataset. The distance is measured in kilometres. The treatment group is defined as individuals that are within 50km of an active mine (a mine in production). Knutsen et al.(2017) limit the sample to a 50km radius due to sample size and commuting considerations. This paper follows their guideline and limits the treatment sample to within 50km of an active mine.

The control group is individuals within 50.1km – 100km of either an active or a future mine (a mine in the feasibility, advanced exploration, or development stage) . If there is no active mine within a 50km radius of an individual, but an active or future mine within a 50.1 to 100km radius the mine status is labelled as "future". Otherwise, the observation is excluded from the sample. This is in line with Benshaul-Tolonen (2018), who limits the sample to Afrobarometer clusters within 100km of a mine. The cut off for the overall sample is informed by Aragon and Rud's (2013, 3) findings that mining effects become insignificant after 100km. By limiting the sample to only those individuals who are within 100km of an active or future mine rather than all individuals within a country, we control for geographical and institutional differences in mining and non-mining areas

(Nunn and Puga 2009; Knutsen et al. 2017).

Individuals are only linked to a mine if that mine is also in the same country as an individual to control for country-specific conditions, including governance quality and economic differences. This relies on the assumption that policies that influence mining within a country, such as rents, taxes, labour laws and other regulatory framework are determined at a national, rather than a sub-national or local level (ECA 2009, 6-8).

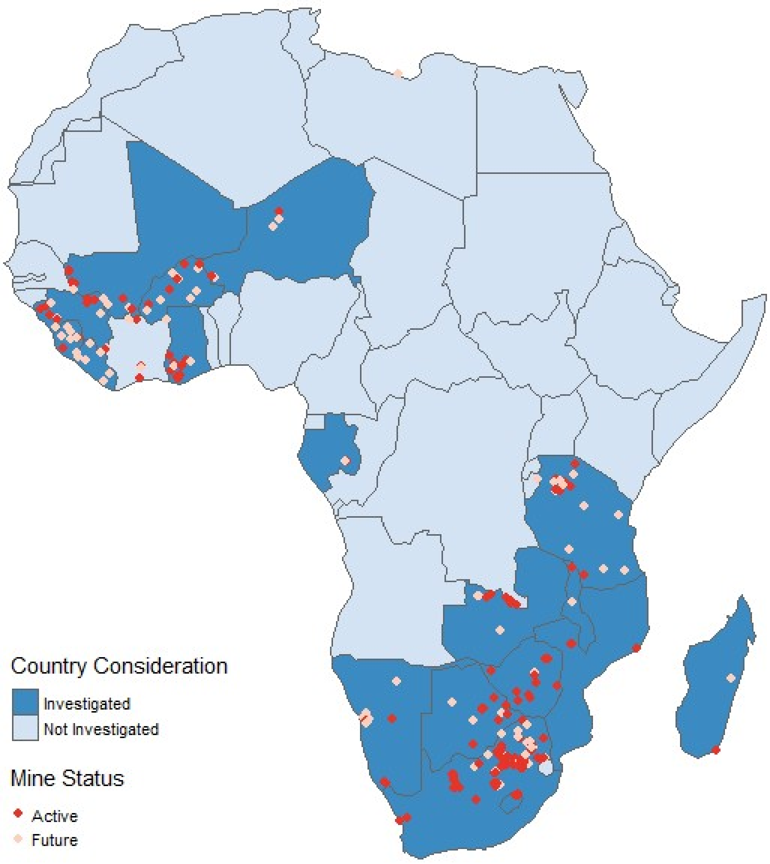

Figure 3: Map of sample

Mine selection is limited to metal and mineral mining and comprises of underground, open-pit, and surface mining. 12% of the mines extract coal, 6% extract diamonds, and the remainder of the sample extract metals. While the inclusion of several metals and mineral types and mining methods may open the analysis up to extraneous factors, the sample is limited to non-lootable resources. Non-lootable resources are resources which

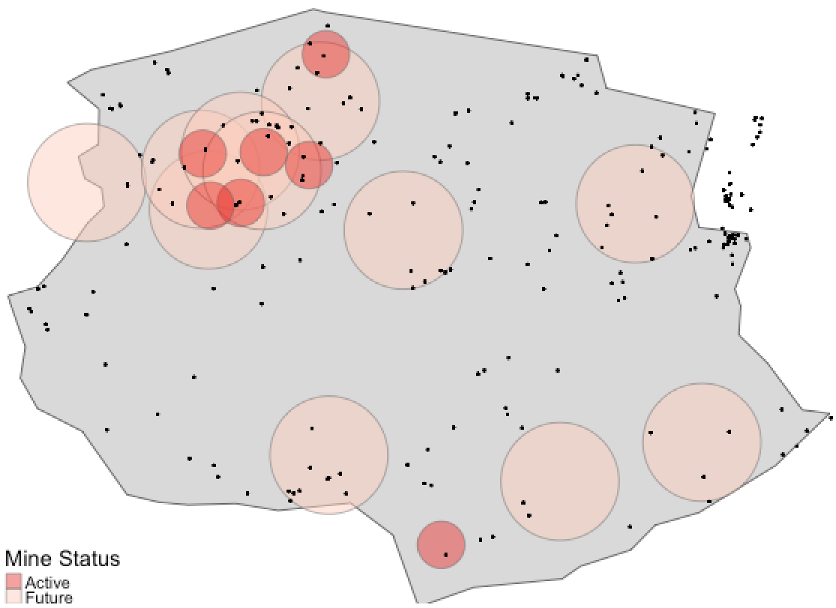

Figure 4: Map of catchment areas

require considerable technical expertise and bureaucratic structures and are therefore less prone to fuelling conflict and civil unrest(Ross 2003; Collier and Hoeffler 2004; Lujala, Gleditsch, and Gilmore 2005). Further to this, while the mining processes and methods involved in underground, open-pit and surface mining may differ, the impact on local communities are comparable. Thus, the impact of commodity and mining type is beyond the scope of this study.

3.5 Data Sources

Mining-level data is retrieved from the World Bank's Power-Mining Project's Database (Arroyo 2014). The database collates information from the United States Geological Survey, Infomine Surveys, various public reports, and mining websites. The database outlines projects operating between 2000–2012 and future mining projects in Africa. It features detailed information on individual mine locations, including GPS coordinates, commodity, and type of mine. While comprehensive, the database does not represent a complete list of mines across the continent, which may result in some mines being omitted from the analysis. The sample is limited to industrial mineral mines with ore reserve value assessed at more than $250 million and excludes artisanal mining.

Individual-level data is obtained from the geocoded Afrobarometer Round 6 surveys (Afrobarometer 2016) which were conducted via face-to-face interviews between March 2014 – November 2015. The PSU's were randomly selected, as were the eight interviewees who are clustered within each PSU (Afrobarometer 2018). Each cluster point or PSU is linked to GPS coordinates and comprises of eight respondents, except for South Africa, which comprises of four. The surveys contain questions on enumeration and household infrastructure, as well as questions regarding individuals personal experience with necessity shortages.

Difficulty sourcing reliable and accessible data for Africa makes the comprehensive public opinion survey a preferable choice for individual-level data. Additionally, Afrobarometer's balanced sample across several countries lends itself well to linear mixed modelling. Francophone countries, including countries with significant mining industries, are underrepresented in this survey, potentially biasing the result.

3.6 Data Preparation

3.6.1 Linking Mining and Individual Level Data

The active mine dummy variable consists of mines currently in production, and mines that we can reasonably assume will become producing mines in the near future. Mines listed as either feasibility, advanced exploration or development are labelled as future. Mines labelled as exploration, prefeasibility, temporary suspension, past producer or closed are discarded. Similarly, types of work are limited to open-pit, open-pit/underground, and surface. Placer, plant, and tailings are discarded. In some cases, mines are duplicated in the World Bank Power Mining dataset because they mine different commodities but are run on the same property by the company. In these cases, the observations are merged.

Once the mining database is sufficiently cleaned, it is linked to the Afrobarometer data set. Both the mining and Afrobarometer datasets contain geographical coordinates. The distance between every mine and survey observation are measured using these coordinates. Then, the closest mine (of any type) located to a survey respondent is identified. Individuals who are further than 100km from an active or future mine are discarded from the sample. If the distance is to a mine is greater than or equal to 50km, it is labelled as future.

In the case of DII , only one respondent per PSU is included in the sample, resulting in an overall sample of 591 observations. This is done to avoid overcounting observations, as infrastructure availability does not differ among respondents who live within the same PSU.

3.6.2 Afrobarometer Round 6 Recoding

Missing values, "don't know's", and "refused to answer" are recoded to NA. The urban/rural variable is recoded to a dummy variable where 1 is urban, and 0 is rural. In the Malawi sample, peri-urban is recoded to rural as per the recommendation of Francis Kibirige, the Afrobarometer network sampling specialist for Malawi. Likewise, in the Botswana sample, semi-urban is recoded as rural as per Professor Maxton Tsoka's recommendation. In addition, the original variable names provided by Afrobarometer are discarded in favour of descriptive variable names.

3.6.3 Constructing Indices

This paper evaluates three separate indices to measure living conditions. These indices measure infrastructure at an enumeration area level, infrastructure at the household level, as well as lived poverty. Each index comprises of several questions from the Afrobarometer survey. A correlation matrix of the question components is provided for each index, confirming the validity of each index's construction. Tables 1 - 4 outline the original variable labels and values as indicated in the Afrobarometer survey, as well as the recoded variables.

The construction of the indices follows the same methodology. Each index is the mean of an individual's scores – creating a composite score from 0 to 1. If an individual has an NA value for over half of the index components, the individual's score for that particular index will be NA. If less than half of the index questions is NA, then a mean is calculated without considering the NA value. For example, if an individual score is the highest possible value for each question, their index score will be 1. Likewise, if they score the highest possible value for 4 out of 5 questions, but the fifth question is an NA, their score will be 1. In all cases, "don't know", "refused to answer", and "missing" are recoded as NA. This section elaborates on the composition of each index.

3.6.3.1 Development Infrastructure Index

The DII is an index comprising of six infrastructure measures, which are aggregated to form a composite score of development infrastructure on a scale of 0 to 1. By combining these questions to create a single index, this paper can investigate if there is a link between local infrastructure and large-scale mines. The question relating to impassible roads is

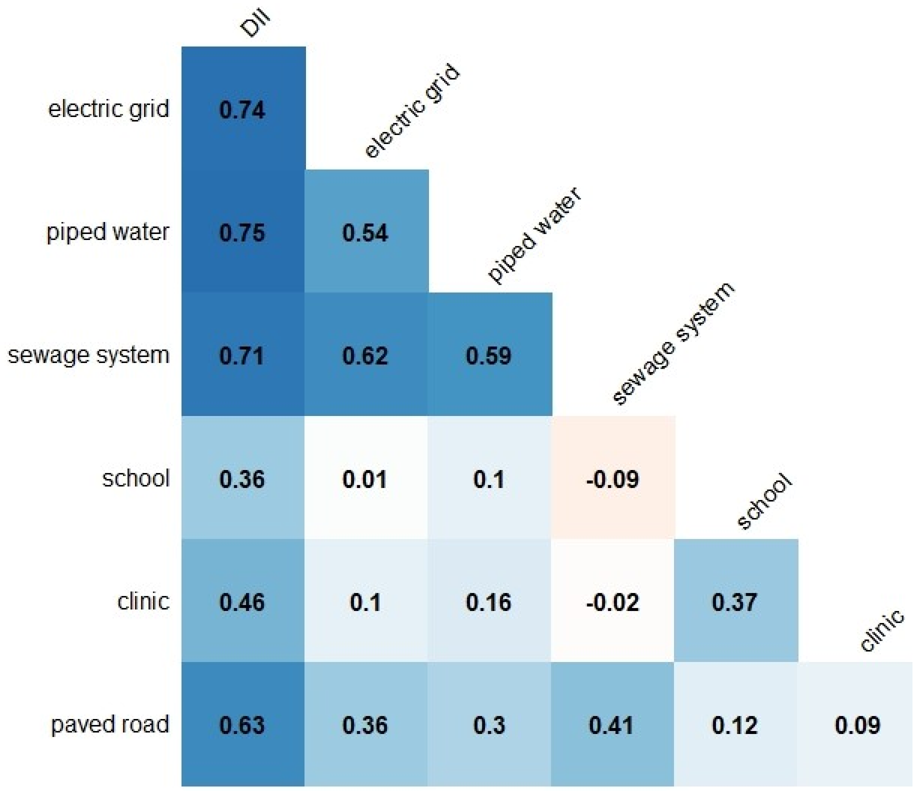

Figure 5: Correlation matrix for DII components

Note: Cronbach's $\alpha = 0.67$

omitted due to the poor correlation with the other components that comprise the DII index.

Interviewers and field supervisors were required to answer questions regarding the infrastructure in each PSU. The question wording is listed below (Isbell 2017, 5-7). Variable labels included 0 and 1 for "no" or "yes" respectively.

Are the following services present in the primary sampling unit/enumeration area:

- *Electricity grid that most houses could access?*
- *Piped water system that most houses could access?*
- *Sewage system that most houses could access?*

Or within easy walking distance of a

- *School?*
- *Health clinic?*

Was the road at the start point of the primary sampling unit/enumeration area paved/tarred/ concrete?

3.6.3.2 Household Infrastructure Index

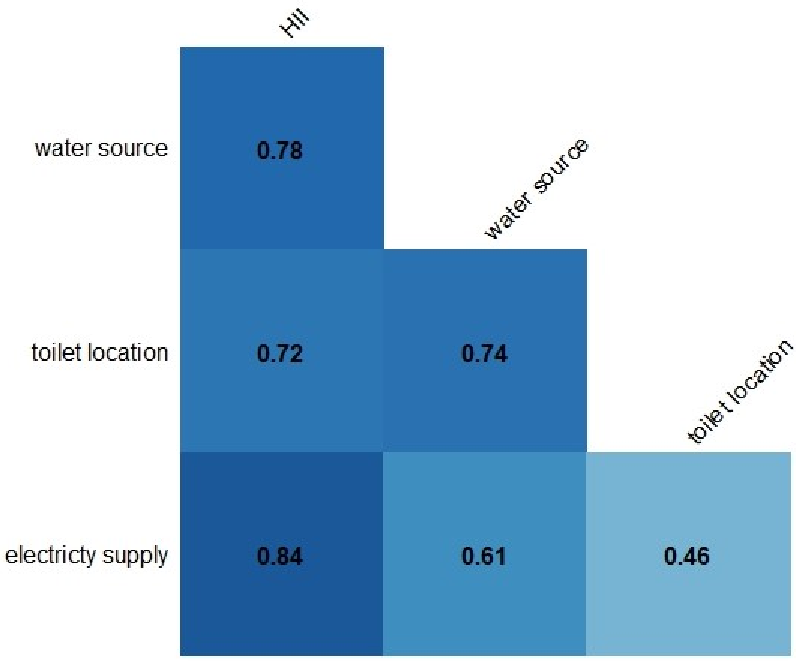

Figure 6: Correlation matrix for HII components

Note: Cronbach's $\alpha = 0.7$

The Household Infrastructure Index seeks to measure an individual's access to household amenities, namely the quality of their shelter, and access to water, sanitation, and electricity. Because toilet location and access to water are highly correlated, these values are half weighted. For consistency, the value labels for water source and toilet location was inverted so that the lowest value is the worst possible outcome, and the highest value is the best possible outcome (for recoded, values please see Table 2).

Please tell me whether each of the following are available inside your house, inside your compound, or outside your compound:

- *Your main source of water for household use?*
- *A toilet or latrine*

Table 2: Recoded water and toilet access

Variable Label	Original Value	Recoded Value
None (toilet/latrine only)	0	0
Inside house	1	3
Inside compound	2	2
Outside compound	3	1

Do you have an electric connection to your home from the mains? [If yes] How often is the electricity actually available?

Table 3: Recoded electricity

Variable Label	Original Value
No mains electrical supply or connection to the home	0
Never	1
Occasionally	2
Half the time	3
Most of the time	4
All the time	5
Note:	Access to electricity is not recoded.

In what type of shelter does the respondent live?

The recoding of shelter type is based on the assumed amenities provided by a shelter type. Formal houses are more likely to have direct access to water and electricity, while temporary structures tend to have limited amenities. Due to its ambiguity and small contribution to the sample size, "other" was removed from the sample.

Table 4: Recoded shelter type

Variable Label	Original Value	Recoded Value
Non-traditional/ formal house	1	5
Traditional house/hut	2	2
Temporary structure/ shack	3	0
Flat in a block of flats	4	4
Single room in a larger dwelling structure or backyard	5	3
Hostel in an industrial compound or farming compound	7	1

3.6.3.3 Lived Poverty Index

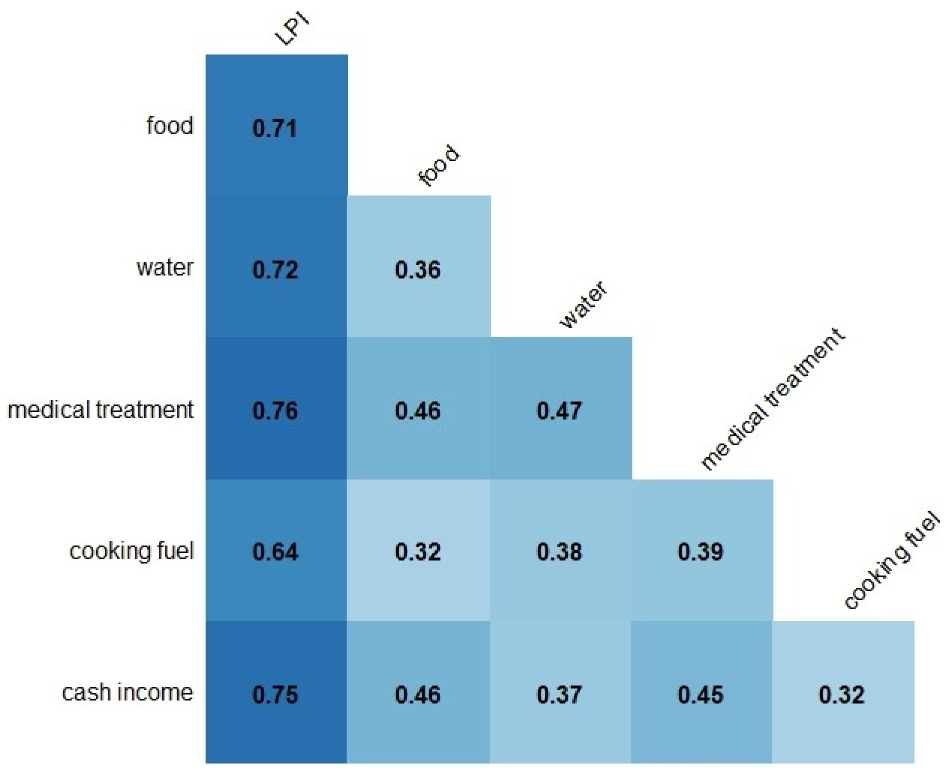

Figure 7: Correlation matrix for LPI components

Note: Cronbach's $\alpha = 0.76$

In line with the index created by Mattes et al. (2003), this paper uses LPI to measure the general living standards of survey respondents. However, the indicators are inverted so that a score of 0 indicates no lived poverty and a score of 5 indicates the constant absence of basic necessitates. The inversion of the scale allows for consistency between LPI and the infrastructure indices. The responses are then added and averaged out for each individual so that each respondent has an aggregate Lived Poverty score between 0 and 1.

Table 5: LPI recode

Variable Label	Original Value	Recoded Value
Never	0	4
Just once or twice	1	3
Several times	2	2
Many times	3	1
Always	4	0

Over the past year, how often, if ever, have you or anyone in your family:

- *Gone without enough food to eat*
- *Gone without enough clean water for home use?*
- *Gone without medicines or medical treatment?*
- *Gone without enough fuel to cook your food?*
- *Gone without a cash income?*

3.7 Summary of Variables

Table 6 lists the sample by country. It provides a breakdown of the number of individuals who live within 50km of a future or active mine, the urban and rural plot, the mean of each country's score for each index, and the mean distance individuals live from an active mine in kilometres. The largest sub-sample is South Africa, which is to be expected because it has the largest and most mature extractive industry in the region.

Table 6: Summary statistics by country

Country	N	Future	Active	rural	urban	DII $\bar{x}$	HII $\bar{x}$	LPI $\bar{x}$	km $\bar{x}$
Botswana	216	0	216	152	64	0.84	0.72	0.76	28.84
Burkina Faso	336	136	200	256	80	0.54	0.47	0.66	47.40
Gabon	120	0	120	16	104	0.76	0.85	0.56	28.78
Ghana	608	56	552	296	312	0.73	0.56	0.84	36.28
Guinea	256	64	192	208	48	0.46	0.48	0.64	35.58
Ivory Coast	72	8	64	48	24	0.50	0.75	0.63	39.46
Lesotho	160	0	160	144	16	0.50	0.41	0.60	33.82
Liberia	80	24	56	64	16	0.30	0.47	0.56	49.58
Madagascar	24	0	24	16	8	0.67	0.34	0.67	27.89
Malawi	72	0	72	72	0	0.59	0.46	0.80	27.91
Mali	80	16	64	80	0	0.33	0.46	0.74	35.90
Mozambique	80	0	80	40	40	0.49	0.55	0.58	29.60
Namibia	296	40	256	8	288	0.63	0.69	0.86	32.71
Niger	32	16	16	24	8	0.38	0.57	0.74	46.45
Sierra Leone	366	175	191	286	80	0.41	0.39	0.69	52.41
South Africa	943	48	895	208	735	0.73	0.84	0.87	23.17
Tanzania	311	24	287	208	735	0.50	0.43	0.73	35.61
Zambia	192	0	192	48	144	0.85	0.70	0.77	16.76
Zimbabwe	552	56	496	336	216	0.55	0.62	0.70	30.77

Table 7: Operational Definitions of Research Variables

Variable	Conceptual Definition	Operational Definition	Level of Measurement	Measurement
DII	Ease of access to development infrastructure	Composite measure of access to services present in the PSU	Composite Ordinal	0-1
HII	Ease of access to infrastructure ideally located within a house or compound	Composite measure of access to electricity, water, and sanitation	Composite Ordinal	0-1
LPI	Frequency with which people experience shortages of basic necessities	Composite index of frequency of shortages of food, water, cooking fuel, medical care and cash income	Composite Ordinal	0-1
distance	Distance an individual is from an active mine	Distance in km between mine coordinates and PSU coordinates	Ratio	0-4
active	Large-scale mine currently in production	Dummy variable of large-scale mines currently in production within 50km of a respondent, otherwise a large-scale mine currently not in production within 100km of a mine	Dichotamous Nominal	active or future
country	Demographic characteristic	Country in which the respondent resides at time of interview	Nominal	Factor country names
urban	Demographic characteristic	Dummy variable of urban or rural primary sampling unit	Dichotamous Nominal	urban or rural

3.8 Procedure for testing hypothesis

To test the hypothesis, I use the lmer function of the lme4 package (Bates et al. 2015) in R, a language and environment for statistical computing (R Core Team 2018). The hypotheses are tested at a probability level of .05 using likelihood ratio tests of the full model with the fixed effect in question against the model without the effect in question. In all three cases, the independent fixed variables are distance in kilometres and a dummy variable indicating if a respondent lives within 50km of an active mine. As random effects, there is an intercept for the country. Also, there is an intercept dummy variable indicating if the respondent resides in an urban area, which is nested within a factor variable indicating the survey country.

In the null form, the hypotheses are:

H_{0_1} : The level of respondents' access to development infrastructure (DII) is not significantly dependent on their proximity to active large-scale mines.

H_{0_2} : The level of respondents' access to household infrastructure (HII) is not significantly dependent on their proximity to active large-scale mines.

H_{0_3} : The level of lived poverty (LPI) experienced by respondents' is not significantly dependent on their proximity to active large-scale mines.

4 Analysis and Results

4.1 Introduction

This chapter presents the results of the study. A bivariate analysis of the variables is conducted, followed by the results of the regressions. The results demonstrate no significant relationship, positive or otherwise, between proximity to large-scale mines and living condition outcomes. Section 4.4 confirm that the results are robust. The chapter concludes with a summary of the findings.

4.2 Bivariate Analysis

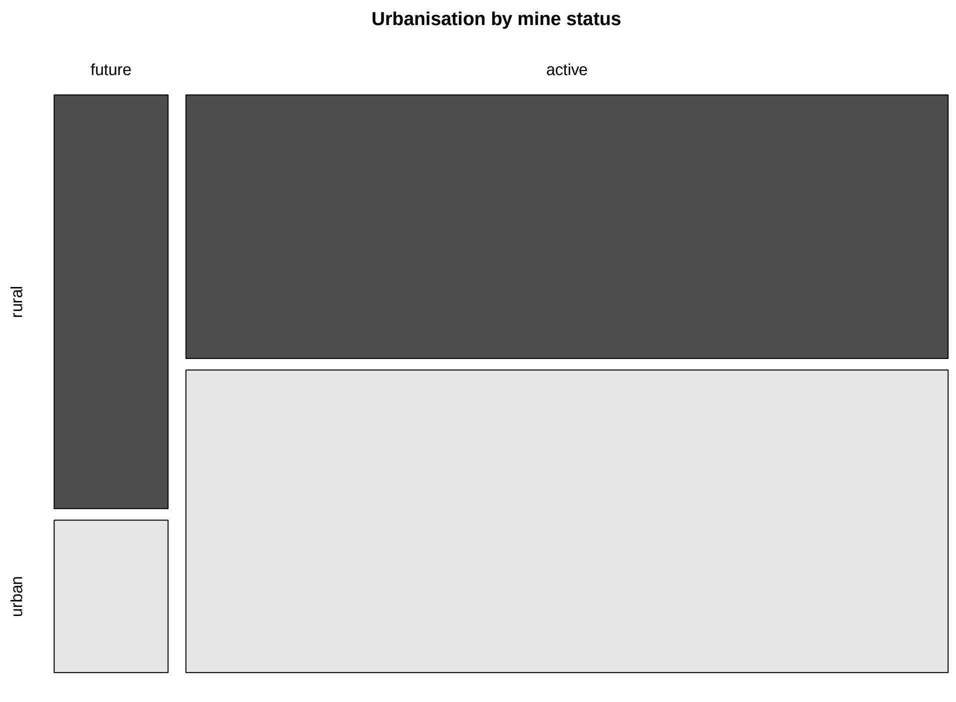

Figure 8: Mosaic plot

Figure 8 illustrates that the sample is skewed towards active mines, which accounts for 86% of the sample. The urban/rural split is balanced, with rural populations slightly over-represented making up 54% of the sample. The difference of proportions mine status and urbanisation is 0.12, indicating that urban areas may be as much as 12% more likely to be located within 50km of an active mine.

Figure 9 show a similar pattern – active mines have higher median index scores than their rural counterparts, although this difference is less pronounced with LPI. Similarly, urban areas have higher index scores across all three indicators, suggesting a positive and notable link between urbanisation and improvement in living conditions.

Figure 10 shows the linear relationship with the living condition indexes and distance from an active mine. In all cases, the index score drops as an individual moves away from the mine, dropping off significantly at the 50km mark. However, this effect is minimal in LPI, suggesting that distance from an active mine is not correlated with lived poverty.

Based on the bivariate analysis, one can expect to see a positive correlation between the infrastructure scores and both fixed effects (distance and mine status) as well as little to no relationship between LPI and mine status or proximity. Similarly, the bivariate distributions suggest that urbanisation effects have a significant impact on living condition outcomes.

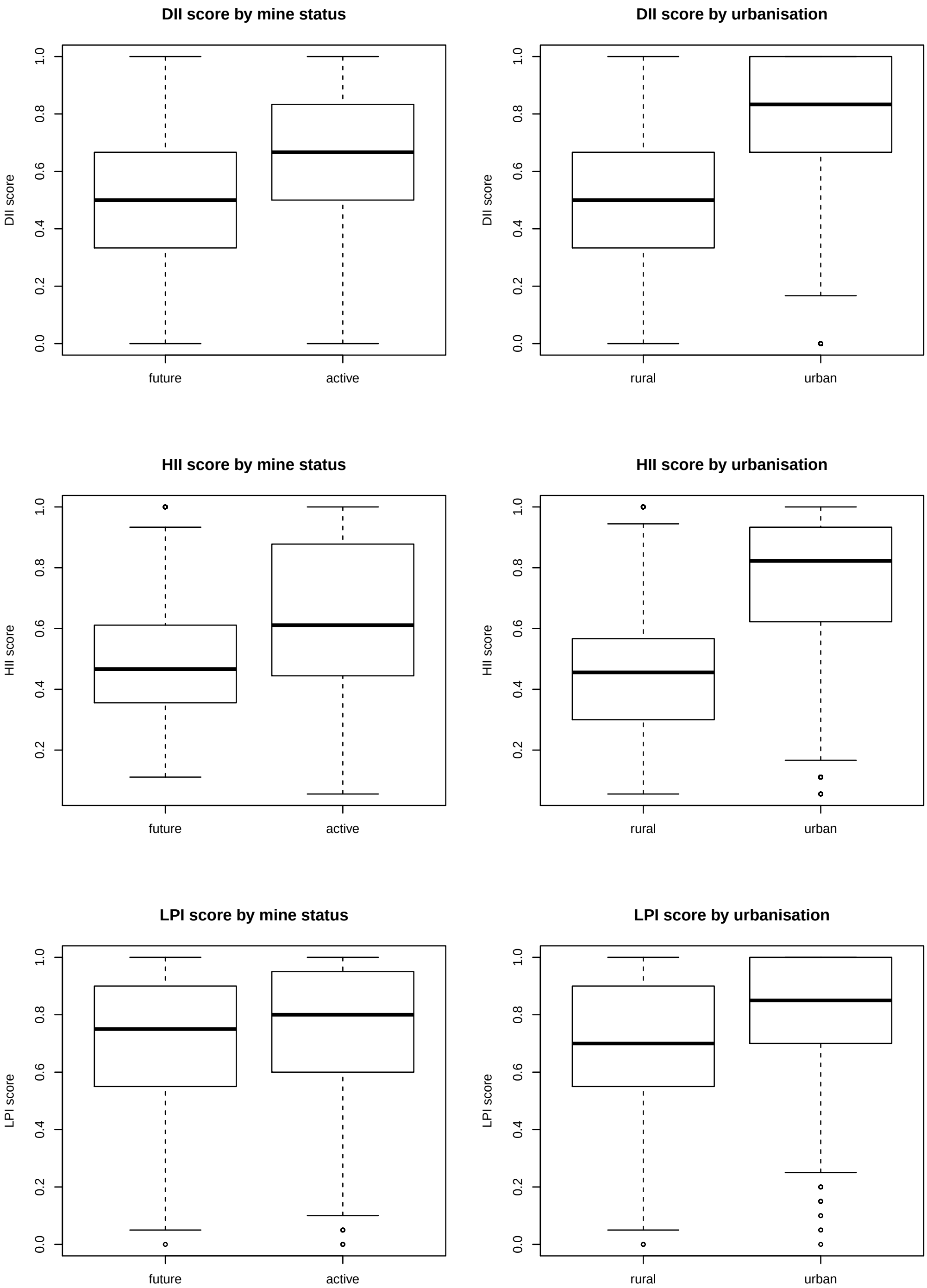

Figure 9: Box plots of index distribution

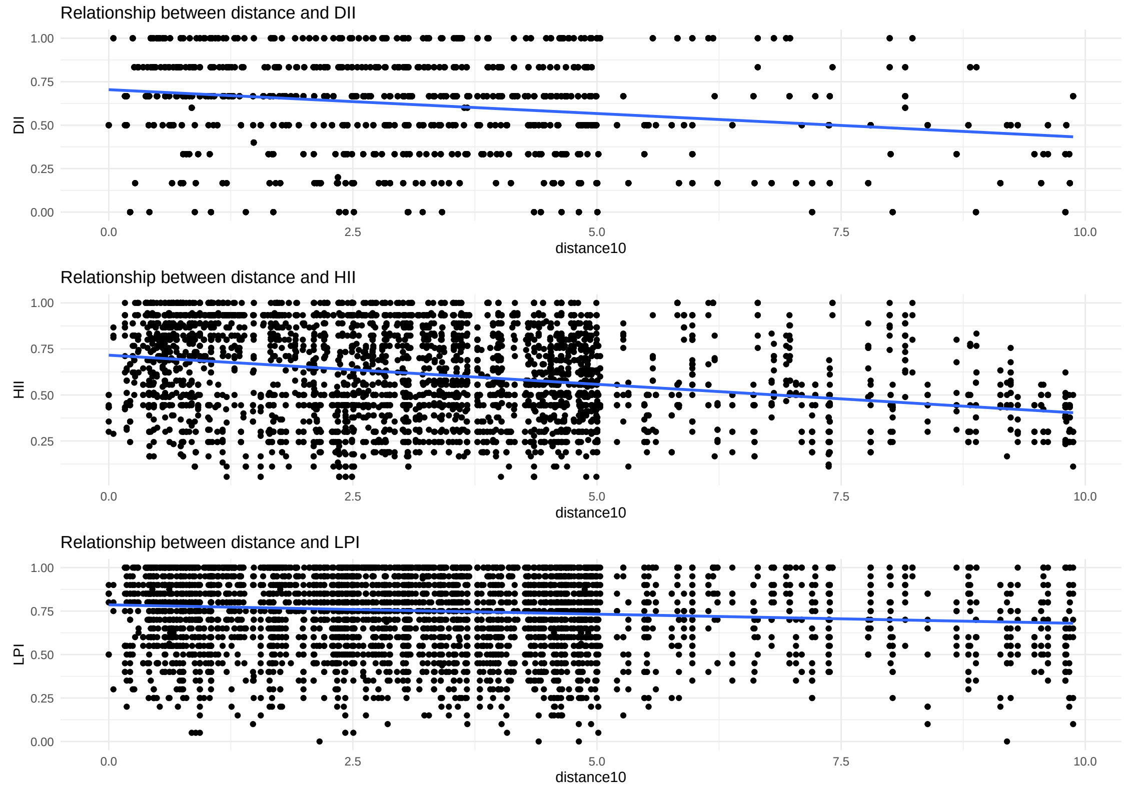

Figure 10: Scatterplots of distance distribution

4.3 Main Results

The results presented in Table 8 indicate that the null hypotheses for each indicator cannot be rejected with 95% confidence. In all cases, visual inspection of residual plots did not reveal apparent deviations from homoscedasticity or normality.

Living within 50km of an active mine increases DII by 1% ($\chi^2(1) = 0.04$, p= 0.85). Expanding the radius from 50km to 100km, the distance in km an individual is from a mine is statistically insignificant,, $\chi^2(1) = 0.18$, p = 0.67. Urban rural effects are not nested within country effects as this specification is too complex given the sample size. Nonetheless, there is a 4% variation between urban and rural enumeration areas, and 2% variation in country effects. The conditional R^2 indicates that the random effects accounts for 52% of the variation in DII. These results indicate that the null hypotheses cannot

Table 8: Main Regression Results

	Dependent variable:		
	DII	HII	LPI
Fixed Effects	(1)	(2)	(3)
distance (100km)	0.003	−0.003	−0.001
	(0.01)	(0.002)	(0.002)
mine status (50km)	0.01	-0.03^{**}	−0.02
	(0.04)	(0.01)	(0.01)
Constant	0.59^{***}	0.63^{***}	0.73^{***}
	(0.15)	(0.04)	(0.03)
Random Effects			
residual σ^2	0.05	0.03	0.04
country ${\tau_{00}}^2$	0.02	0.00	0.01
nested urban ${\tau_{00}}^2$		0.03	0.00
urban ${\tau_{00}}^2$	0.04		
ICC	0.52	0.51	0.21
Observations	591	4,795	4,793
Country N	19	19	19
Marginal R^2/Conditional R^2	0.000/0.520	0.001/0.510	0.000/0.207
Note:			*p<0.1; **p<0.05; ***p<0.01 Standard errors reported in brackets P-values obtained via likelihood ratio tests

be rejected with 95% confidence.

The null hypothesis that distance from an active mine has no impact on an individual's HII score cannot be rejected with 95% confidence. The results indicate that mining activity has a small negative effect on HII. Individuals living within 50km of an active mine are likely to have a 3% lower HII score than those living around future mines, score $\chi^2(1) = 5.92$, p = 0.02. For every 10km an individual lives away from an active mine, ,an individual can expect to have a 0.3% lower HII score $\chi^2(1) = 1.93$, p =

0.16 ± 0.002 (standard errors). Urbanisation accounts for 3% of the variation in HII.

This mirroring between the DII and HII results is expected – one would expect for these two indicators to be closely related, mainly because one cannot have access to household infrastructure without the presence of development infrastructure in one's enumeration area or neighbourhood. Similarly, the variation accounted for by urbanisation in both models suggests that improved access to infrastructure is more a result of urbanisation rather than the mining activity itself. However, it remains unclear as to what the mechanism for urbanisation is, which may very well be as a result of industrial mining.

Similar to the infrastructure indices, the the explanatory power of the LPI regression is weak, as indicated by the low marginal and conditional R^2 indicated in Table 8. Neither the fixed nor the random effects shed significant understanding of what may be driving the levels of lived poverty within local mining communities. Furthermore, likelihood ratio tests confirm that the fixed effects provide no explanatory power to the predictions. The predicted values using marginal effects echo these results. This initial analysis shows that when country and urbanisation effects are controlled, the infrastructure access benefits to local mining communities seemingly disappear.

Further analysis of the random effect coefficients is illuminating. The overall pattern in Figure 11 indicates that countries with higher GDP per capita [2] perform better on the DII index, suggesting that a country's standard of living, rather than the raw size of the economy, is a better predictor of access to development infrastructure at a local level. The exceptions to this are Malawi and Madagascar, who both achieve positive residuals despite having significantly smaller GDP per capita scores than the six other positively

2. GDP per capita graph (Figure 17) available in Appendix (World Bank 2019; Arel-Bundock 2019)

scoring countries.

The strongest predictor of HII is a household being in an urban area (figure 12). Notable exceptions are Liberia, Guinea and Sierra Leone who score negative residuals in their urban areas, and Botswana, Gabon and Ivory Coast whose residuals for rural areas are positive. Given Ivory Coast's relatively low rates of urbanisation and GDP per capita, the country perform unexpectedly well when compared to other countries in the sample.In contrast to the infrastructure indices, neither country nor urban rural effects produce much variation in LPI scores, as evidenced by the overlapping confidence intervals in Figure 13. This suggests that effects not accounted for in this model is affecting its outcome.

To gain further insight regarding the mechanisms driving these results, the outlying cases of Malawi, Madagascar and Ivory Coast is discussed in Chapter 5.

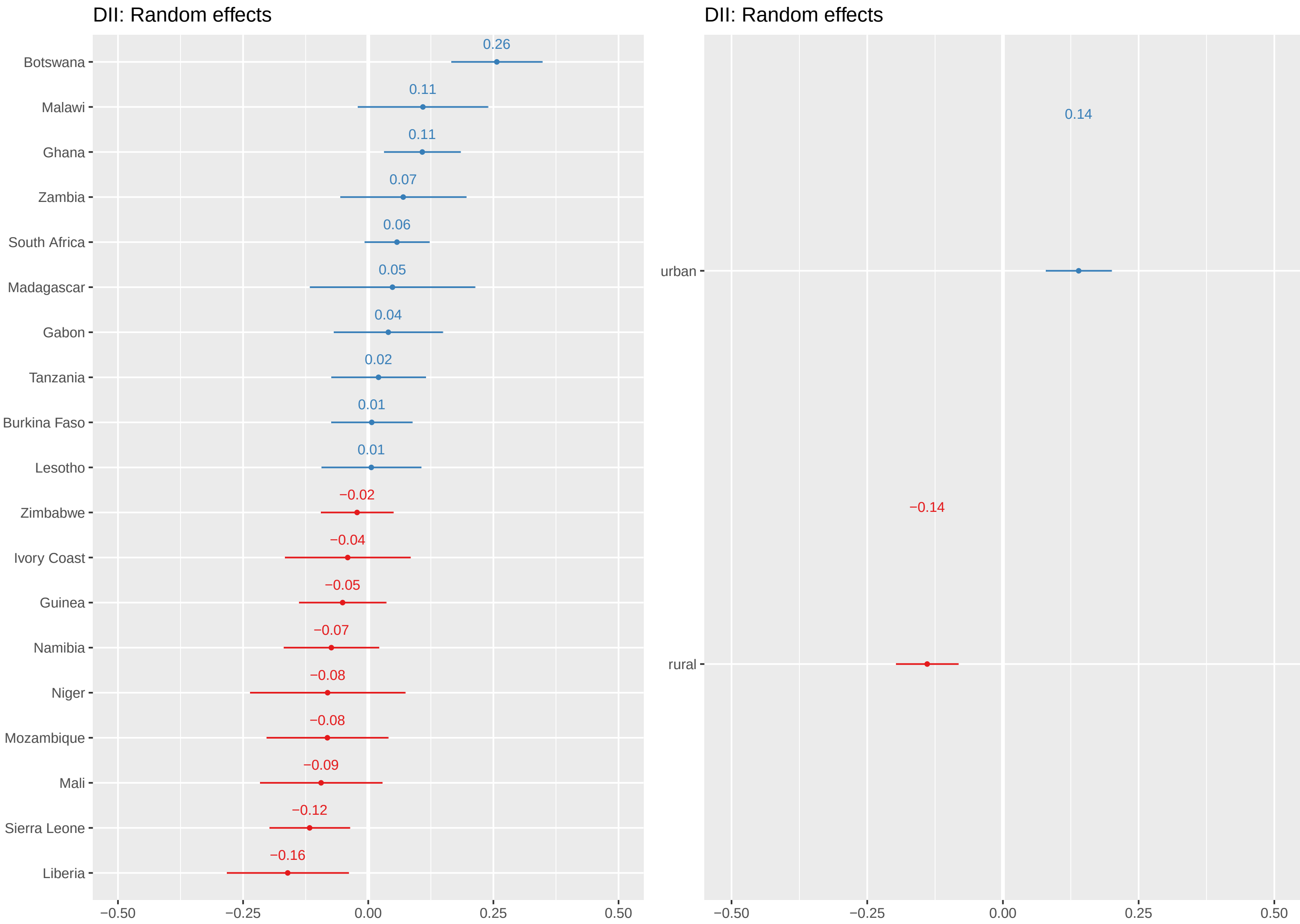

Figure 11: Random effects for DII

Figure 12: Random effects for HII

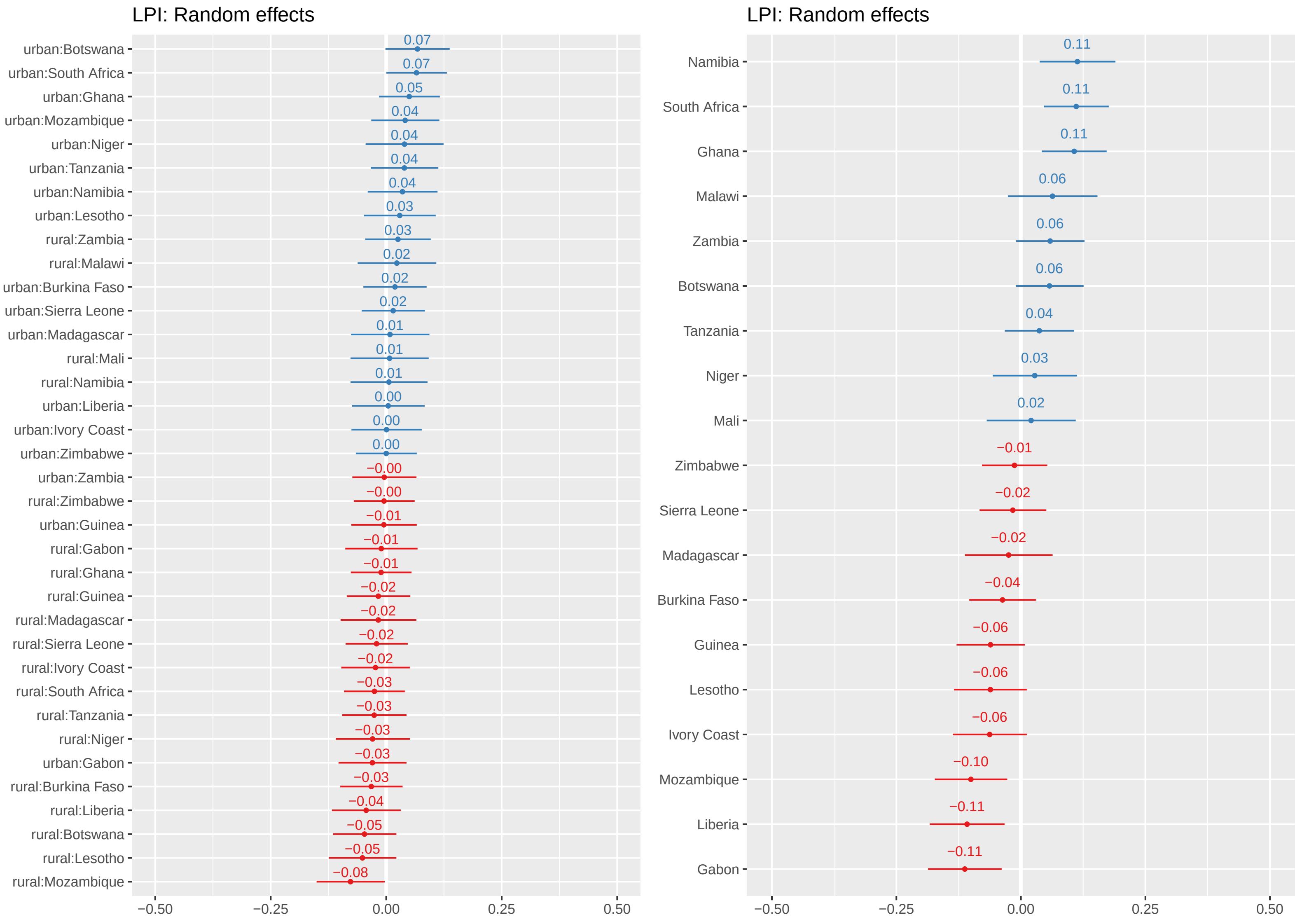

Figure 13: Random effects for LPI

4.4 Robustness Checks

4.4.1 Alternative Models

Presented in Table 9 are the results using the generalised linear mixed-effects models where the dependent variables index proportions (i.e successes versus failures or trials) and regular binomial regressions. The binomial models yield similar results to the main regression but are not the preferred model due to its poorer ICC and conditional R^2 scores. Likewise, simple linear regressions yield comparable results to the main regressions, without the added sensitivity provided by mixed nested models (Table 11). By selecting a mixed-effects model with country and urban terms specified as random effects, this model is able to control for extraneous factors more effectively than is possible with a least ordinary squares regression.

Despite these differences and shortcomings, the general trend of all the alternative models are similar – the null hypothesis cannot be rejected for the three indices. This parallel does suggest that the null results have internal validity and are robust. In addition to investigating the dependent variables of interest, this study also investigated each component of the DII index separately by country.

Table 9: Alternative GLM models

	Dependent variable:					
	DII prop	DII	HII prop	HII	LPI prop	LPI
	(1)	(2)	(3)	(4)	(5)	(6)
distance (km)	0.01	−0.01	−0.02***	0.02	0.003	−0.02
	(0.02)	(0.08)	(0.01)	(0.03)	(0.01)	(0.03)
mine status	0.03	0.14	−0.12***	−0.07	−0.04	−0.15
	(0.14)	(0.44)	(0.03)	(0.15)	(0.03)	(0.17)
Constant	1.00***	0.11	1.19***	0.29	1.34***	1.61***
	(0.35)	(0.65)	(0.22)	(0.31)	(0.13)	(0.25)
Random Effects						
residual σ^2	3.29	3.29	3.29	3.29	3.29	3.29
country ${\tau_{00}}^2$	0.08	0.00	0.14	0.08	0.12	0.05
nested urban ${\tau_{00}}^2$		1.54		1.65		0.18
urban ${\tau_{00}}^2$	0.17		0.08		0.02	
ICC	0.07		0.06	0.35	0.04	0.07
Observations	591	591	4,795	4,795	4,796	4,793
Country N	19	19	19	19	19	19
Marginal R^2/Conditional R^2	0.000/0.069	0.000/0.061	0.001/0.346	0.000/0.041	0.000/0.066	
Note:						*p<0.1; **p<0.05; ***p<0.01

4.4.2 Simulations

Simulations are run using the R function "shinyMer" in the merTools (Knowles and Frederick 2019) package to determine how much the variation in the index scores are a consequence of the distance from a mine versus country effects. For each model, 1 000 simulations are run using random observations from the original regressions' posterior distributions if all else is held constant. Figures figures 14 and 15 illustrate the magnitude of effects of the simulations, which are consistent with the findings reported in Table 8.

Using the function REimpact from the same package, a new data frame is created for each index which includes a calculation of the average predicted value for each case as the simulated data is moved from the first to the fifth magnitude quantile (ranking bin) of the grouping term for each case, which in this case is country effects.

Each data frame comprises of a total of 23 980 cases. The results of this simulation differ slightly from the main results, but the general pattern holds. The results indicate that distance from a mine has no impact on living condition outcomes, as evidenced by the virtually identical estimations for each bin. Similarly, country effects have the most substantial impact on the index scores, as seen in Figure 16.

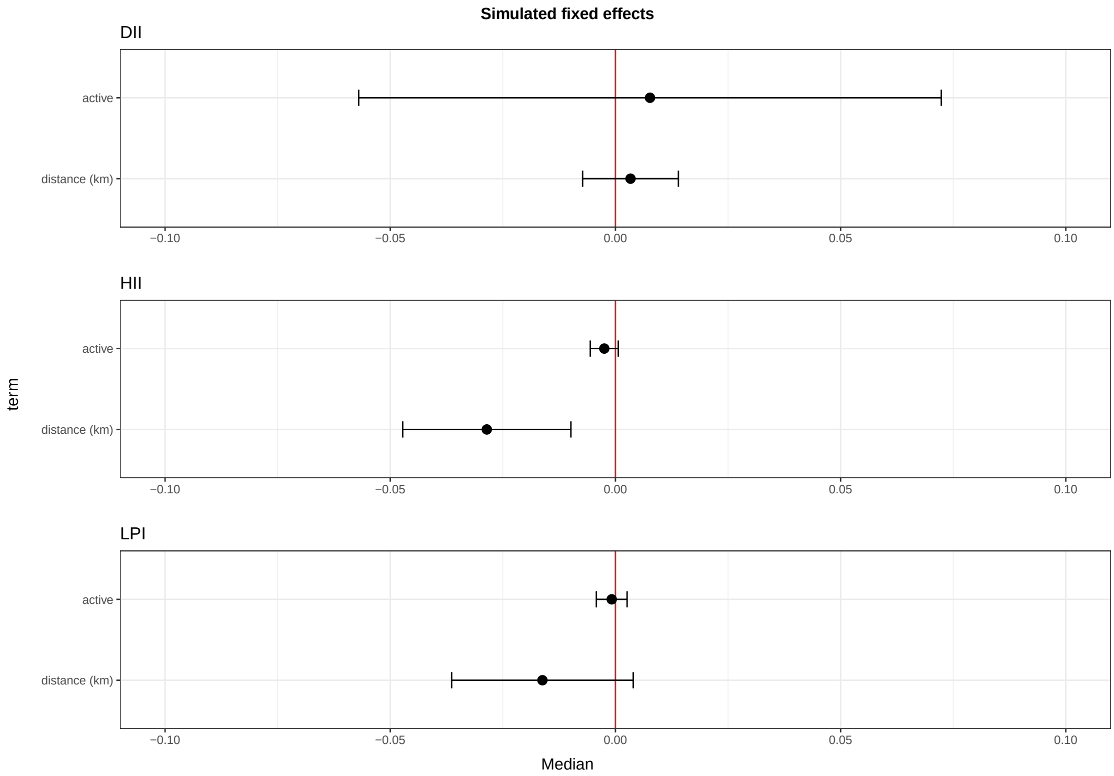

Figure 14: Simulated fixed effects

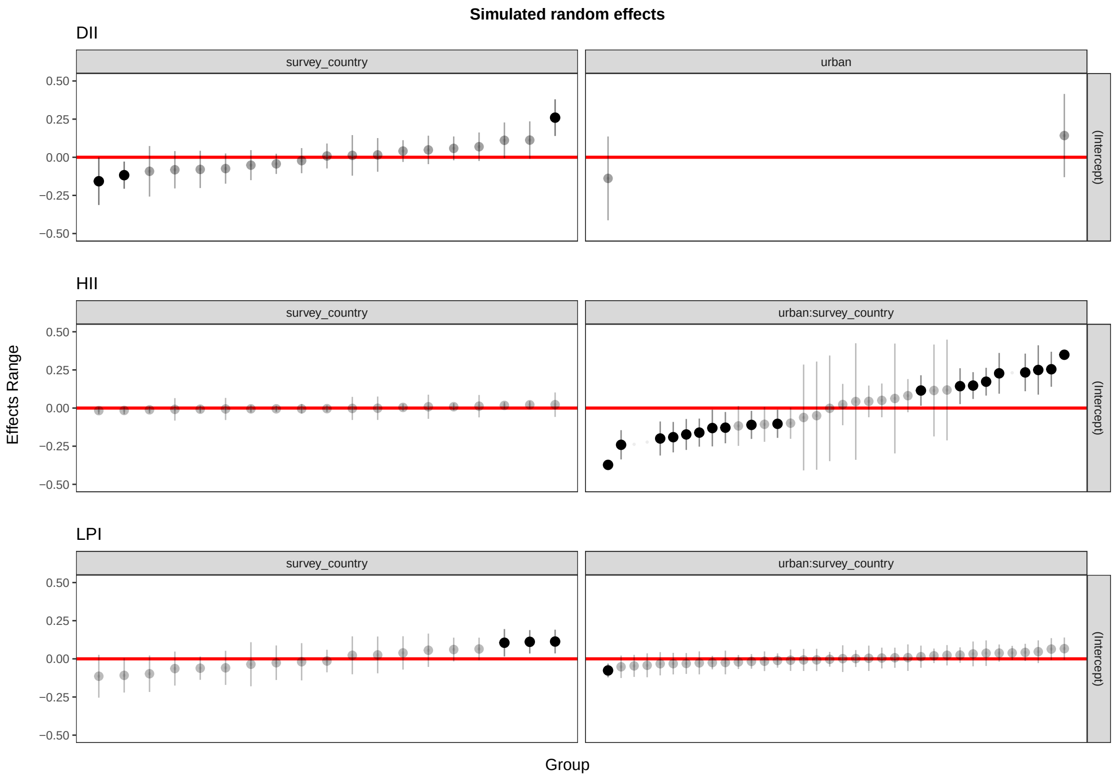

Figure 15: Simulated random effects

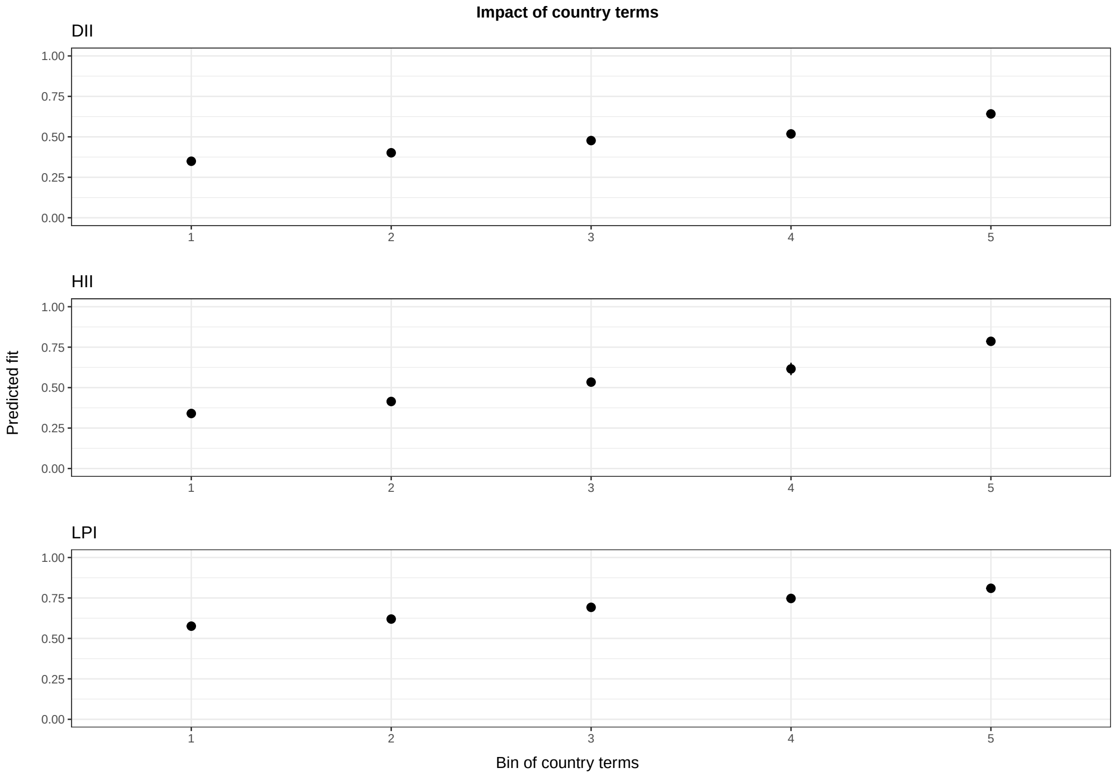

Figure 16: Simulated impact of country terms

4.5 Conclusion

The results of this study indicate the following:

1. Overall, proximity to a large-scale mine has little to no effect on an individual's living conditions.
2. Communities that are located near a large-scale mine are slightly more likely to have access to development infrastructure when compared to similar communities without a local mine in proximity.
3. The presence of a mine in an area makes has a small positive impact on access to household infrastructure.
4. Proximity to large-scale mines has no impact on poverty levels in surrounding communities.

Furthermore, the random effects reveal that the strongest indicator of access to development infrastructure is the country in which an individual resides, while access to household infrastructure is increased if an individual lives in an urban area. Concerning LPI, the results may indicate that the best predictor of lowered lived poverty levels is the size of a country's GDP per capita.

5 Case Studies

5.1 Introduction

Chapter 4 provided an overview of the main regression results, where results indicated that there is no notable relationship between local living condition outcomes and large-scale mine proximity. However, visual inspection of the random effects' coefficients revealed notable outliers from the general pattern of urban areas and countries with larger GDP per capita outperforming their counterparts. To gain further insight, this chapter investigates each of these countries – Malawi, Madagascar, and Ivory Coast.

5.2 Malawi

Malawi is highlighted as a notable outlier because of the country's positive residual in the DII regression (Figure 11). Malawi's sample is comprised entirely of rural observations located within 31km of the Kayelekera uranium mine. Despite the rural and agricultural leaning of the sample, most respondents report living in a formal or non-traditional house with the remainder of the sample living in traditional dwellings such as huts. Kayelekera is Malawi's largest mine and at its peak provides 1% of the world's uranium. Owned by Paladin (Africa) Limited, a subsidiary of Paladin Energy, the mine itself is located 52km west of Karonga (Chareyron 2015, 6-7).

Phiri et al. (2013) note that following the construction of the Kayelekera mine, Paladin has renovated the local primary school as well as the hospital and school situated in nearby Karonga. In addition, Paladin has constructed a water plant which was transferred to local government and a footpath bridge near the local village. Along with these infrastructure investments, more banks have been established in Karonga following the opening of the mine, suggesting more money is now in circulation. These activities are likely correlated with the positive DII score, suggesting that large-scale mining may indeed have a positive and notable impact on local communities' access to the development of infrastructure.

However, it would be remiss not to note that this result did not translate to the outcomes for HIIand LPI. Indeed, as this section will reveal, the positive infrastructure gained may not be worth the negative impacts of the mine on local communities, including impacts felt as a result of radiation and corruption.

Malawi's legislation regarding mineral governance is unsatisfactory. The Mines and Minerals Act of 1981 does not require any input from civil society and parliament to grant a mining license because minerals of Malawi are vested in the President, and therefore can be granted at the ministerial discretion (Masebo 2013). Consequently, the legislation lacks the necessary foundation to ensure the transparent and fair establishment of any mine. This legislative deficiency is apparent in the establishment of Kayelekera.

The deal struck between the two parties favours Paladin at the expense of Malawi's potential for earnings. Several concessions were made for Malawi's government to gain a 15% stake in the mine including a 3% reduction in corporate tax, the elimination of resource rents, and enjoying a VAT exemption for the duration of the mine's lifespan. Furthermore, the standard royalties' arrangement of 5% of the gross value of minerals was reduced to 1.5% in the first three years and 3% after that (Phiri, Nyoni, et al. 2013).

Compounding this loss of revenue for the state is that since its establishment, Kayelekera has never reported a profit resulting in the government never benefiting from its 15% stake. Phiri et al. (2013, 26) note that “there seems to be no relationship between the price of uranium oxide and the quantity exported” and that this “violates the natural laws of economics”. They conclude that this contradiction is likely due to illicit financial flows in the form of shifting profits to holdings in tax haves such as the Netherlands.

In addition to the revenue losses sustained by the government, the local communities surrounding the mine have been affected negatively (except for the improved development infrastructure). Interviews conducted by Lindskog (2015) and research conducted by Maseba (2013)suggest that chiefs and community leaders have received bribes of Paladin to quiet community dissent, effectively disempowering local communities. Data gathered one year after the mine suspended production due to a dip in world uranium prices by Environmental Justice Organizations, Liabilities and Trade (EJOT) shows that the nearby Sere river’s radiation levels exceeds WHO standards and that workers are at an increased risk of cancers and non-cancerous pathologies. The EJOT report further notes that Paladin has been uncooperative and has not released its radiation monitoring results (Chareyron 2015). These findings are supported by Lindskog’s (Lindskog 2015) observations of dead fish washing ashore and interviews with former workers who cannot return to farming due to illnesses presumably contracted from working at the mine.

The establishment of Kayekere has also resulted in the disruption of local communities’ way of life. Communities have reported an increase in incidences of HIV and AIDS, and prostitution. Furthermore, police records indicate an uptick in crime. The increase of money in circulation in the area has raised the prices of goods and services and led to inflation. However, the most significant disruption in local livelihoods is because of displacement and resettlement. Relocated families were given 95 as compensation for lost land and crops and to restart their lives (Masebo 2013, 4). Lindskog (Lindskog 2015, 16) describes a relocated man who can no longer afford school fees due to inadequate compensation for loss of income.

In sum, although the presence of the Kayekere mine has provided an improvement in the infrastructure surrounding the mine, it has come at the expense of local communities. Furthermore, these local costs are not offset by income for the state due to poorly negotiated terms between the Malawian government and Paladin.

5.3 Madagascar

All 24 observations making up the Madagascar sample are within 50km of the Fort Dauphin Open Pit Ilmenite Mine. The sample is mainly rural (16 observations) with almost half of the respondents working in agriculture and more than half living in temporary dwellings such as shacks. The mine is owned by QIT Minerals Madagascar (QMM), a subsidiary of the UK-Australian multinational mining firm Rio Tinto.

Like the Malawi sample, Madagascar outperformed more developed countries in the sample in the DII measure, suggesting that the presence of QMM has afforded local communities positive gains in terms of development infrastructure access. Interviews conducted by the Andrew Lees Trust (Andrew Lees Trust 2009) in the same year that extraction began reveal that this is the case; however, improved access to infrastructure has come at the cost of lowering experiences of lived poverty. This case study highlights how the establishment of the QMM mine near Fort Dauphin has altered the way of life for the surrounding communities.

The Fort Dauphin mine was established in 2005 on 6000 hectares of the last remaining coastal rainforest in Madagascar – the equivalent size of San Marino (the European micro-state surrounded by Italy) with 1 000 hectares of that area earmarked for conservation efforts. This area is one of Madagascar's poorest, with its majority reliant on subsistence farming, fishing and the forest's resources before the mine's establishment. The mine itself extracts illemite (the primary source of titanium oxide used in toothpaste, paints and cosmetics) and requires large amounts of freshwater and an artificial lake (Seagle 2012).

The Fort Dauphin project was greeted with optimism by key actors who speculated that the project would be a catalyst for significant economic development and global investment in Madagascar, all while embracing ethical and environmentally responsible methods. In 2008, Rito Tinto was acknowledged for going "above and beyond the legal requirements necessary to reduce its carbon footprint and impact on the environment" (452) when US-based think tank Ethisphere named the company one of the most ethical in the world. In addition, the project enjoyed the support of the World Bank via its Integrated Growth Poles Project which aims to increase economic opportunities and access to infrastructure by encouraging international investors via land reform (Harbinson 2007, 38 - 39).

QMM has improved the development infrastructure of the surrounding mines in numerous ways, including the improvement of the Mandena access road, and building a new port, several schools and health clinics, and providing homes to relocated families (Harbinson 2007). Fanja, a 22-year-old woman from nearby St Luce, remarks that "[QMM] built wells for the local community...and a health centre... Before, pregnant women... had to go to Mahatalaky to deliver their babies. Bringing a woman on a stretcher [on foot] to Mahatalaky was not easy... Now, a pregnant woman can go to the health centre in the village. [So] I am grateful that there is a health centre available to us now...” (Andrew Lees Trust 2009, 20). QMM also provided compensation to local communities for loss of land and income. However, this amount was too low to maintain the same standard of living before QMM’s arrival, with one villager noting that, “QMM gave money to people, and now they are poor” (Seagle 2012, 458).

QMM has made good on its promises of incorporating conservation efforts and improving the development infrastructure of the area. However, these efforts have been inadequate compensation for the loss of livelihood and biodiversity of local communities. Furthermore, QMM’s strategy of “biodiversity offsetting” (Seagle 2012) has disenfranchised local communities and has repositioned these communities as enemies of biodiversity, and QMM as its guardian. Seagle (2012) outlines five avenues of compensation that QMM has implemented as a means of sustainable development and how these programmes have been used as tools to offset environmental responsibilities and cost onto local communities. These compensation initiatives include; ecotourism, increased agricultural productivity, improved fishing practices, the introduction of reed and eucalyptus plantations, and conservation area management.

Prior to QMM’s arrival, local communities were heavily reliant on nearby fauna and flora to meet basic human needs including food, water, medicine, shelter and a means to generate income. However, much of this land is now in control of QMM who heavily restricts access as noted by 83-year-old Olina of St Luce; “[QMM] owns everything, the land, the forest, everything belongs to them. Even our ancestral land belongs to them. Amazing!” (Andrew Lees Trust 2009, 26). Land set aside for conservation by QMM is no longer accessible to local populations and is punishable by fines. This means that villagers no longer have access to their ancestral burial grounds, the abundant tropical fruit, medicinal plants or materials to construct homes. Several villagers interviewed by the Andrew Lee Trust (2009) complained of increased food insecurity and experiences of lived poverty since QMM's arrival. Due to the lack of available land nearby, locals are forced to grow their staple crops on less fertile mountainous terrain and are threatened with fines by government officials. Additionally, QMM attributes sharp reduction in quantity and size of fish in local waters to overfishing, rather than the creation of the dam. In response to this claim, the mine implemented conservation measures, including the introduction of sustainable fishing nets and fines for catching juvenile fish. In sum, locals have been disposed of land, offered no suitable alternative, and cast as the principal cause of biodiversity loss.

5.4 Ivory Coast

The Ivory Coast sample mostly comprises of individuals who live around the country's largest gold mine Bonikro (48 observations) followed by Tongon gold mine (16 observations) and Lauzoua Manganese mine (8 observations). Ivory Coast outperforms its wealthier counterparts on HII in both its rural and urban samples. This case study focuses on the Bonikro and Tongon gold mines to shed light on why Ivory Coast performed well on the HII measure, and if this is attributable to the large-scale mines in the area.

Ivory Coast is notable for its relatively advanced infrastructure system. It boasts an extensive road network with over 75 000km of paved road in a country and is home to two modern deep-water ports, one of which is the second largest port in West Africa. The country is also a net exporter of energy due to its hydro, gas, and coal industries, and has a reliable national airline (Mining Review Africa 2017). As of 2015, 93.1% of its urban population and 68.8% of its rural population has access to clean drinking water (FOA 2016) and and 88% of its urban population and 31% of its rural population has access to the electricity grid(Power Africa 2019). The country has undergone rapid economic expansion since the end of its civil war in 2007 and the election of Alassane Ouattara in 2010, with an average GDP growth rate 9.2% over the 2012- 2016 period, making Ivory Coast the fastest growing economy in Africa at the time (Toure 2018). To support this rapid growth, the government has prioritised improving its infrastructure system by increasing spending in health, education, security, and rural electrification.

Literature investigating the impact of the mining industry on local communities is limited to the consequences of artisanal mining on industrial mining and the proliferation of child labour (Kouame Joseph Arthur Kouame et al. 2016; Irene Schipper, Esther de Haan, and Mark van Dorp 2015). Similarly, very little information is publicly available on the three mines included in the sample, with media information mostly limited to business dealings.

Bonikro Mine is situated in the south-central region of the country, three and a half hours away by car from Abidjan and a 25-minute drive from the closest town, Hiré. Respondents live between 8.5 – 48km away from this mine. The average HII score of respondents near Bonikro mine is 0.75. At the time of the survey, the mine was under the control of the Australian company Newcrest Mining LTD (Afrique Gold acquired the mine in 2018). Before the opening of the open-pit gold mine in 2008, local communities relied mostly on subsistence farming and cash crops as a living.

Newcrest's sustainability reports reveal an initial substantial infrastructure investment in the areas surrounding the mine. In 2011, Newcrest invested $750 000 in the refurbishment of surrounding schools, the hospital, the football stadium, and nearby roads. In 2012, Newcrest formed a partnership with the UNDP to provide vocational training to local boys and girls, community-based infrastructure, including sanitation services and income-generating activities (Newcrest Mining Limited 2011, 30). Later sustainability reports do not provide further information on the status of these projects, and instead, shifts focus to their malaria and Ebola management projects (Newcrest Mining Limited 2015, 2016).

Despite this initial investment in community-based infrastructure, local communities feel that ultimately the presence of the mine has worsened, rather than improved, access to infrastructure. Due to the opening of the mine, Hiré has seen its population proliferate, far outstripping the town's capacity. Locals report frequent electricity outages and water shortages due to demand exceeding supply, with villagers forced to buy water from private vendors. Similarly, locals bemoan the change to the community fabric that has resulted from the mine opening, with one local stating "Before the arrival of miners, people held doors open for each other [...] They say 'good morning' and hugged each other when they met in the streets" (Kouassi 2016) .Although resettlements of local communities were carried out per IFC policies (Newcrest Mining Limited 2011, 83), relocated communities are unsatisfied with the resettlement deals, with member Bandamankro village council Paul Kadio describing the resettlement packages as "woefully inadequate" (Kouassi 2016).

From publicly available accounts, the establishment of Bonikro mine has been one of mixed blessings for local communities. While Newcrest has invested in new infrastructure and facilities for the local population, the availability of jobs has resulted in a population boom which the current infrastructure cannot support. Furthermore, the mine has brought with is a disruption to the social fabric of nearby villages, leaving communities frustrated and disempowered.

In contrast, communities surrounding the Tongon Gold mine have benefited from steady community projects over a prolonged period. Located in the north of the country near the Mali and Burkina Faso borders, the site was owned and run by Randgold until 2018, when it merged with Barrick Gold Corporation. Randgold's sustainability reports between the period from 2013 – 2017 suggest a robust, sustainable development plan that goes beyond the mine's expected closure. At the time of the Barrick merger, Randgold had spent $10 million on community programmes in the areas of education and training, potable water supply, food security, health, agribusiness, microlending, and sports development (Mining Technology 2019; Randgold 2017, 2016).

The Tongon subsample mirrors Randgold's investment. The two rural PSU's are within 31km and 77km of Tongon mine. The PSU located within 31km of Tongon mine enjoys greater access to development and household infrastructure than the subsample counterparts, suggesting that there may be a correlation between infrastructure access and proximity to the mine.

Randgold has prioritised hiring locals as a matter of policy, including training and upskilling locals to take over management and technical positions initially filled by expatriates. By 2016, 97% of the Tongon Mine workforce was Ivorian, and 80% of operational labour was from the surrounding villages (Randgold 2016). Randgold began implementing its succession plan in 2014, six years before the mine's projected close. The succession plan mainly focuses on developing agribusiness within the area, including scaling up the farming of fish, pigs, poultry and produce. A microfinance scheme was also established to support these projects and enable individuals' autonomy, allowing locals, 54% of whom are women, to establish businesses throughout the value chain

(Randgold 2016, 2017).

Due to the lack of research into the impacts of the Bonikro and Tongon mines on surrounding communities, it is impossible to draw definitive conclusions as to whether large-scale mining has benefitted communities in Ivory Coast. However, this initial review reveals that the Ivory Coast government has prioritised infrastructure development. In the case of Randgold's operations in Tongon, the mine has sought to support the government's goal of infrastructure proliferation through long-term sustainability planning. Conversely, the Newcrest Bonikro population appears to have placed extra strain on the area's infrastructure system, with little social investment occurring beyond the first investment towards improving development infrastructure. Therefore, the Ivory Coast illustrates that for positive impacts to occur within mining communities, mining firms and government must work together over an extended period to maximise social good within the area.

5.5 Conclusion

This chapter delved into specific mining communities that performed better than expected on the infrastructure measures. It began by discussing cases that performed well on the DII measure. Both the Paladin mine in Malawi and the Rio Tinto mine in Madagascar invested in infrastructure that local communities benefited from, however this came at the cost of communities' self-reliance and social fabric. Next, the chapter discussed Ivory Coast, which performed well on the HII measure. It showed that Ivory Coast had a robust infrastructure network before Bonikro and Tongon opened, and that with the right long-term strategy, large-scale mining programmes can enhance pre-existing government policies. The following chapter discusses the implications of this paper's findings.

6 Discussion and Implications

6.1 Introduction

This section discusses each hypothesis in light of this dissertation's results and limitations. It then proceeds to discuss the questions raised in this paper and the possible practical implications of the findings of this study. The chapter concludes with an overview of the arguments raised in this chapter.

6.2 Impact of large-scale mining on local communities' access to development infrastructure

The literature reviewed in Chapter 2 finds that improved development infrastructure is often a spillover effect following the establishment of a mine but that this effect is small (McMahon and Moreira 2014; Lippert 2014). The results reported in Chapter 4 follow this trend, having found a small but statistically insignificant pattern that indicates DII scores decrease by 0.3% for every 10km that an enumeration area is from a mine. The studies referred to in Chapter 2 argue that development infrastructure spillover effects are due to production considerations and do not necessarily benefit local communities. Mining firms are obligated to run as efficiently as possible to generate maximum profits for their shareholders. In the absence of robust policies and adequate government and non-governmental organization (NGO) oversight, these firms have little incentive to establish infrastructure outside of what is necessary for extraction. In the case of transportation infrastructure, mines will make use of mine to sea railways and roads, negating the need for transport infrastructure that could benefit local communities. Similarly, due to the unreliability of electricity in many African countries, firms rely on their power supply, which creates no linkages within the local community (McMahon and Moreira 2014).

The case studies which investigated Malawi and Madagascar support the abovementioned arguments. Both Paladin in Malawi and QMM in Madagascar notably improved the development infrastructure of nearby communities, particularly with regards to updating or building new roads, schools, and health facilities. However, as the case studies indicate, in the absence of robust policies and effective oversight mechanisms, development infrastructure spillovers may overlap with worsened living condition outcomes for local communities, particularly in rural areas.

Despite the overlap between the findings of this dissertation and the literature reviewed, these results cannot be interpreted as evidence of direct causation. The sample size of 591 observations is too small to reject the null hypothesis with 95% confidence. Because this dissertation makes use of one round of Afrobarometer surveys, this dissertation provides a snapshot, rather than a long-term perspective of the effects of large-scale mining on local communities. The simulated fixed effects depicted in Figure 16 reflects these limitations, as the confidence intervals for the DII scores are wide. Despite this, the DII results mirror the results of previous research.

While the null hypothesis fails to be rejected, the influence of random effects suggests that the potential for large-scale mining as a mechanism for the provision of development infrastructure by international organisations such as the World Bank may be overstated. With urbanisation and country effects accounting for as much as 52% of the variation in the DII model, the results support previous findings that resource extraction is most likely to be parlayed into infrastructure provision in the presence of effective legislation and public pressure. Furthermore, the results may suggest that development infrastructure provision may be more a function of regional and national government capacity rather than private sector involvement.

6.3 Mine proximity and access to household infrastructure

Like its DII counterpart, the null hypothesis that proximity to a large-scale mine has no effect on HII scores and by extension access to household infrastructure is not rejected. The construction of the HII index is a preliminary attempt to create a consistent and replicable measure of household infrastructure access which can be tracked over time. Due to its novel construction, this index is particularly vulnerable to issues of validity. However, its results mirror its DII counterpart and previous research, suggesting internal validity.

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The impact of urbanisation in HII outcomes suggests that the process of urbanisation, rather than the presence of large-scale mining, is what drives positive HII outcomes for local communities. However, this is not to say that large-scale mining cannot induce urbanisation. Research on mining-induced urbanisation is scarce, and the nature of the causal relationship between mining and urbanisation is undetermined. Establishing mines in rural areas centralises “employment, resources and trade” (Emuze and Hauptfleisch 2014, 882) which can engender urbanisation. Historically, there is a correlation between mining and urbanisation, as was the case Koidu, Sierra Leone; Johannesburg, South Africa; the Zambian Copperbelt and Ghana’s Gold Coast. Similarly, the most urban provinces in sub-Saharan African countries frequently correlate with mining density, as is the case for Zimbabwe (Kamete 2012).

Furthermore, the case study investigating Randgold’s operations at the Tongon gold mine demonstrates that under the right circumstances, mining can be an effective mechanism for infrastructure provision. However, because this dissertation only analyses one round of Afrobarometer surveys, no conclusions can be drawn regarding the long-term implications of large-scale mining within local communities, nor large-scale mining’s role as an urbanisation catalyst.

6.4 Mine proximity and experience of lived poverty

This dissertation fails to illuminate the mechanisms involved in influencing LPI levels of local communities – the null hypothesis is not rejected, and the variance of the random effects fail to provide any explanatory power. The null result may suggest that either the model does not adequately capture mechanisms that influence lived poverty in mining areas or that quantitatively, the presence of large-scale mines makes no significant impact on local communities’ experiences of lived poverty. The latter statement is supported by the findings of previous research that either finds a negligible impact on socioeconomic outcome (Chuhan-Pole, Dabalen, and Land 2017) or worsened levels of poverty and inequality (African Development Bank (AfDB) 2016; Pegg 2006; Gamu, Billon, and Spiegel 2015; Wan 2014; Loayza and Rigolini 2016).

The case studies investigating Paladin in Malawi and QMM in Madagascar highlight the potential for large-scale mining to increase experiences of lived poverty despite monetary compensation, while Randgold in Tongon demonstrates the potential for large-scale mines to drive innovation and lift communities out of poverty. These vastly different outcomes reflect the contradictory findings of much of the research investigating the resource curse. The methodological approach of this dissertation uses newly geocoded Afrobarometer data to measure LPI outcomes in communities across sub-Saharan Africa and confirms the null hypothesis. The null result may be capturing the wide variation of lived poverty outcomes in local communities and presents an interesting hypothesis for future research.

6.5 Urbanisation as a mechanism for improved living standards

In the case of infrastructure provision, the DII and HII models reported in Chapter 5 suggest that urbanisation is strongly linked to infrastructure provision. Urbanisation is often put forward as a desirable outcome because, in the developed world, urbanisation is historically linked with industrialisation and improved living conditions. The process of urbanisation centralises populations into denser areas, resulting in more efficient and cost-effective provision of infrastructure by governments. Additionally, urban areas can breed innovative ideas due to knowledge spillover as well as increased production via economic growth (Jones 2015).

However, in developing nations that rely on natural resource exports, urbanisation does not lead to industrialisation. So, while natural resource exports do lead to urbanisation and increased income per capita, it does not increase manufacturing and service output within cities and is thus as not as effective as a mechanism for long-term development when compared to industrialisation induced urbanisation. When compared to its non-mining industrialised counterparts, and controlling for income per capita, cities that experience mining-induced urbanisation experience higher poverty rates and a higher proportion of their population living in slums (Gollin, Jedwab, and Vollrath 2016).

Case studies suggest that because industrialisation rarely follows, mining-induced urbanisation is reversed following the closure of the mine, at a high cost to the social fabric of the local inhabitants. The Zambian Copperbelt once dotted with bustling towns and the infrastructure urbanisation affords, morphed into villages with limited access to water and electricity, derelict infrastructure and a marked increase in poverty rates following the closure of mines (Mususa 2012). Similarly, mining towns in Zimbabwe have experienced the pendulum swing between prosperity and penury ghost towns as the commodity market waxed and waned (Kamete 2012).

Additionally, the establishment of any mine comes at a human cost. Large-scale mines are often established in rural areas that require existing communities to be resettled. Although usually compensated, the move disrupts locals social and cultural way of life. A notable example is that of the Basarwa people of Botswana, who shifted their lifestyle from hunting and gathering to pastoral and arable farming. This abrupt shift alienated the Basarwa and precipitated an "idleness, alcoholism [and] despair" (Gwebu 2012, 616). For the migrants that flock to these areas for work, the consequences are no less harmful. The influx of workers usually outpaces the delivery of infrastructure and housing, increasing informal settlements, communicable diseases (especially Tuberculosis and HIV) and an uneven male to female ratio (Gwebu 2012). This is further illustrated by the experiences of local communities surrounding the QMM mines in Chapter 5.

Given that mining does not always result in urbanisation, and that urbanisation may be reversed following the mine's closure, exploring other, more effective, and long-term approaches to urbanisation may be preferable to large-scale mining.

6.6 State capacity, regulation and the local resource curse

In the case of DII and LPI, country effects are responsible for a fair amount of variation in the model outcomes. One explanation for this is that state capacity and legislation regulating the extractive industry varies widely across countries. In recent years, good governance has been lauded as absolutely necessary to ensure that mineral abundance results in positive outcomes; however, few quantitative cross-country studies assess this link.

The pilot Mineral Governance Barometer [for] Southern Africa (Alence and Mattes 2016) includes a composite mineral governance indicator which measures state capacity and for community impact in ten Southern African countries. The Mineral Governance Barometer finds that Madagascar, Zambia, South Africa and Botswana perform the best in terms of community impact regulations (27). This result parallels the results of this dissertation, with the same countries scoring positive residuals for DII and LPI. This suggests that positive outcomes for local communities are primarily a function of state capacity, accountability, and regulation, rather than large-scale mining itself.

6.7 Implications for development policy and investment

Arguments in support of large-scale mining as a catalyst for socioeconomic development cite CSR investments in education, health, job development and infrastructure. Intuitively, this result makes sense. Previous research has indicated that benefits to local communities are only reaped in the presence of robust legislation in which all actors are held accountable. Furthermore, the policies implemented by Randgold in Tongon illustrates that mining firms can provide positive and sustainable changes to local communities. However, this dissertation has shown that when country and urbanisation effects are controlled, the presence or absence of large-scale mining is inconsequential on infrastructure access and poverty levels. Furthermore, the case studies reviewed illustrate that oftentimes, the jobs created do not counteract the loss of land, impact on the environment and abrupt change of lifestyle that comes with large mining projects.

If the results of this dissertation hold, it implies that rather than framing local socioeconomic development through the prism of attracting international mining firms to provide a cash injection and stimulate the local economy, governments and international agencies should instead approach local development as an exercise of accelerating urbanisation and improving government capacity.

6.8 Conclusion

This chapter discussed each finding of this dissertation in greater detail. It noted that when country and urbanisation effects are controlled, the impact of large-scale mining on local communities is minimised. It argues that the results indicate that urbanisation is a more effective mechanism for improving living conditions of local communities, but that large-scale mining rarely provides sustained urbanisation effects. Finally, it highlights the findings of Alence and Mattes (2016) and argues that legislation and government capacity must be present at the community level to effectively leverage large-scale mining into positive outcomes for local communities. The following and final chapter concludes this thesis and provides suggestions for further studies.

7 Conclusion

This paper empirically investigated the impact of large-scale mining on local communities in sub-Saharan Africa. It linked opinion data from round 6 of the Afrobarometer surveys to large-scale mining data from the Africa Power–Mining database using GPS coordinates. To measure the impact on living conditions, it used three separate indices to measure various contributors to overall living conditions – DII, HII and LPI. A linear mixed-model regression controlling for country and urbanisation effects was used to investigate the relationship between the outcome variables and the dependent variables, distance in km and mine status. It found that when country and urbanisation effects are controlled for, proximity to a large-scale mine makes little to no impact on living condition outcomes. This chapter provides a summary of this dissertation and concludes with recommendations and suggestions for further studies.

7.1 Conclusion

This dissertation constructed empirical indicators to measure three aspects of living conditions – access to development infrastructure such as access to paved roads, sewage systems, clinics and schools (DII), access to household infrastructure including quality of shelter, access to running water and toilet location (HII) and experience of lived poverty (LPI). Despite the immense effort focused on developing sub-Saharan Africa's extractive industry by governments and international actors, research on the effects of large-scale mining on local communities is mixed. Furthermore, most research in this field focuses on qualitative studies in localised areas with few cross-country studies available.

The absence of cross-country quantitative and replicable methods to assess the impacts of large-scale mining on local communities hinders the capacity of policymakers to make informed decisions regarding inclusive and sustainable development. This dissertation aims to bridge this gap by using easily accessible geocoded datasets to measure the impact of large-scale mines on local communities empirically. This study suggests a new methodology to reliably assess large-scale mining's impact on communities.

Overall, this dissertation finds that when country and urbanisation effects are controlled, large-scale mining has no impact on local communities. The random-effects reveal that the best predictors of infrastructure access are if an individual lives in an urban or rural area. Country effects have the most substantial influence on LPI, with a correlation between GDP per capita and improved LPI scores noted but not explored.

The case studies highlight the risks and rewards that local communities must contend with when large-scale mining operations are established within their proximity. The cases of Madagascar and Malawi illustrate the importance of state capacity, accountability and community engagement to ensure equitable and positive outcomes for local communities, and the risk the absence of these structures pose to the livelihoods of locals. Conversely, Ivory Coast illustrates that commitment to long term projects in cooperation with local communities and government can yield positive living condition outcomes for local communities.

7.2 Recommendations

The extractive industry presents a convenient mechanism for economic growth, industry development, as well as attracting foreign direct investment (FDI). However, careful attention must be paid to skills development, equitable distribution and appropriate management and administration of funds by the government, to benefit from natural resource abundance fully. In particular, local communities stand to benefit the most from large-scale mining when long term projects are implemented with the goal of extending economic and social benefits beyond the lifespan of the mine.

The results of this dissertation suggest that urbanisation is correlated with improved living conditions. As such, policymakers should implement policies that encourage long-term urbanisation rather than short-term infrastructure implementation and employment opportunities often associated with the extractive industry. Thus, governments and international organisations should focus on mechanisms to urbanise in addition to growing the economy to achieve socioeconomic development, lower poverty and improve living conditions for all citizens.

7.3 Suggestions for Further Studies

This dissertation presents a novel methodology to quantitatively assess the social impact of large-scale mining in sub-Saharan Africa using easily accessible and newly geocoded Afrobarometer data. As such, many potential avenues for future research exists.

The methodology for allocating catchment areas in this dissertation, although consistent with similar studies, is relatively arbitrary. More accurate results may be obtained by using travel times based on local commuter and traffic data. This dissertation analyses one round of Afrobarometer surveys. By expanding the analysis to include several Afrobarometer mines, the potential exists to track changes to communities over an extended period, likely leading to more nuanced insights.

Similarly, future studies may wish to investigate the impact of conflict on the living conditions of local communities, particularly between mining firms and other stakeholders. Obtaining a richer mining dataset, such as the longitudinal IntierraRMG dataset will allow for broader analysis, including assessing the impact of commodity type and small-scale mining on local communities.

Finally, this dissertation showed that individuals who live in urban areas fare better than their rural counterparts on all three living condition indicators assessed. Therefore, more studies should investigate the link between large-scale mining and urbanisation.

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Appendices

Table 10: Active mines used in the analysis

Mine Name	Country	Commodity	Type of Work
Ngaka Thermal Coal	Tanzania	Coal	Open-Pit
Agnes	South Africa	Gold	Underground
Ahafo / Subika - Ntotoroso	Ghana	Gold	Open-Pit/Underground
Arlit	Niger	Uranium	Open-Pit
Athens	Zimbabwe	Gold	Underground
Bafokeng Rasimone	South Africa	Palladium	Underground
Bafokeng Rasimone	South Africa	Gold	Underground
Bafokeng Rasimone	South Africa	Platinum	Underground
Baluba	Zambia	Copper	Underground
Bambanani	South Africa	Gold	Underground
Barberton	South Africa	Gold	Underground
Bathopele	South Africa	Platinum	Underground
Benga / Tete	Mozambique	Coal	Surface
Bibiani Mine	Ghana	Gold	Open-Pit
Boke Bauxite Mine	Guinea	Bauxite	Open-Pit
Bokoni Mine	South Africa	PGM	Underground
Bonikro	Ivory Coast	Gold	Open-Pit
Bosjesspruit Coal Mine	South Africa	Coal	Underground
Bulyanhulu	Tanzania	Gold	Underground
Buzwagi	Tanzania	Gold	Open-Pit
Central Rand Project	South Africa	Gold	Underground
Chirano	Ghana	Gold	Open-Pit/Underground
Cullinan Mine	South Africa	Diamond	Underground
Damang/Abosso	Ghana	Gold	Open-Pit/Underground
Debele	Guinea	Bauxite	Open-Pit
Doornkop - Randfontein	South Africa	Gold	Open-Pit/Underground
Eland	South Africa	Platinum	Underground
Elandsfontein Coal Mine	South Africa	Coal	Open-Pit
Elandsrand - Elandskraal	South Africa	Gold	Underground
Erpm	South Africa	Gold	Open-Pit/Underground
Essakane	Burkina Faso	Gold	Open-Pit
Ezulwini	South Africa	Uranium	Underground
Ezulwini	South Africa	Gold	Underground
Finsch Mine	South Africa	Diamond	Open-Pit/Underground
Fort Dauphin	Madagascar	Ilmenite	Surface
Freda Rebecca	Zimbabwe	Gold	Underground
Friguia	Guinea	Bauxite	Open-Pit
Geita Gold Mine	Tanzania	Gold	Open-Pit
Gounkoto	Mali	Gold	Open-Pit
Greenside Coal Mine	South Africa	Coal	Underground
Horizon	South Africa	Chromium	Underground
Hwange Coal Mine	Zimbabwe	Coal	Open-Pit/Underground

Idupapriem Gold Mine	Ghana	Gold	Open-Pit
Impala Platinum Mine	South Africa	Palladium	Underground
Impala Platinum Mine	South Africa	Platinum	Underground
Impala Platinum Mine	South Africa	Rhodium	Underground
Inata	Burkina Faso	Gold	Open-Pit
Jwaneng Mine	Botswana	Diamond	Open-Pit
Kalgold	South Africa	Gold	Open-Pit
Kalsaka	Burkina Faso	Gold	Underground
Kao	Lesotho	Diamond	Open-Pit
Kayelekera	Malawi	Uranium	Open-Pit
Khumani	South Africa	Iron Ore	Open-Pit
Khuseleka	South Africa	PGM	Underground
Kiniero Mine	Guinea	Gold	Open-Pit
Koffiefontein Mine	South Africa	Diamond	Open-Pit/Underground
Koidu Kimberlite Project	Sierra Leone	Diamond	Open-Pit
Konkola North	Zambia	Copper	Underground
Konongo	Ghana	Gold	Surface
Landau Coal Mine	South Africa	Coal	Open-Pit
Lauzoua Mine	Ivory Coast	Manganese	Open-Pit
Lauzoua Mine	Ivory Coast	Manganese	Open-Pit
Lefa	Guinea	Gold	Open-Pit
Letlhakane Mine	Botswana	Diamond	Open-Pit
Letseng	Lesotho	Diamond	Open-Pit
Liqhobong Project	Lesotho	Diamond	Open-Pit
Lumwana	Zambia	Copper	Open-Pit
Lupa Goldfield/Luika	Tanzania	Gold	Surface
Mamatwan	South Africa	Manganese	Open-Pit/Underground
Mana Mine	Burkina Faso	Gold	Open-Pit
Marange	Zimbabwe	Diamond	Surface
Marikana - Lonmin	South Africa	PGM	Underground
Marikana - Lonmin	South Africa	Platinum	Underground
Masimong	South Africa	Gold	Open-Pit/Underground
Middelbult Coal Mine	South Africa	Coal	Underground
Mimosa	Zimbabwe	PGM	Underground
Minas Moatize	Mozambique	Coal	Open-Pit
Moab Khotsong	South Africa	Gold	Underground
Moanda/ Eramet Manganese	Gabon	Manganese	Plant
Moanda/ Eramet Manganese	Gabon	Manganese	Open-Pit
Moatize Coal	Mozambique	Coal	Open-Pit
Modikwa	South Africa	PGM	Underground
Mogalakwena -Potgietersrust	South Africa	PGM	Underground
Moma	Mozambique	Ilmenite	Surface
Morila	Mali	Gold	Open-Pit
Morupule	Botswana	Coal	Underground
Mothae	Lesotho	Diamond	Surface
Mototolo JV	South Africa	Platinum	Underground
Mowana Mine	Botswana	Copper	Open-Pit
Mponeng	South Africa	Gold	Underground
Mufulira	Zambia	Copper	Underground

Murowa	Zimbabwe	Diamond	Open-Pit/Underground
Ngezi	Zimbabwe	PGM	Underground
Nkana	Zambia	Cobalt	Open-Pit/Underground
Nkana	Zambia	Copper	Open-Pit/Underground
North Mara	Tanzania	Gold	Open-Pit
Nsuta	Ghana	Manganese	Open-Pit
Obuasi Mine (Ashanti)	Ghana	Gold	Open-Pit/Underground
Old Nic And Angelus	Zimbabwe	Gold	Open-Pit/Underground
Optimum Colliery	South Africa	Coal	Open-Pit
Orapa Mine	Botswana	Diamond	Open-Pit
Otjihase	Namibia	Copper	Open-Pit/Underground
Palabora Mine	South Africa	Nickel	Open-Pit/Underground
Palabora Mine	South Africa	Copper	Open-Pit/Underground
Pandora Jv	South Africa	Platinum	Open-Pit/Underground
Perkoa	Burkina Faso	Zinc	Underground
Phoenix Mine	Botswana	Copper	Open-Pit
Phoenix Mine	Botswana	Nickel	Open-Pit
Pilanesberg	South Africa	Platinum	Open-Pit/Underground
Rossing Uranium Mine	Namibia	Uranium	Open-Pit
Sabodala	Senegal	Gold	Open-Pit
Samira Hill Mine	Niger	Gold	Open-Pit
Sangaredi	Guinea	Bauxite	Open-Pit
Secunda Coal Mines	South Africa	Coal	Open-Pit/Underground
Selebi-Phikwe	Botswana	Copper	Underground
Shamva And Howe Mine	Zimbabwe	Gold	Surface
Sierra Rutile	Sierra Leone	Rutile	Open-Pit
Sierra Rutile	Sierra Leone	Zirconium	Open-Pit
Sierra Rutile	Sierra Leone	Ilmenite	Open-Pit
Siguiri Mine	Guinea	Gold	Surface
Smokey Hills	South Africa	Platinum	Open-Pit/Underground
South Deep	South Africa	Gold	Underground
Steenkampskraal	South Africa	Rare Earth	Underground
Sub Nigel	South Africa	Gold	Surface
Syama	Mali	Gold	Open-Pit
Target (Quality Op)	South Africa	Gold	Open-Pit/Underground
Tarkwa Mine	Ghana	Gold	Open-Pit
Tau Lekoa	South Africa	Gold	Underground
Tautona	South Africa	Gold	Underground
Thorncliffe	South Africa	Chromium	Underground
Tongon	Ivory Coast	Gold	Open-Pit
Townlands	South Africa	Coal	Open-Pit
Tshipi	South Africa	Manganese	Open-Pit
Two Rivers	South Africa	Platinum	Underground
Two Rivers	South Africa	Ruthenium	Underground
Two Rivers	South Africa	Rhodium	Underground
Two Rivers	South Africa	Palladium	Underground
Two Rivers	South Africa	Gold	Underground
Union Section	South Africa	Platinum	Underground
Vanggatfontein	South Africa	Coal	Open-Pit/Underground

Venetia Mine	South Africa	Diamond	Open-Pit
Vubachikwe	Zimbabwe	Gold	Surface
Waterval Mine	South Africa	Chromium	Underground
Wessels	South Africa	Manganese	Underground
Williamson	Tanzania	Diamond	Open-Pit
Yatela	Mali	Gold	Open-Pit
Yekepa	Liberia	Iron Ore	Open-Pit

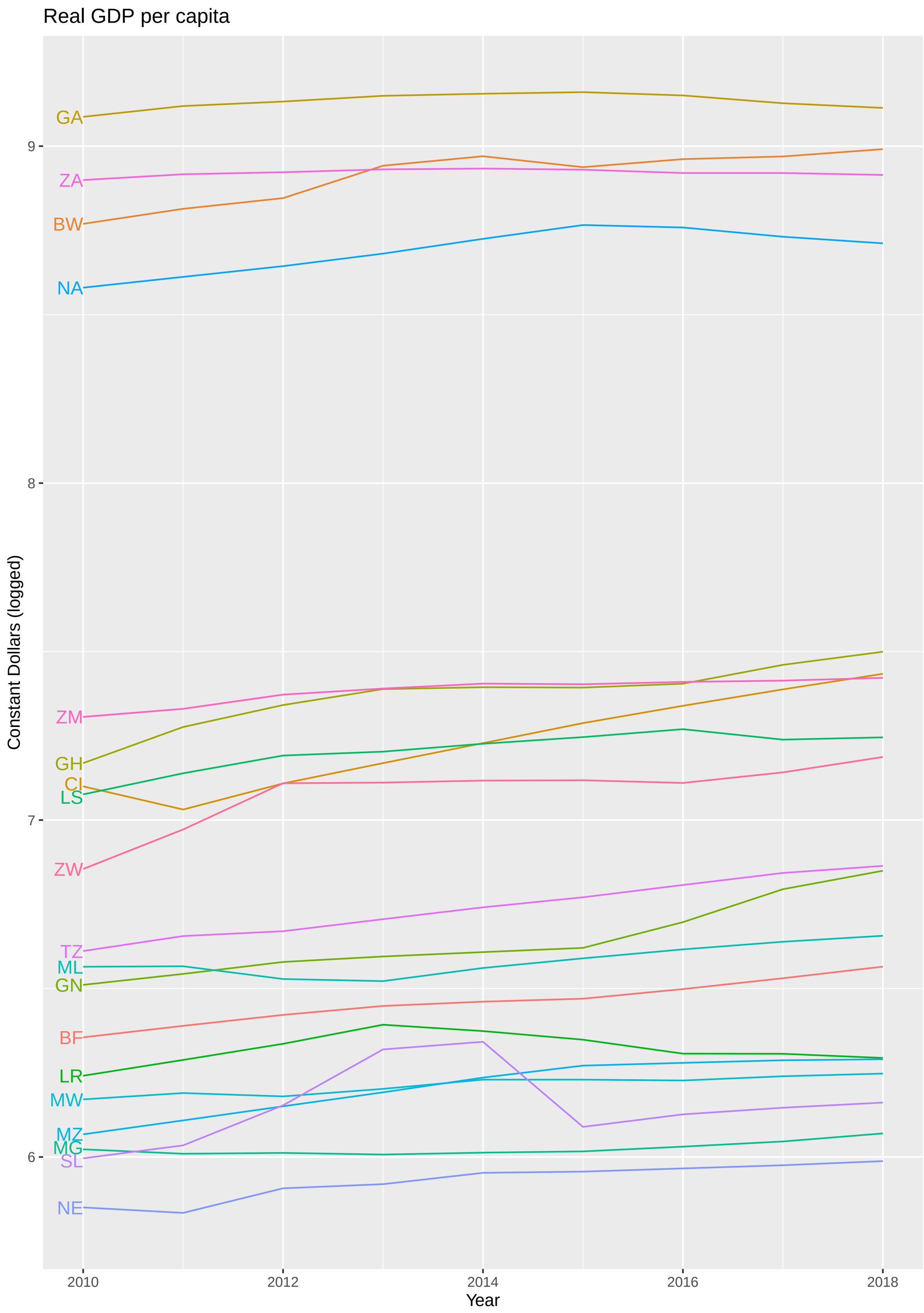

Figure 17: GDP per capita (constant 2000 US$)

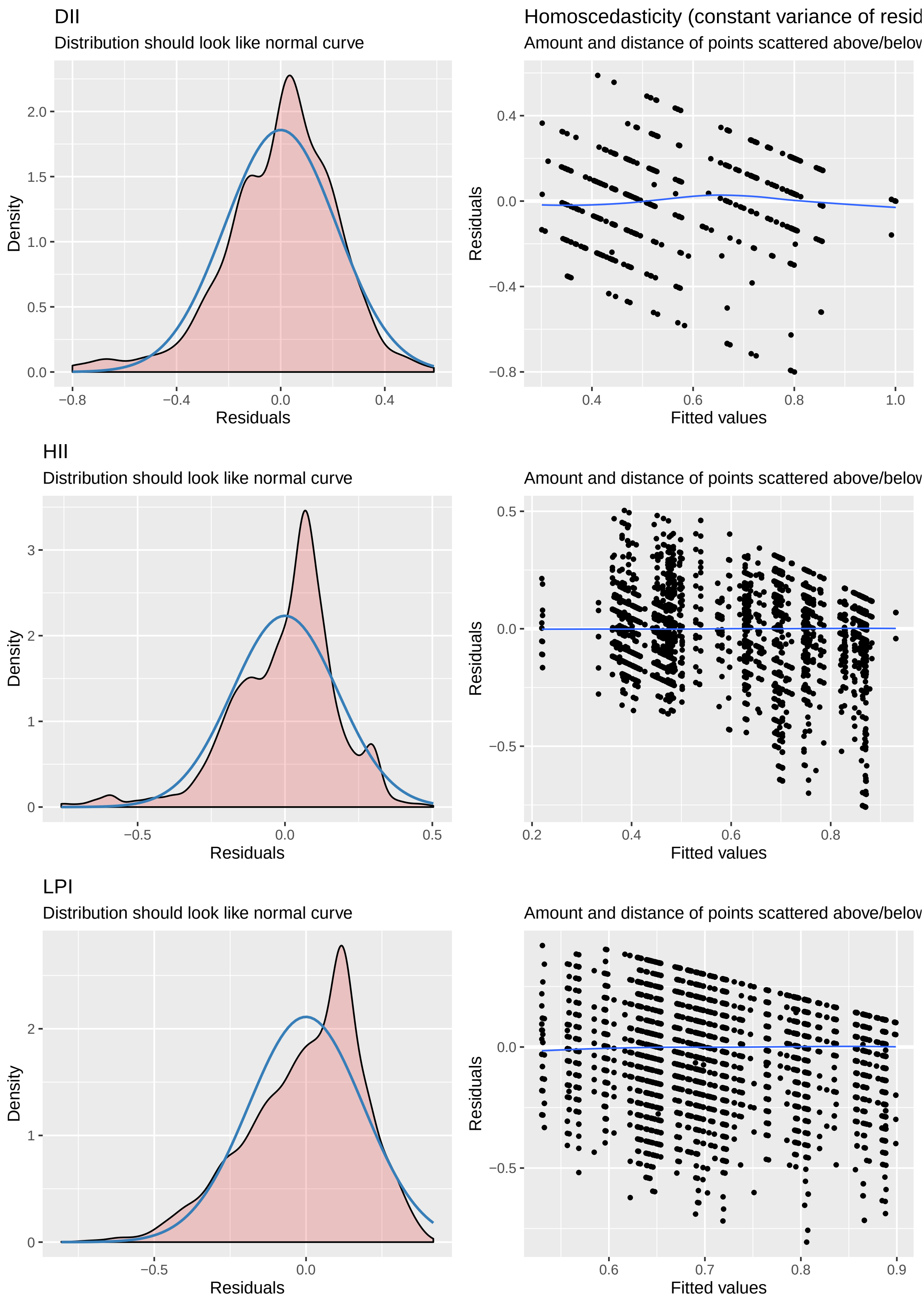

Figure 18: Diagnostic plots for main regressions

Table 11: Alternative simple linear regression model

	Dependent variable:		
	DII	HII	LPI
	(1)	(2)	(3)
distance (km)	0.004	-0.004^{**}	-0.0000
	(0.01)	(0.002)	(0.002)
mine status	-0.002	-0.04^{***}	-0.01
	(0.04)	(0.01)	(0.01)
urban	0.28^{***}	0.19^{***}	0.06^{***}
	(0.02)	(0.01)	(0.01)
Burkina Faso	-0.29^{***}	-0.24^{***}	-0.10^{***}
	(0.05)	(0.02)	(0.02)
Gabon	-0.24^{***}	0.03	-0.22^{***}
	(0.07)	(0.02)	(0.02)
Ghana	-0.18^{***}	-0.20^{***}	0.07^{***}
	(0.05)	(0.01)	(0.02)
Guinea	-0.35^{***}	-0.23^{***}	-0.12^{***}
	(0.06)	(0.02)	(0.02)
Lesotho	-0.29^{***}	-0.27^{***}	-0.14^{***}
	(0.06)	(0.02)	(0.02)
Namibia	-0.38^{***}	-0.16^{***}	0.06^{***}
	(0.06)	(0.02)	(0.02)
Sierra Leone	-0.43^{***}	-0.32^{***}	-0.07^{***}
	(0.06)	(0.02)	(0.02)
South Africa	-0.24^{***}	0.03^{*}	0.08^{***}
	(0.05)	(0.01)	(0.01)
Tanzania	-0.27^{***}	-0.25^{***}	-0.02
	(0.06)	(0.02)	(0.02)
Zambia	-0.19^{**}	-0.11^{***}	-0.01
	(0.08)	(0.02)	(0.02)
Zimbabwe	-0.32^{***}	-0.12^{***}	-0.07^{***}
	(0.05)	(0.01)	(0.02)
Constant	0.75^{***}	0.71^{***}	0.75^{***}
	(0.07)	(0.02)	(0.02)
Observations	591	4,795	4,793
R^2	0.42	0.48	0.22
Adjusted R^2	0.40	0.48	0.21
Residual Std. Error	0.22 (df = 569)	0.18 (df = 4773)	0.19 (df = 4771)
F Statistic	19.36^{***} (df = 21; 569)	209.60^{***} (df = 21; 4773)	63.12^{***} (df = 21; 4771)

Note: *p<0.1; **p<0.05; ***p<0.01