Essays on Natural Resources and Local Economies

CHOMBA KALUNGA

Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy

Adam Smith Business School

College of Social Sciences

University of Glasgow

September, 2018

THESIS ABSTRACT

Development economics studies the dynamics in various areas such as poverty, health outcomes, economic development, economic growth etc.

This thesis brings together a set of chapters that summarises and synthesises varied areas of development microeconomics. The thesis is composed of three main empirical chapters contributing to varied aspects of development economics, mainly the areas of natural resource curse and local communities, divestiture and its effects on local economies and the health and welfare impact of mining in a developing country setting. While researchers and policy makers focus on governance and macro-fiscal risks to identify areas for improvement, very little attention is being paid to the benefits gained by local communities living close to mining centers. This thesis has thus helped fill a gap that has been identified in previous literature by for example Cust and Poelhekke (2015) who observed that scholars are increasingly turning to within-country evidence to deepen our understanding of the potential drivers, and outcomes, of resource wealth effects. This shifts attention away from cross-country studies, thereby offers new perspectives on the resource curse debate, and can help overcome concerns regarding endogeneity.

Chapter 1 provides an outline and introduction of the thesis. Chapter 2 provides an extensive and analytical review of how the natural resource curse affects the living standards in developing countries that have a rich endowment of natural resources focussing on the sub-national level. It discusses the causal economic impact of Zambia’s copper mines, a country located in sub-Saharan Africa endowed with vast copper deposits on living standards. It gives a detailed empirical literature on the natural resource curse and its relationship to local economies. Further, this chapter empirically analysed constituency data from 1996 to 2010, exploiting an episode where global copper prices were rising. The results highlight a significant impact of copper production on living standards. After splitting the constituencies close to and far away from the nearest mine, the results document that constituencies close to the mines benefited significantly from the increase in copper production. Finally, the results are not consistent with the natural resource curse hypothesis; findings show a positive causal relationship between the presence of natural resources and socioeconomic outcomes in less developed countries, particularly for constituencies close to the mines in Zambia.

Chapter 3 provides a detailed analysis of the effect that privatization has on local economies. It provides the main objectives of privatization. It also gives a detailed empirical literature of privatization, mining and how developing countries have been impacted by privatization. This chapter empirically analyses the impact of a resource boom and of the privatization of the copper mines in Zambia on living standards by using a unique constituency level dataset of 150 constituencies in Zambia over the period 1996-2010 following the Living Conditions and Monitoring Survey years. Using a 2sls fixed effects model approach and controlling for constituency characteristics the results show that the privatization of the copper mines benefited the local economies through improved living standards. Lastly, a causal relationship exists between natural resource extraction and living standards even when there have been changes to the structural relationship between the economy and the mining sector is run privately.

Chapter 4 focusses on the effect of copper mining on health outcomes. Mining can be an engine and catalyst for economic growth, but often results in heavy metal releases, that could negatively impact human health. High levels of pollution may cause temporary illness, which in turn may cause lost work hours. Using regression analysis, this chapter analyzed the impact of copper mining on health in Zambia. It further explored changes in health outcomes for constituencies located within 200km to nearest mine as these are the ones to be greatly affected by pollution. Matching just over a decade of repeated cross-section survey data on living conditions in constituencies in Zambia in a 2SLS fixed effects approach, it was observed that an increase in copper mining which led to a copper boom from 2003 induced some changes in health outcomes for constituencies located close to the mining operations after the privatization of the mines. It also finds that the probability of suffering from general sicknesses becomes less likely if a constituency is located close to an open pit mine or in a rural area while it increases if a constituency is located close to an underground mine. The results illustrate that copper mining somehow reduces the prevalence of certain health conditions, for example, anaemia and chest infections. Finally, chapter 5 provides a conclusion for the thesis.

Overall, the thesis endeavored to make a little empirical contribution to the literature on natural resources and local economies by establishing the causal effects of natural resource endowments on local economies in a single country at a subnational level using a novel panel dataset.

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Acknowledgements

I would like to take this opportunity to thank everyone who made it possible for this project to come to an end. First and foremost, I extend my deepest gratitude to God Almighty for giving me life, good health and all other blessings including giving me a Mum in Alice Nsama who made me know Gods love and mercy that gave me the ability to conduct this research.

I would also like to express sincere appreciation to my supervisors Dr Arjuanan Subramanian and Dr Luis Angeles for the unreserved support, encouragement and guidance that they have provided towards my development as a researcher. I have especially been benefited by the discussions and enormous encouragements and critical comments that have given me strength and courage to forge ahead during rugged moments of my journey in research. I am also grateful to the Copperbelt University for granting the financial support throughout the course of my study and making it possible.

I would also like to thank the participants at the Centre for Studies on African economies (CSAE) Oxford Conference (2018) for their useful comments and suggestions.

I am indebted to my friends and colleagues who made my stay in Glasgow a memorable experience. I will miss the fellowship we had together sometimes even late into the night. Cynthia and family, Mrs. Winnie Michelo and family, Blandine and family and others too numerous to mention by name. Thank you all and may God continue blessing you.

I would like to thank the administrative staff of the Adam Smith Business School. They have been most friendly and helpful. In particular Christine Athorne who has assisted me on numerous occasions.

I am most appreciative to my husband and friend Kapambwe, who has been a great source of love and strength. I also wish to say a heartfelt thankyou to my parents, the Mumbis for all the prayers and encouragements. Without the love inspiration, understanding and continued moral and spiritual support from you and the Fiwila team it would have been impossible to undertake and complete this project. Finally, a special thankyou to all friends and family not mentioned. To my brothers, sisters and their families you've been more than I could ask for from God.

A special dedication to God and my late Mum.

DECLARATION

I Chomba Kalunga hereby declare that the work presented in this thesis entitled *Essays On Natural Resources and Local Economies* is my original work and has never been presented elsewhere for any academic qualifications. Any references in terms of books or any other written materials are indicated in the references section.

Student’s signature

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Chapter 1

1.1 Introduction

This thesis has empirically analysed the impact of natural resources on local economies to shed more light on how copper mining could alleviate the poor and general welfare in an endowed natural resource developing country. A fundamental theme in this thesis is the recognition that being endowed with natural resources could generally improve the welfare of local economies. This fact is often neglected in the context of developing countries, mostly because in the natural resource curse hypothesis literature, it has been generally concluded that the presence of natural resources in developing countries is a '*divine curse*' rather than a '*divine blessing'*. However, this thesis has presented a number of empirical results and identified the key effects of copper mining on local economies that show an entirely opposite result.

More specifically, this thesis pays attention to the local economic effects of copper mining at a sub-national level. This contrasts with the various relevant literature on the natural resource curse that has focused more on cross-country studies. This thesis for example pays attention to local economic effects of copper mining in specific areas such as the effects on living standards both before and after the privatization of the copper mines. It also analyses the effects that copper mining externalities such as pollution have on the health outcomes of the local populations. Although much has been discussed on the natural resource curse and a lot of interest has developed over the years on why resource-rich developing countries remain poor despite having enormous wealth in the land, few studies have provided a thorough research on this topic at a microeconomic level. There is much unknown in this developing subject: what is the impact of increasing copper output on the living standards of populations at a sub-national level? How do exogenous shocks from the international prices affect the living standards? Are natural resource endowments endogenous and if so in what sense? What about the process of divestiture of the mining sector, does it cause any changes? And in what direction are these changes? Is there any reverse causality between natural resources and local economic factors such as health outcomes? These are among the important questions that this research targeted at answering.[1]

Thus, the thesis contributes to the literature on natural resources through the identification strategy, which utilized the world price as an instrument for per capita mine level copper output to identify the effect of resource booms on local economies. This contrasts with the rest of the resource curse literature which used cross-sectional variation only, resource endowments or production over time that may be endogenous to other factors than geology, or prices in combination with weights across units that may be correlated with unobservable characteristics (Cust, Harding and V'ezina, 2017). This thesis instead resolved the potential endogeneity problem of resource endowments or production that is highlighted in previous literature by highlighting the reverse causality that may exist between natural resource endowment and local economies. In addition, the focus was on a less commonly studied mineral-copper. This stands in contrast to the rest of the literature on natural resource curse that has previously focused on oil or gold.

There is also an aspect of trying to resolve the endogeneity problem by instrumenting natural resource endowments with world prices. Several papers on natural resources have utilized exogenous prices. For example, Bazzi and Blattman (2014) and Dube and Vargas (2013) who study the effects of commodity price shocks on conflicts, Harding and Venable (2016) instrument natural resource exports with prices to study the effects on non-resource trade, Tolonen (2016) in a study on how extractive industries affect the rates of criminality in Africa also used international mineral prices to instrument mining production and Cust, Harding and V'ezina (2017) study the effects of oil and gas booms on manufacturing firms interacting oil and gas windfalls with yearly variation in oil prices. In all these studies, there is no emphasis on the effects of natural resources on local economies especially in a less common mineral resource-copper.

Lastly, a contribution was made to economic literature through the use of a novel panel dataset which was specifically constructed for this research. The household data from the Living Conditions and Monitoring Surveys (LCMS) was aggregated at constituency level

[1] It is interesting to note that recent research has found positive welfare effects of natural resource extraction in Africa. This is from the findings of Anja K. Tolonen (2016)

which enabled the analysis to be conducted at a sub-national level. This data was combined with mining data from the Zambian government, the central bank in Zambia (Bank of Zambia), mining companies and Westmetall in order to form a novel panel dataset. Description of the variables used is made in Table A2 of the appendix.

The research was motivated most importantly by the interest in trying to mitigate the potential reverse causality between natural resource endowments and local economies. The challenge faced with natural resource-rich countries performing poorly in terms of their economic growth was another motivation to investigate the causal effects of the volatility of copper prices on living standards in Zambia in the presence of exogenous shocks to the economy. There is evidence of economic development due to natural resource booms (Sachs and Warner, 1995, 2001; Aragon and Rud, 2013b; Lippert, 2014). This research, however, concentrated on the socio-economic outcomes of workers and the general public conditional on the copper production. This is alluded to the theory of production were the Marginal Factor Productivity of labor is expected to rise because of the improvement in living standards. Thus, the increase in copper output in Zambia (World Bank (2011), based on this work, can be attributed to the improved well-being of workers. It is a well-known fact that healthy workers tend to be more productive, for example Henry Ford experienced increased productivity from his workers when he made a decision to treat them well by doubling their wages in 1914. The last but not the least motivation was the interesting results obtained by Tolonen (2016) and Chuhan-Pole et al (2017) on the positive welfare impact of natural resources on local economies in Africa and this further motivated me into studying the effect of other minerals (apart from gold and diamonds) of local economies.

In section 1.1, this thesis has provided essential background information about copper mining in Zambia and the natural resource curse in relation to a developing economy as well as the motivation of this research. A short description of the primary approaches employed by this thesis is also highlighted. This section concludes with the outline of the thesis in section 1.2.

1.1.2 Country Background

Zambia, located in the sub-Saharan region of Africa is richly endowed with mineral resources from twelve mines.[2] As the eighth largest producer of copper in the world, in the year 2015, the country contributed five-percent to the total world copper production. This copper makes up about seventy-five percent of Zambia's export revenues which in turn contributes about two percent to the country's' domestic revenue (Bank of Zambia, 2016). In 2013, "Zambia's Gross Domestic Product (GDP) averaged not less than five percent" (Central Statistical Office, 2013).

1.1.2.1 Economic history

Before the country's political independence, between 1953 and 1963, Zambia was under British colonial rule and part of the Central African Federation (of Northern and Southern Rhodesia and Nyasaland, which is now today Zambia, Zimbabwe and Malawi, respectively). During this period, despite the presence of mineral resources, the country was hardly developed because rents from mining were actually expropriated to Salisbury, in Southern Rhodesia which was the Federations' capital. There was no infrastructural development and no industries as these were all located in the capital.

As a result, at independence, Zambia's inheritance in terms of infrastructure, industry and public administration was much less than most former colonies. Zambia domestically also faced challenges of few trained and educated citizens capable of running the government, despite the considerable mineral wealth it possessed. During the decades preceding independence, the country supported nationalist movements in Southern Africa. This support handsomely cost the country from an economic perspective as the conflicts led to the closure of Zambia's borders with Southern Rhodesia posing severe problems with international transport and power supply. To solve the problem of international transport, a railroad to the Tanzanian port of Dar es Salaam was built with Chinese assistance. This reduced Zambia's dependence on railroad lines south to South Africa and west through an increasingly troubled Angola.

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[2] Zambia currently has 12 mines that are fully operational. This paper deals with 10 mines that were operational during the survey period.

Zambia has experienced three major political transformations with a fourth currently running: The first republic (1964-1972), the second (1972-1990), the third republic (1991-2011) and the fourth currently running since 2011. It is important to note that each era has been characterized by a distinctive political ideology and preferred approach to running the national economy which has had its own socio-economic changes and impacts. One notable example is the approach used to run the first and second republics. Emphasis in these two was mainly on infrastructural development.

Due to poor infrastructural development inherited at independence, the government under the rule of Dr. Kenneth Kaunda set up National Development Plans (NDP). These plans were aimed at directing the profits of the newly nationalized copper mines towards infrastructural developments. This led to the revenues from the mines being used to build schools, hospitals, universities and providing subsidies to state-owned manufacturing companies and consumers. This, at that time was possible because the international copper prices were favorable to realize enough revenues. They as such contributed over 50% of the country’s foreign exchange and two-thirds of the central government revenue. During this period, the mining companies also made social provisions to its employees through recreational facilities, health, education and other basic consumer necessities such as food.

The first decade of independence saw major economic progress being made in Zambia. Zambia had one of the best growth performances in the world from WWII to 1974. With savings and investments of 30 percent of GDP and average per capita income growth of close to 4 percent per annum (McPherson, 1995). The future development of the country looked bright until 1974 when the first oil crisis occurred. This crisis coupled with the decline in copper prices slowed down the country’s development forcing the government to borrow from the international community in the hope that the fall in the copper price was transient. The copper prices bounced back, and the country briefly recovered but not to its might. Such that in 1979, when the second oil crisis occurred, this saw the downturn of Zambia’s economy. Interest rates went up and a severe debt crisis emerged. Twenty years following the second oil crisis, and the continued decline of copper prices, per capita income reduced by 50%, leaving Zambia the 25th poorest country in the world. At this time the mining sector recorded an extremely poor performance.

The fall in the copper prices, continued demand for income from ZCCM, high mining labor force and the burden of social provisions led to the poor performance of the mining sector. These colossal financial burdens on the mining conglomerate meant that there was little or barely any capital for reinvestment. ZCCM could no longer afford to buy advanced cost-effective equipment and machinery and let alone service the existing ones. Costs for the company went up and it plunged into making losses.

While this was happening, the performance of Zambia's economy was dwindling. In 1983, the government was forced to partly adopt a systematic structural adjustment program as a requirement to receive external finance from international financial institutions, especially the International Monetary Fund (IMF) and the World Bank. Later, in 1985, the country implemented the most comprehensive economic adjustment policies whose centerpiece was the foreign exchange auctioning. Due to demonstrations over the continued increase of prices of essential commodities and workers' deteriorating living conditions, on May 1, 1988, President Kaunda cancelled the IMF agreement.

The performance of Zambia's economy from independence to 1991 is seen to have shifted from a growing economy up to 1975, and later a declining economy. Yet through this shift from 1975 to a collapse of the economy, the government was reluctant to embark on any economic reforms. There was some consolation from international forecasters like the World Bank that copper prices would increase at some point. As such this may have provided some hope for the government which consequently encouraged it to postpone reforming of the economy.

1.1.2.2 Economic Reforms

For a long time, despite the collapsing economy, the government rejected reform. This rejection led the country to be termed a chronic non-reformer. Over the period 1976- 1991, the government led by then President Kaunda adopted seven donor supported adjustment programs (McPherson, 1995). Yet none of these were ever successful and worst of all carried on to the end. Each of the programs was designed to reduce internal and external balances and restore the conditions for sustainable growth, as reveled by the policy measures they comprised of. Unfortunately, they were all abandoned and this reinforced a decline in the economy.

The first attempt at economic reform with international support was in 1978. With a second attempt being made in 1980 and immediately after that, one was embarked on in 1981. Later on, 1984 and 1985 are the other two years that witnessed further attempts at reform.

The 1985 reform was as result of the governments' realization that there was no other way of recovery as the copper prices had stayed low for a decade by then. These reforms ran for almost two years, with the central feature of these reforms being the imposition of controls on the exchange rate, interest rate and consumer prices. During the same year, the government abandoned its earlier policies and shifted to liberalization with the central feature being the introduction of an auction for foreign exchange. Two years down the line, the government re-imposed controls on markets for commodities, credit and foreign exchange. This shift in policy meant breaking off the ties with IMF consequently leading to the suspension of credit from the World Bank and most donor countries. But, in 1989, the government switched back to market oriented economic policies.

Behind the scenes of all these attempts at economic reform, there was mounting pressure on the ruling government from the citizens. Demonstrations over the badly performing economy were being run, all these can largely be attributed to the supposedly worsening living conditions. Consumer prices kept increasing, forcing the government to introduce subsidies on maize meal. These attempts by the government did not assume any favor on the political front. More and more calls were being made to transform the country from a one-party political state into a multi-party state. In 1990, the government gave heed to these calls and by 1991, the first democratic multi-party elections were held. A new government came into power and this government now embarked on a radical economic reform process.

The new government begun what was later called the "new recovery program" under the Structural Adjustment Program (SAP). The major objective of this program was to gain regular access to international finance. This came in the wake of the lost financial reputation of the country as a result of his huge un-sustained international financial debt which led the country to lose donor and international confidence. Under this adjustment package, the country was expected to be credible and sustainable by adopting a set of measures acceptable to the international community. Some of the policies included in this package were the elimination of maize meal (Zambia's staple food) subsidies, the removal of most import restrictions, the abolition of export licenses, a faster rate of crawl in the official exchange rate, the removal of barriers to entry in the financial and insurance market and the lifting of import ceilings.

Another major landmark of the reforms was to reduce the role of the state in state-owned enterprises. This was to be a reversal of the previous governments' policy of nationalization. This came out of a realization that the governments' role in most companies was limiting their efficiency and as such the government was now expected to privatize the companies it owned. Moreover, the government was being forced to bail out these companies in times of financial crises, consequently leading to huge expenditures. This privatization process meant that the mining sector also had to be privatized.

1.1.2.4 Nationalization and Privatization of the Mines

From independence, the mining companies were run by two foreign companies which are the Roan Selection Trust and Anglo-American Corporation. Due to misunderstandings between these two companies and the ruling government over the royalty system and lack of reinvestment into the mines, the Zambian government decided to nationalize the mines. This meant that the mining companies were forced to give 51% of shares in all existing mines to the state. By 1982, the two nationalized companies were combined to form the Zambia Consolidated Copper Mines (ZCCM).

In 1991, the country underwent its first democratic elections which saw a new government being ushered into power. The new government agreed to implement the previously cancelled reform package which included the general liberalization of the economy. This also included the privatization program which saw the privatization of the mining conglomerate, ZCCM. This process of privatizing the mines begun in 1997 and ended around 2000 as ZCCM had to be broken up into small units in order for it to be sold. Due to the low value of the mines at privatization, the government signed development agreements with the new mine owners which entailed tax holidays for the mine owners. Meaning that rents accruing to the government from the mines were modest.

Six years after the privatization of the mines, coper prices begun rising on the international market. Consequently, the copper production output which went to as low as 255,000 metric tons at the time of privatization begun rising and at the end of 2014, Zambia’s copper production was triple of what was produced at privatization. New mines have since been opened such as Lumwana Mine in Mwinilunga, Kansanshi and Kalumbila mines in Solwezi and Lubambe and Konkola Deep Mines in Chililabombwe.

It can be safely concluded that in the mid-1970’s, the price of copper, Zambia’s principal export, suffered a severe decline worldwide. The economy underwent a decline from 1975, with per capita GDP falling and subsequently mining’s contribution to national GDP falling as well. Zambia was forced to turn to international lenders for relief, but as copper prices remained depressed, it became increasingly difficult to service its growing debt. Such that by mid-1990's, despite limited debt relief, Zambia's per capita foreign debt remained among the highest in the world. The country was forced to implement structural adjustment programs as a requirement for financial assistance. In 1997, as part of an agreement for assistance, the government began the privatization process of the mining conglomerate, ZCCM. This process subsequently ended and saw the country plunge further into problems of severe poverty. At this time, poverty levels reached as high as 80% in rural areas. The question at hand is whether the changes in these copper prices have had an impact on living standards in Zambia.

Zambia has a long history as a mining country and ranks as the eighth largest copper producer in the world. The role that natural resources, specifically, the mining sector has played in the development of Zambias' economy and the world economy at large cannot be underscored. "The availability of natural resources in general and copper in particular constituencies constitutes an important asset (or source of wealth) for a developing country" Meller and Simpasa (2011). While copper extraction, its discovery or subsequent mining has been a 'divine blessing' to countries like Chile, unfortunately, it has been the opposite for Zambia- 'a divine curse'. Despite the copper prices rising to as high as seven thousand three hundred United States dollars (US$7,300) per ton and the demand for copper from China and other parts of the world increasing annually, Zambia is one of the worlds' poorest nations with external debts of thirty-two percent of Gross Domestic Product (GDP).

The history of copper production in Zambia dates back to the first half of the 20th century, meaning that the history and economics of the country is a story of copper mining. Zambia's share of global copper production decreased sharply from 6% at the beginning of the 1980's to below 2% in 2000. Its share has since increased to almost 4% in 2008 and 5% in 2014. This increase in annual copper production increased the total export revenues almost tenfold between 2003 and 2010 (Lippert, 2014).

Unfortunately, Zambia seems to be a high cost producer of copper. Per World Bank data (2008), the average unit cost of production is around US$1,500-US$1,800 per ton compared to global average of US$750-US$1,000. These high costs could be attributed to the type of geology and geography the country is faced with (Adam et al, 2014 and Sikamo et al, 2016). This though, is on average expected to fall as the share of output accounted for by the new Lumwana, Kansanshi and Lubambe mines increases (Ibid).

In addition, Topalova (2010) observed that the past fifty years have witnessed the greatest improvement in technology globally and an increased output in natural resources, which was also experienced by Zambia. Zambia particularly experienced an increase in copper production from about 430,000 tons in 1990 to 720,000 tons in 2010 (World Bank, 2011). Yet poverty levels still seem to have increased to their peak, reaching a record high of 81.5% in rural areas (CSO, 2010) during the period of increased copper prices and subsequent increases in copper production.

The year 2003 was the beginning of a demand driven increase in the world price of copper which is an exogenous shock to Zambia.[3] Inspite of this rise in copper prices, mining companies operating in Zambia have argued that profits being realized from the mining activities are very low. They have further stated that the costs of production are high and as such this leads them to realize low profits.[4] The perceived inefficiencies when the mines where state-run led to the privatization of the mines. In the mid 1990's, the mines were deemed to be the least asset by ZCCM and were later eventually sold for $3million in cash plus optional payments up to $25million (Craig, 2000).[5] This in one way or the other may be contrary to the expectations of the mass citizenship of Zambia which expects the mines to contribute towards the improvement of living standards in the communities surrounding the mines. It is also expected that the mines would provide positive externalities to the local economy rather than negative externalities such as pollution. Even though the tax structure changed after privatization of the mines, this change has been realized to benefit the investors more than the local economies with the new mine investors paying less taxes.[6] Auty (2003) argued that economic development can be accelerated through the supported boosting of capital investment. This is owed to the fact that abundance in natural resources is likely to increase exports and resource rents so that more capital goods can be imported. This was not the case for Zambias' copper mines.

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[3] See graph A1 in appendix.

[4] High costs which at one point in time led to the suspension of production at the Kansanshi mine in the 1990s.

[5] Zambia Consolidated Copper mines (ZCCM) was the mining conglomerate running the mining operations in Zambia up until the privatization of the mines. This is a parastatal company with a major shareholding from the state.

[6] The marginal rate of tax paid by the mining companies has been computed as zero.

Despite abundant resources, Zambia has some of the worst poverty levels in Africa. From the fourth highest gross domestic per capita in Africa at independence in 1964, 50 years down the line, in 2014, the country had some of the worst social and poverty indicators on the continent (Whitworth, 2014). [7] This is despite achieving a sustained GDP growth averaging 5% since 1999. Whitworth (2014) blames the increased poverty levels largely on the misguided macroeconomic and microeconomic policies adopted by the Kaunda era which got independence from British colonial rule in 1964 and formed the first Zambian government. Zambia's economic decline is also believed to have started with the rising oil prices of the mid 1970's, which coincided with the drop in world copper prices-being the mainstay of Zambia" (Milimo et al, 2002).

Poor living standards, the problem at hand is not new to Zambia. The country's economic decline has taken place in the context of political change since independence in 1964.This decline in some sense, can be blamed on the political disposition of the ruling government during the first republic that failed to make the necessary adjustments during resource booms and slumps. This assertion is further supported by Milimo et al (2002) who alluded this decline to the economic difficulties of increased debt (which had to be repaid and serviced every year) and the Structural Adjustment Programs (SAP) the country underwent from the mid-1990s. These led to a big drop in the quality of life as the situation increasingly worsened. In 2006, rural poverty rates remained stubbornly high at 81.5% whilst urban poverty rates were reported to have declined from 49% to 34% (Chapoto et al, 2011). This evidences the widespread consensus that poverty is a severe problem in Zambia, a view which is supported by past empirical studies (Milimo et al, 2002; Kapungwe, 2004; Thurlow and Wobst, 2007; Simler, 2007; Masumbu and Mahrt, 2014 and Whitworth, 2014).

With the decline in living standards at some time especially just after the privatization of the mines mostly affecting the urban areas, it remains a puzzle as to whether this can be attributed to the changing performance pattern of the mining sector. From a historical perspective, it can clearly be observed by Fraser and Lungu (2007) that the economic

[7] Figure 2.1 shows the movements in copper prices and the per capita Gross Domestic Product (GDP) for Zambia.

downturn which consequently led to declined living standards has in some way been following the performance pattern of the mining sector.

This thesis therefore analyses the effect that changes in copper mining has had on living standards and health outcomes in Zambia. Chapter particularly looks at the effect of the copper boom on living standards. Due to the predominant literature on privatization of utilities, I found in necessary to fill the gap in existing literature of the effects of privatization of natural resource endowments on living standards. It was therefore important to introduce chapter 3 to the thesis. Lastly, chapter 4 endowed to highlight the effects of the copper mining on the health of people.

1.2 Outline of the thesis

This thesis is a collection of three independent research papers which represent the following three chapters respectively. Chapter 2 considers the effects of natural resources on living standards of local economies. Chapter 3 diverts on a different angle by focussing the analysis of the effects of copper mining on living standards during a period of a structural break in form of privatization. This looks at how exogenous shocks tend to affect living standards when there is divestiture in an economy. In chapter 4, a 2SLS model is used to test the possibility of reverse causality between health outcomes and copper mining.

In addition, in a study on gold mining in sub-Saharan Africa, Chuhan-Pole et al (2017) also find some positive welfare impact of natural resources. Their analysis and results conclude that, on average, mining communities experience positive yet limited welfare benefits. Some benefits appear more frequently in localities close to a mine, but these benefits are not uniform across all mining communities. Mining and mineral processing can also produce well-known negative externalities—such as environmental degradation, health risks, pressure on other scarce natural resources, and social dislocations—which can affect local community welfare.

Chapter 2

Natural Resources and Living Standards: An Empirical Analysis Applied to the Case of Copper Mining in Zambia[8]

2.1 Introduction

Poor living standards are one of the major challenges being faced by most developing countries. The problem is massive and can be attributed to numerous complexities. One of these complexities consists of effectively utilizing the potential benefits of natural resources so that they can be used as a tool to improve living standards. Poverty as generally defined by Ringen (1987) is having a low standard of living. In simple terms, this is being deprived in a way of life because of insufficient resources to avoid such deprivation (Botchuoy, 2013).[9]

Natural resources have proved to be an engine for economic development and a catalyst for improved living standards. This is evidenced by Botswana and other South American countries like Chile and Brazil that were able to successfully utilize natural resources to industrialize and improve living standards (Mamo et al, 2017). This importance of natural

[8] This paper was presented at the Oxford University Centre for Studies on African Economies (CSAE) conference in March 2018.

[9] Were absolute poverty is defined as a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information. It depends not only on income but also on access to services." (UN, 1995, p57). Overall poverty can take various forms including: "lack of income and productive resources to ensure sustainable livelihoods; hunger and malnutrition; ill health; limited or lack of access to education and other basic services; increased morbidity and mortality from illness; homelessness and inadequate housing; unsafe environments and social discrimination and exclusion. It is also characterized by lack of participation in decision-making and in civil, social and cultural life. It occurs in all countries: as mass poverty in many developing countries, pockets of poverty amid wealth in developed countries, loss of livelihoods as a result of economic recession, sudden poverty as a result of disaster or conflict, the poverty of low-wage workers, and the utter destitution of people who fall outside family support systems, social institutions and safety nets." (ibid, p57)

resources to the world economy, has led to an extensive study into their relationship with economic outcomes. With existing literature suggesting that abundance of natural resources may fail to improve living standards, or may hinder economic performance, especially in the presence of bad institutions (Mehlum, Moene and Torvik 2006) and conflict Dube and Vargas (2013). Natural resources such as copper are no exception. This is what is referred to as "the natural resource curse" which has been the focus of this paper, with results showing that Zambia may not have necessarily been exposed to the natural resource curse with average constituency level real incomes increasing by 0.124 percentage points per 1 percent increase in the copper output ceteris paribus. Results further show that a significant decline in the average constituency poverty levels (CSO, 2010)

This chapter endeavored to prove that there is reverse causality between natural resource endowments and living standards even in developing countries. In essence, the presence of natural resources leads to improved living standards; while the improvement of living standards which may lead to a healthier population may lead to an increase in output from natural resources. This stems from the argument from some bodies of literature that wealthier people tend to be more productive as they are more able to work (Strauss and Thomas, 1998 and Smith, 1999)

With a high volatility of global commodity prices, this chapter also contributes towards the literature on how exogenous changes such as international price movements of natural resources affect local communities. This is because of the recent shift in literature to focus more on within country correlations and variations which consider economic, political and cultural differences. It therefore examines a period when the copper prices on the world market were extremely volatile. The volatility in the copper prices culminated into an increase in copper output; providing an opportunity to study the effect of an exogenous shock to the local economy. To this end, the framework of Caselli and Michaels (2013) is used to evaluate the effect of natural resources in a developing economy, specifically Zambia. With observations being made by Sachs and Warner (2001) and Bulte et al (2003) that resource rich countries suffer from a natural resource curse.

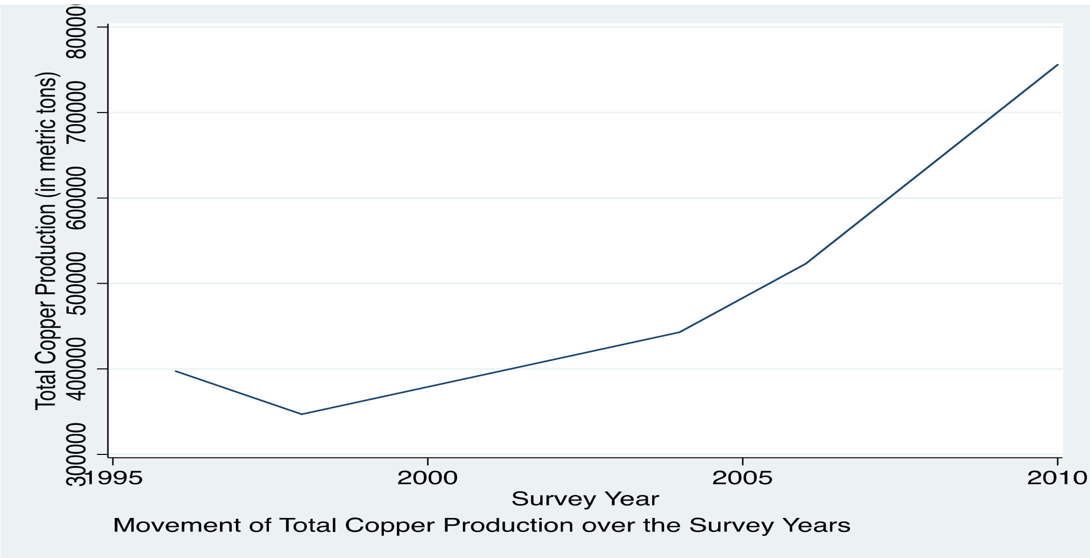

Figure 2.1a Movements of total copper output over the survey years

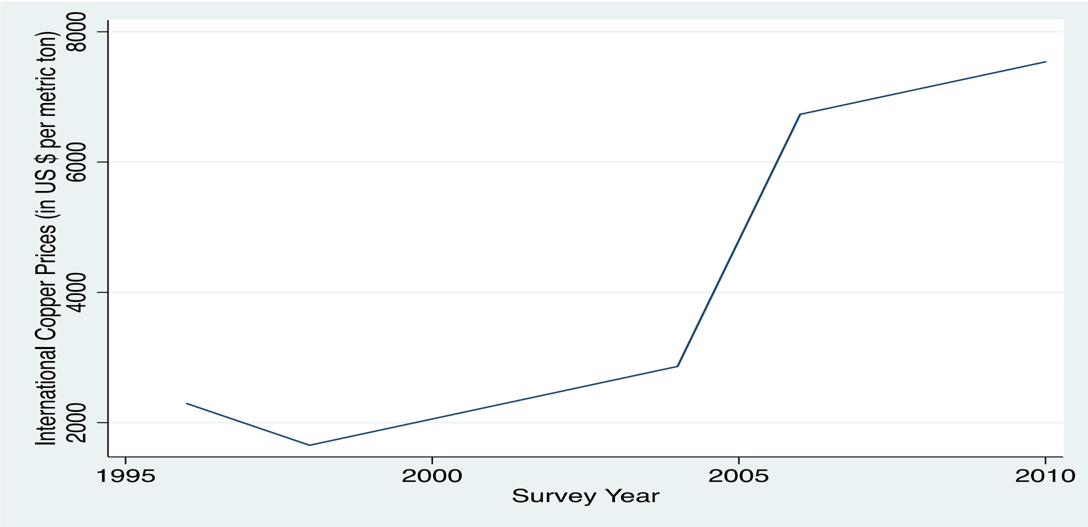

Figure 2.1b Movements of copper prices over the survey years

Even though the nature of the relationship between natural resources and economic development has been actively discussed by many scholars, thorough empirical analyses on how exogenous shocks related to natural resources tend to affect living standards within a single country are non-existent. The potential heterogeneous effects of production expansion because of introducing new mines also remain scarcely known. This chapter aims to fill the void by systematically exploring the causal effect of an increase in mineral resource extraction on living standards in Zambia at constituency level. In particular, it explores this in the wake of increasing global copper prices. The representation of the changes in the copper prices and the subsequent ‘copper boom’ can be observed in figures 2.1a and 2.1b. These figures clearly show that as the copper prices was matched by a subsequent increase in the total copper output which was mainly the case after the privatization of the mines after the year 2000. Using IV 2SLS technique, I analyze the extent of resource booms from the mines affect living standards. I construct a uniform measure of economic activity at constituency level using household data particularly from the Living Conditions and Monitoring Survey (LCMS). This is combined with mine level data on copper prices and production.

In building on the work of Caselli and Michaels (2013), an empirical contribution is made to the literature on reverse causality. The causal relationship that may arise between the production of natural resources and living standards is analyzed. I deliver on the causal interpretation by utilizing the household survey data aggregated at constituency level and relate it to the copper output through forming a novel panel dataset. This dataset is compiled using the Living Conditions and Monitoring Survey (LCMS) for five waves that are available and complemented with data on copper output, copper prices and government funding to each constituency. A major source of reverse causation in a study of this nature could be selection. Investors could select more prosperous constituencies for mining rather than mining driving development. It therefore analyses all the constituencies to determine whether this reverse causation is present in the case of Zambia. There is a possibility of selection being present as the more prosperous and attractive mines tend to fetch a higher price and therefore attract huge foreign investors.

Using regression analysis, results show that an increase in copper production significantly improves living standards at constituency level for constituencies close to the mines in Zambia over the period 1996 to 2010.[10] This period was selected as it is the period around which copper prices were rising on the global market and there was a corresponding

[10] Constituencies are regarded as being close to a mine if they are located within a mean radius of 420 kilometers to the nearest mine.

increase in the levels of copper output in Zambia.[11] Furthermore, the use of the IV technique helps to deal with the challenge of the endogeneity of natural resource extraction. The endogeneity is attributed to the many unobservable factors affecting economic development which under certain conditions such as government policies meant at alleviating poverty are correlated with the production of natural resources. The problem of endogeneity of natural resource extraction is further highlighted by Cust and Harding (2014) and Mata and Toscani (2015). To overcome the problem of endogeneity, the 2SLS Instrumental Variable (IV) approach which considers copper output as endogenous was used. The international copper price is therefore used as an instrument for the mine level copper output as adopted in previous literature by Bazzi and Blattman (2014) and Dube and Vargas (2013) study the effects of commodity price shocks on conflicts and Harding and Venables (2016) and Cust, Harding and V´ezina (2017) who study the resistance of the Dutch disease in Indonesia.

The case of Zambia, a country located in the sub-Saharan region of Africa and the eighth largest world producer of copper in 2015 is used. Zambia has 10 operational mining deposits located in the north-western part of the country. Most mining regions are on average not as poor as other regions of the country, as they have some economic interaction with the mines; with part of the working population being employed by the mining industry.[12] Zambia's mines are export-oriented, capital intensive and have undergone massive changes over the study period. As documented in this thesis, the mines experienced some changes. Firstly, there was a period for the privatization of the mines between 1997 and 2001.[13] Later there were exogenous shocks stemming from the international copper price changes between 2003 and 2008 which led to a copper production boom.

With this framework in mind, we examine the effect of the increased copper production on constituencies' living standards using households' survey data for five waves and complemented by mine data for the years 1996, 1998, 2004, 2006 and 2010. The five waves are used as they are the ones in which the surveys were conducted. Results from

[11] Details on the movement of copper prices and the levels of copper output are shown through a graph in the appendix.

[12] Mines are in the urban areas and urban poverty levels are much lower than the rural poverty levels. This can be seen in table 2

[13] This period of privatization and its effects is later analyzed in greater detail in chapter three of the thesis.

previous studies show that expansion of mining influences local incomes and living standards only through strong backward linkages. This chapter complements findings from previous studies by showing that, the effect of changes in the copper output on average constituency level real incomes changes with differences in distances between a constituency and the nearest mine to it.

The results are robust to alternative sample estimations. Alternative sample estimations are used to check the robustness of the results, such as focusing on a smaller sample through excluding some constituencies.

The rest of the chapter is structured as follows. In the next section, we provide an overview of literature on the natural resource curse. The subsequent section describes the data in detail and discusses the empirical framework. Section 2.5 presents the main results corresponding to the baseline model. Followed by the alternative explanations which are the robustness checks. Lastly, section 2.6 concludes.

2.2 Literature Review

There is now an enormous literature on the natural resource curse with both theory and empirics concentrated on the relationship across countries (Deaton 2011, Frankel et al. 2012, Van der Ploeg 2011). There is now more evidence that the curse might operate more locally, within countries, but relative to the cross-country evidence, this remains relatively thin (Arag´on and Rud 2013). At the cross-country level, the blame for the curse has fallen on poor institutions and the enervating influence of resources on institutions due to the availability of large and tempting rents ((Mehlum et al. 2006), Robinson et al. 2006). But this in turn has opened up the issue of the kinds of institutions that matter and their relationship to natural resources. An important open question is how the effects of resources play out under different institutional structures. This thesis fills a gap in the existing literature by focusing on this important question.

The resource curse or excess availability of natural resources presents a particularly interesting analysis when it comes to economics and often underpins many of the policies and theories which can be looked at in relation to how the government can organize its own economic behavior, so as to achieve long-term economic growth (Acemoglu, 1996). The purpose of this section of the literature review is to look at factors associated with the resource curse. In particular, the explanations of the resource curse and the way in which they may potentially be dealt will be examined, before putting the resource curse into context and then discussing measurement techniques and empirical studies looking specifically at how these may be used in relation to the resource curse in Zambia. Crucially, it is noted that there is empirical data to suggest that countries with a higher level of natural resources were also seen to be displaying trends of low economic growth (Alexeev and Conrad, 2009). This seemingly presents a potentially interesting point of analysis for those involved in developing policies that will enable a country with a high level of natural resource to achieve a better level of economic growth as a result (Ibid).

Theories of the Natural Resource Curse

The concept that natural resources may become what was seen to be an economic curse emerged during the 1980s, with the actual terminology "resource curse" first being used in 1993 (Sachs and Warner, 1995). These theories essentially created an analysis of a counterintuitive situation whereby it was shown that countries with a high level of natural resource were not developing economic growth at the expected rate. A wide variety of studies, notably those by Sachs and Warner (1995) aimed to show the link between natural resources and economic growth, which then led to a wide variety of studies on precisely why this negative relationship appeared to exist (Mauro, 1995). As a result, a wide variety of different theories have been used as a means of describing why this relationship exists.

The resource curse is the observation that countries endowed with a rich source of natural resources can struggle to make effective use of these and often end up with low levels of economic development than countries with low levels of natural resources.

There are various reasons put forward to explain this resource curse, such as corruption, appreciation in the exchange rate, foreign ownership and conflict. Examples of resource-rich countries, with relatively poor rates of economic growth, include Nigeria, Zambia, Sierra Leone, Angola, Saudi Arabia and Venezuela. Resource-poor countries, such as Korea, Taiwan, Hong Kong, Japan and Singapore, by contrast, have experienced better rates of economic growth. However, other economists are more sceptical and argue that natural resources can be consistent with improved living standards.

Reasons for the natural resource curse

Reasons for the resource case are sometimes viewed as theories of the 'natural resource curse'. Some of the reasons that have been attributed to the natural resource curse are discussed in brief:

i. Civil war in control of ownership. Countries with a rich source of wealth, especially, diamonds, gold and silver can be more vulnerable to civil conflict with competing interests fighting for control of the natural wealth. In countries, such as Congo, Angola and Sudan, the seeds of civil strife can be, at least, partly related to conflict over mineral resources. Civil war is the most striking reason for delaying and reversing economic development. Conflict leads to wasted resources, lost human capital and resources diverted away from productive investment.

However, the link between natural resources and civil conflict is not direct. Civil conflict is more closely associated with lack of stable government and tradition of political democracy. Many countries with rich sources of natural resources have not witnessed civil war. This in other literature is referred to as political conflict. In many cases, the conflict can be somewhat hidden, with different groups within society all competing secretly for budgetary allocation from the government, thus creating a situation whereby the government finds it harder to operate effectively and is consistently navigating conflict between the various groups (Bannon and Colllier,2003). This theory suggests that a country with a large amount of natural resources may be more susceptible to internal and political conflict. This, in turn, can cause difficulties for the government, when it comes to establishing a strong economic performance and a suitably robust governance structure. For example, research by Bannon and Colllier, in 2003, suggested that where a country has commodity exports which make up approximately 25% of gross domestic product, it then has a 33% risk of internal political conflict, whereas if it exports just 5% of gross domestic product, the expectation of internal conflict reduces to just 6%.

ii. Limited (or lack of) investment in diversified industries/ Lack of Development of Further Resources. A country with strong natural resources will invariably specialise in the production and export of this natural resource. Therefore, there is less incentive (or necessity) for the economy to diversify into different industries, such as the service sector and manufacturing. It can also inhibit the growth of human capital as the workforce is employed in low-skilled manual labour (mining) This is a problem because the economy becomes reliant on the price and demand of this commodity. If the resource runs out, the economy is left with only small industrial sector and scope for growth.

Finally, there is also a body of research which suggests that the resource curse can be attributed to the lack of attention and investment placed on other sectors (Cotet and Tsui, 2010). More specifically, when the region is producing such a large income stream, naturally, it can be tempting to ignore other areas, and in certain developing countries, the government in question will often rely heavily on the income being derived from natural resources, without planning for the future by developing the infrastructure in such a way that other factors can also evolve alongside the natural resource boom. Also, as it is relatively common for these natural resource industries to achieve a large amount of financial return, but not necessarily to provide a large amount of jobs, it can be the case that education and intellectual knowledge is disregarded (Ding, and Field, 2005). This could be the case of Zambia were the largest proportion of export revenues is realised from the export of minerals (mostly copper and cobalt).

iii. Appreciation in the exchange rate. A country which finds natural resources will tend to have an appreciation of the exchange rate due to the resource effect. This has a benefit of making imports relatively cheaper (important if the country is net food importer). However, the appreciation of the exchange rate can damage other export industries and make them less competitive. This results in an unbalanced economy where only sectors which can thrive are the resources. This is also known as the "Dutch Disease"

For example, in the mini-oil boom of 1979-81 countries like Mexico, Venezuela and Nigeria saw rapid appreciation in the exchange rate due to the discovery of oil, but this meant virtually no other industries remained internationally competitive. A damaging effect in the long-term.

iv. Income elasticity of demand. Primary products tend to have a lower income elasticity of demand than services and manufactured goods. With rising global growth, there is a relatively smaller percentage increase in demand for primary products. This means countries producing primary products experience declining terms of trade.

v. Monopoly ownership. Natural resources tend to be owned by firms with significant degrees of monopoly and monopsony power. Often, they are global multinationals, e.g. De Beers diamond mining, Oil production by Shell, BP and Esso. This means that the profits from selling natural resources are taken primarily by a small percentage of wealthy shareholders (often foreign). This means profits flow back to the country of the multinational and do not directly benefit the developing economy. Furthermore, the level of tax paid by multinationals is often set at low level to attract investment. Developing economies with weak legal structures and history of business also see profits syphoned off by corruption. Mining companies do provide employment, but the percentage of earnings going to workers is often low.

"Easy riches lead to sloth" A non-economic argument. But the idea that countries who achieve 'easy wealth' have less incentive to work hard and develop a culture of entrepreneurship.

Lastly, a further review of existing literature relevant to the understanding of the nature and type of relationship that exists between natural resources and economic performance reveals that attempts at explaining this relationship date back to as far as the sixteenth century. With more recent thinking in development economics stressing the lack of positive externalities coming from natural resource sectors in contrast to manufacturing. The first explanations of the resource curse were based on the structuralist's theses of the 1950's, focusing on the decline in the terms of exchange between primary and manufactured products (Prebisch,1950), the volatility of primary product prices, or the limited linkages between the natural resource sector and the rest of the economy (Hirschman, 1958). However, none of these explanations was unequivocally confirmed by empirical tests (e.g. Moran, 1983; Behrman, 1987; Cuddington, 1992; Lutz, 1994; Dawe 1996 and Fosu, 1996). Moreover, it has been observed that because the primary sector remains important in low-income countries, the scale of natural resource rents and socio-economic linkages that they generate affects the aims of the government and development trajectory of the economy in important ways (Sachs and Warner, 1995a, 1995b; Karl, 1997; Ascher, 1999; Ross, 1999 and Auty, 2001, 2003). This thesis therefore aims at contributing to the already identified scant empirical studies to confirm the empirical tests of the natural resource curse hypothesis.

Empirical studies

Cross country studies

According to the existing literature, resource wealth adversely affects development. Natural resources such as copper are no exception. Even though most studies have focused on oil, they all seem to draw conclusions that there is a positive correlation between natural resources and adverse outcomes which include the focus of this paper, socio-economic outcomes. Sachs and Warner (1995, 2001) and Fafchamps et al (2015) in their studies focused more on cross-country correlations.

With the general growth of literature on natural resources, it is hardly surprising that the relationship between commodity prices and outcomes in an economy has also attracted considerable attention in recent years (McConachie and Binns (2007); Fisher et al (2009); Aragon and Rud (2013) and Caselli and Michaels (2013). While some of the more popular work such as Sachs and Warner (1995, 1997, 2001) lacks a critical dimension as they do not tackle the empirical relationship, the emphasis of resource wealth having an impact on economic growth, has nevertheless been valuable in fostering research into interactions within an economy and the presence of natural resources not only as 'subordinate' but also as playing a significant, at times not so visible role in economic growth. This influence also motivated this study of understanding the role that the exogenous shocks arising from the volatility of natural resource prices plays in influencing not only the general economic growth of an economy but also the socio-economic outcomes of local communities.

This therefore raises a growing need to carry out empirical examinations such as the one this thesis carried out to ascertain whether the earlier theories can be able to explain what is prevailing within individual resource rich economies. Even though several recent studies have tried to move beyond the cross-country correlations and examine resource discoveries using within-county regional variation (Assuncao, 2007; Aragon and Rud, 2009; Bobbins and Morrow, 2010 and Michaels, 2011), not much has been done on Zambia. With one well known study by Lippert (2013) which did not capture the role of the exogenous shock in copper prices and the potential endogeneity of natural resource extraction.

Several cross-country studies have been conducted on growth and poverty mostly examining the relative importance of growth and distribution (Easterly, 1999; Barro, 1999; Dollar and Kray, 2002; Ross, 2003 and Dollar, 2004). Even though these studies have observed that growth can reduce poverty, they failed to highlight on the influence that external factors may have on an economies' growth. Ross (2003) observed the link between exports of mineral resources and poverty but the focus was not on how resources specific to countries tend to affect those countries. But, Bourguignon (2002) suggests that understanding the effects of distributional changes necessitates more micro-level analysis. It is therefore imperative to carry out an analysis within a single country and thereby understand the effects of external shocks on the poor and the growth of an economy in general.

Although there has been a growing recognition of the role of natural resources on an economy, most of this research has tended to focus on the relationship with conflict (Montague, 2002; Hilson and Yakovleva,2007; Maconnachies and Binns,2007; Angrist and Kugler,2008; Arrelano,2011 and Dube and Vargas, 2013.) Others have brought in issues like corruption (Monteiro and Ferraz, 2009; Vicente, 2010) and agriculture (Maccombie and Binns, 2007). And other literature on mineral wealth and the poor by (Deaton and Miller, 1995; Ross, 2003; Fisher et al, 2009; Pegg, 2005; Deaton, 1995 and Hilson, 2010). It is therefore imperative to address the challenge faced with natural resources in terms of the causal effects of the volatility of copper prices on living standards in Zambia in the presence of exogenous shocks to the economy. This is alluded to the theory of production were the Marginal Factor Productivity of labor is expected to rise because of the improvement in living standards. The increase in Total Factor Productivity (TFP) which led to an increase in copper output would in this case be attributed to the improved well-being of workers.

Within country studies

Studies such as Cavalcanti, Mata and Tosconi (2015) have furnished an argument that cross-country studies usually use very aggregate variables and make it difficult to control for institutional and cultural frameworks and for policy variation between different countries. This has led to a shift in literature; with attention being focused more on within country correlations and variations (Ibid). This has also led to a growing strand of literature giving more attention to more detailed analyses on the mechanisms of how natural resources impact the economy. Major contributions have come from Michaels (2000), Monteiro and Ferazz (2012), Allcot and Keniston (2013); Dube and Vargas (2013); Caselli and Michaels (2013) and Aragon and Rud (2013).

Research into the area of the socio-economic impact of resource booms is an area where there have been few empirical studies, which have been mainly examining the relationship in one direction (Wilson, 2012; Aragon and Rud, 2013b; Lippert, 2014). It is believed that natural resources are assumed to affect local communities, when local communities may also affect the production of natural resources. This research filled this gap by gaining rich insights into the causal relationship that exists between natural resource production through changes in the international commodity prices and socioeconomic outcomes in economies where the commodities are produced.

Even though there has been an observed correlation between natural resources and economic outcomes, evidence on the causes of this relationship within a country is relatively scant and at times results seem to be inaccurate as they only display what takes place in the short-run and not in the long-run (Topalava,2010). Moreover, less attention has been devoted to the fact that natural resources can lead to positive economic development: Halvor et al (2006). This research therefore endeavored to fill this gap by gaining rich insights into the type of relationship between natural resources and economic performance within a single country without pre-conceived ideas of poor economic performance and at a sub-national level.

A growing number of studies have been conducted on the relationship between natural resources and economic outcomes (Deaton and Miller, 1995; Gylfason et al, 1999; Sachs and Warner, 1995, 2001; Aragon and Rud, 2013b; Lippert, 2014). Consequently, recent theoretical advances have brought income and wealth distributions back into a prominent position in growth and development theories, and as determinants of specific socio-economic outcomes such as health or levels of violence (Elbars et al, 2003; Collier and Hoeffler, 2004, 2005 and Dube and Vargas, 2013). With Halvor et al, (2006) observing that countries rich in natural resources constitute both growth losers and growth winners. This is supported by the World Bank which found that five of the top eight countries, per natural resource wealth where among the top fifteen high income countries. With theory and cross-country studies also observing that there is a positive correlation between the presence of natural resources and poor economic performance.

Data and Methodological issues in the literature

Indeed, a large body of predominantly macro literature documents a negative correlation between living standards and resource reliance by exploiting variation in cross-national data. This paper contributes to the strand of literature on natural resource curse by examining the local impact of 10 copper mines in the context of a single developing economy. This stems from the gap in literature identified by Cavalcanti, Mata and Toscani (2015); who argue that cross-country studies on the natural resource curse that have dominated the literature use aggregate variables making it difficult to control for institutional and cultural frameworks, and for policy variation between different countries. This chapter therefore contributes to the growing strand of literature by giving more detailed analyses on the mechanisms of how natural resources impact the economy within a single country. This, however, adds one limitation related to the generalization and extrapolation of the results from this work. Notable contributions have come from Michaels (2000), Monteiro and Ferazz (2012), Allcot and Keniston (2013), Dube and Vargas (2013) and the study closest to this paper on natural resources and local communities by Caselli and Michaels (2013) who studied the impact of onshore and offshore oil on municipalities in Brazil and Venables (2016) who analyzed the reasons why it has proven difficult to use natural resources for development. While significant intellectual energy went into documenting the adverse consequences of natural resources in developing countries, establishing causality has remained somewhat elusive in this largely cross-country literature.

A further review of relevant literature to an understanding of the role of natural resources and their welfare implications reveals a serious limitation in that there has been an emphasis on the short-term effects, by using count data (Fisher et al, 2009) and there has been a lack of sufficiently detailed high-quality data on distributions (Elbers et al, 2003). Consequently, this makes it difficult to ascertain whether the improvements in material living standards are permanent or transient. Thus, with the availability of repeated cross-sectional data, this analysis is an extension of previous studies.

Most poverty analyses have traditionally relied heavily on single household surveys of consumption or incomes, with somewhat minimal set of other relevant variables. Unfortunately, such data were once only used to inform a rather narrow range of policy measures, notably targeted interventions. This is because conventional cross-sectional datasets are less than ideal for analyzing issues concerning the dynamics of poverty, including its state dependence and for dealing with certain problems of endogeneity. They also pose a challenge of omitted variable bias. For this reason, there has been some progress in analyzing cohorts from repeated cross-section surveys (Deaton and Paxson, 1994). However, there is still a high return to longitudinal datasets, particularly for the analysis of poverty dynamics especially in low-income countries like Zambia. Thus, we constructed a panel dataset from repeated cross section data. The use of a panel dataset is also a contribution to studies on natural resources and development as this helps to assess the natural resource curse over time. We also address issues of endogeneity of natural resource extraction.

To overcome the various limitations identified, including the potential problem of the endogeneity of natural resource extraction, we employed an instrumental variable estimation with fixed effects which captured the important role of the international copper price in a quasi-natural experiment with exogenous variations from copper production.[14]

In terms of design and results, this chapter is also related to the literature on the impact of natural resources on an economy, especially the strand of literature that focuses on the impact of natural resources on welfare. Important contributions include Aragón and Rud (2013) Dube and Vargas (2013), Lippert (2014) and Fafchamps et al (2015). Within this literature, our paper is closely related to Dube and Vargas (2013) who explored the relationship between commodity price shocks and civil conflict in Columbia and Caselli and Michaels (2013) who look at the effect of onshore and offshore mining on local communities.

The role of prices in the natural resource curse literature

There also appears to be a little evidence on how changes in commodity prices that lead to fiscal windfalls affect living standards. Despite finding that presence of natural resources tends to lead to certain outcomes; previous studies have not considered the role that natural resource prices play in the living standards. Examples of such studies include: McCombie and Binns (2007) who observed a strong link between agriculture (in terms of food production) and mining in Sierra Leone; Dube and Vargas (2013)- who focused on conflict and oil windfalls in Colombia; Caselli and Michael (2013) on the effects of oil windfalls and corruption in Brazil; Aragon and Rud (2013a) who analyzed the adverse environmental impact of Gold mining in Ghana and Lippert (2014)'s analysis of living standards in Zambia in the context of copper production booms. This research sought to fill the gaps identified by exploring a quasi-natural experiment of analyzing the effect of changes in the levels of

[14] Fixed effects models in this analysis are the most beneficial as they consider the heterogeneity that exists in the constituencies and the time-variant unobservables are taken care of.

copper output on local communities using observational data. This was conducted in the presence of exogenous shocks to global copper prices and structural changes on poverty and analyzes the implications which will be useful to policy-makers for future interventions in poverty programs.

Despite large endowments of natural resources unarguably providing vast opportunities for economies to grow and develop, the impact of natural resources wealth on economic development is still the subject of ample debate among Economists. With the effect that volatility of natural resource prices can have on socio-economic outcomes still an issue that needs to be explored, as they also affect economic development. This is because shocks may be transmitted to greater volatility and uncertainty in individual earnings of individual workers which may be because of the shocks affecting an entire economy such as the shock brought about by global prices of natural resources (Pellandra, 2015).

The presence of natural resources in Zambia, the copper boom and living standards

Even though some theorists like (Sachs and Warner, 2001; Frankel, 2010; Alexaar and Conrad, 2009 and Gylfason et al, 1999) have observed poor economic performance in natural resource rich countries, reports on poverty in countries like Zambia have shown a decline in the levels of poverty in the recent past. A report by the United Nations Development Program (UNDP) showed that the rates of poverty in Zambia which were once at eighty percent have gone down to about sixty seven percent. But, Arellano (2012) still argues that there may be other reasons that could be attributed to the poor economic performance of the countries that are rich in natural resources.

Studies conducted on Zambia closest to this paper include Ormande, (2011) and Lippert, (2014). In a study on the impact of mining on poverty by Ormande, (2011), it was found that mineral rents have not helped in poverty alleviation in Zambia. This study lacked empirical evidence. In addition, both studies seem not to have considered any causal relationship that may exist between poverty and mining in Zambia. Furthermore, Lippert’s use of only an Ordinary Least Squares (OLS) regression model was inadequate as there may be a causal relationship between copper output and living standards. In addition, there is a potential endogeneity of natural resource extraction.[15]

A previous study by Kiiru (2010) reveals that the use of OLS may result in overestimation or underestimation of the impact on standards of living of changes in copper output because of changes in the copper prices. Another study close to this paper is Dube and Vargas (2013) who studied the impact of natural resources on conflict in municipalities of Columbia. They used a differences-in-differences approach. But, as earlier mentioned, the closest study to this paper is a study on offshore and onshore mining its effect on living standards in Brazil by Caselli and Michaels (2013) were an Instrumental Variable technique was used.

Thus, this chapter seeks to contribute to existing literature by investigating the causal relationship between living standards and copper output in the presence of changes in prices of copper in an economy. Our study adds on to this literature by examining a reverse causality between living standards and copper production, which was not explored. There exists a link between labor productivity and poverty which can be examined through the production of copper output. This stems from economic theory on labor productivity were employment and productivity are linked with the aggregate output of an economy. These links can only be understood if their interaction with income is not ignored. There ultimately also seems to be a link between the labor productivity and material well-being of a population as poor living standards can reduce labor productivity while on the other hand labor productivity can stimulate production. This is supported by Van Ark and McGuckinh (1999) who aptly stated that productivity is only one of the factors determining living standards, which also depend on 'how many mouths need to be fed' from what is produced. It has furthermore been observed that poverty persists because of the failure by societies to effectively deal with unemployment, low productivity and income inequality.

In addition, this chapter attempted to resolve any questionable issues regarding whether we can sorely attribute any changes in the living standards in Zambia to the exogenous shock (resulting from the rise in international copper prices) which culminated into a resource

[15] Lippert (2014) provides evidence on the spillover effects of resource booms (in relation to copper booms in Zambia) on standards of living in Zambia. He used an Ordinary Least Squares (OLS) regression, which lacked an inference of the causal relationship between "the resource boom" and living standards.

boom. It is thus aimed at also comparing the living standards in an unexamined region which is non-mining, away from both a mining region and the transportation links for copper during the period of the resource boom. This stems from arguments by Hans Lofgen, Sherman Robinson and James Thurlow (2002) that the slump in copper production as a result of low prices and subsequent threatening of closing the mines in Zambia led to the tremendous improvement of export-led sectors in agriculture and related industries; Hirschman (1958) that mining is generally considered an enclave activity with limited linkages to the regional and national economy; and that the mining sectors' linkages to the rest of the economy are weak (Adam and Simpasa, 2009; Fraser and Lungu, 2007).

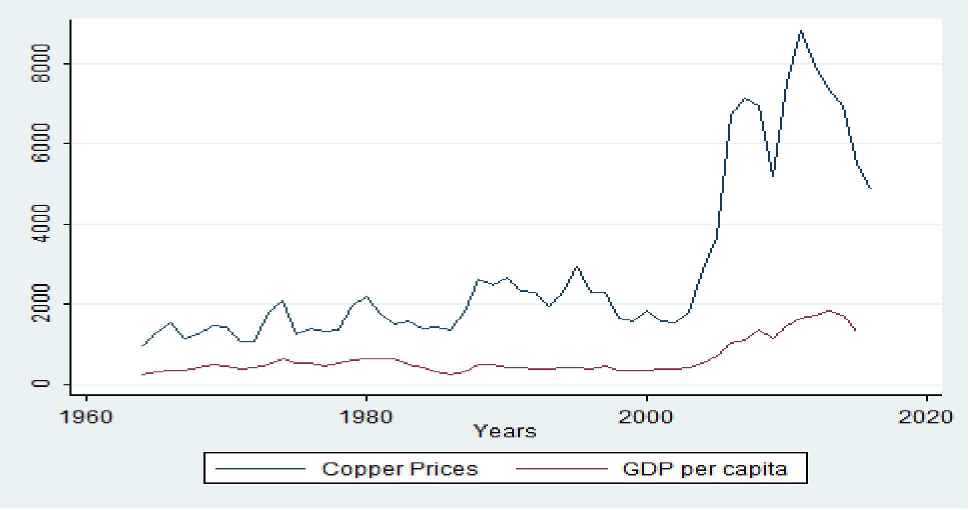

Figure 2.2 Movement of copper prices and per capita Gross Domestic Product (GDP) from 1964 to 2016

The main body of documented literature on the natural resource curse broadly identifies three potential channels through which natural resources could hinder development. First, natural resource exports could appreciate the real exchange rate thereby disadvantaging the tradable non- resource sector (or the modern sector) of an economy (Corden and Neary, 1982). Adverse development outcomes could be permanent, if competitiveness cannot be regained.[16] Second, over-reliance on natural resources for government revenue could give

[16]This argument may not be relevant in the Zambias' context as the manufacturing sector is small and the exchange rate is not viewed as a key constraint for the same in Zambia (Bigsten and Söderbom, 2006).

rise to corruption and weak institutions such as political, economic and financial institutions as the state would no longer require relying on the non-resource sector as a major source of revenue (Robinson et al., 2006). Third, the high volatility of global commodity prices could disadvantage resource rich developing countries as they become more exposed to global shocks and macroeconomic instability (Deaton, 1999; Ramey and Ramey, 1995). In the case of Zambia, the economy was resilient to global shocks that took place around 2008 and 2009 this is evidenced by the stability in macroeconomic indicators such as stable exchange rates and increased GDP growth rate. The GDP growth rate stood at 7.8 percent in 2008 and 9.2 percent in 2009 (World Bank, 2017). This was much higher than its neighbors such as Zimbabwe which stood at 6 percent in 2009 (Ibid). The movement of the per capita GDP in the wake of increasing copper prices is represented in figure 21; with changes in the GDP per capita following the performance pattern of copper prices.

2.3 Data and Methods

2.3.1 Data and main variables

The empirical analysis combines household data with information about the constituency and mining activities for the period between 1996 and 2010. For constituencies, we used repeated cross sections of the Living Conditions and Monitoring Survey (LCMS), a household survey collected by the Zambian Central Statistical Office (CSO). The survey consists of a stratified household sample representative at the constituency level. We focused on aggregates at constituency level. The main outcome variable is income which is represented by the household consumption expenditure.[17] The adult equivalence scale weights this as adopted by the Central Statistics Office in Zambia in accordance with the United Nations Statistics Division (2005).

The use of household expenditure as a proxy for household income was arrived at because of the documented theoretical and practical reasons. Firstly, individuals feel more comfortable to provide information on consumption than income. Secondly, consumption provides a better picture of long-term welfare than income (Deaton, 1999). Lastly, income measurements in countries with widespread informal employment and a large segment of agricultural households are highly inaccurate compared to expenditure measurements. Given that there is not much savings in Zambia, I use the household consumption expenditure as a proxy for income. According to the International Labor Organization (ILO), the informal sector accounts for 72 percent if employment in sub-Saharan Africa. In Zambia, it accounts for 8 percent. It is therefore justifiable to use the household consumption expenditure than the household income. The income was later deflated using the poverty line.[18] Aragon and Rud (2013) also support the use of this method.

The focus of this study was the living standards at constituency level. Such work requires datasets that focus on all the constituencies through time. This makes it possible to

[17] Household consumption expenditure serves as a useful proxy for household income, which in many cases tends to be under-reported by most households. It is in this regard that Government institutions, non-governmental organizations and individuals responsible for policy formulation and poverty reduction have a special need for household expenditure data.

[18] The poverty line is estimated by the Central Statistical Office (CSO) as the value of the minimum consumption basket that guarantees an adequate living standard. It is calculated using local prices and varies within region and over time

ascertain the relationship between living standards and the changes in copper output levels. The data for this paper is thus drawn from a variety of sources which include the Central Statistical Office (CSO), the Ministry of Mines and Minerals Development, Bank of Zambia (BoZ), Westmetall, the World Bank and various annual reports from the mining companies with an established presence in Zambia.

These sources were combined to construct a novel panel data set at constituency level comprising of 750 observations observed at five different points in time. The dataset covered 150 constituencies for the survey periods of 1996, 1998, 2004, 2006 and 2010.

In Zambia, poverty data is collected by the using the Living Conditions and Monitoring Surveys (LCMS) providing for count data. Unfortunately, no panel datasets on poverty were available in Zambia at the time of the research; as such a novel panel dataset had to be constructed from five different rounds of the survey. This comprises household survey data from these rounds of the LCMS, which are repeated cross-section surveys. They are used to monitor poverty among other things and the data from the surveys covers a wide range of key indicators of living standards that are relevant at sub-national and locational (i.e. rural and urban) levels. These are the 1996, 1998, 2004, 2006 and 2010 rounds. This data was used to form a novel panel dataset at constituency level.

The LCMS cover all the population residing in Zambia at the time of the survey. Each survey round is relatively large, covering roughly 1 in every 113 households. In 1996 - 11,788 households comprising of 61,455 individuals were surveyed, in 1998- 16,718 households comprising of 93,471 individuals, in 2004- 54,100 individuals from 9,741 households, in 2006 97,738 individuals from 18,662 households and in 2010- 102,882 individuals from 19,398 households.

To quantify the exposure to the mine's center of activities, we construct a measure of distance from the centroid of each constituency to the nearest mine. This distance is the length of the shortest distance between the center of a constituency to the nearest mine.[19] The distance ranges from 1 to 912km with an average of 420km and a median distance of 401km. Table 2.1 shows some summary statistics of the main variables from the household

[19] The results are robust to the alternative measures of distance.

survey.[20] The value of the copper production is measured in metric tons while the nominal income is measured in thousands of kwacha.[21] In terms of poverty lines, these show the different classifications using the Cost of Basic Needs (CBN) approach which is the most commonly used measure of welfare outcomes (Ravallion, 1994; CSO, 2008).

The classifications of the poverty lines as previously stated are extreme poor, moderately poor and non-poor. The extreme poor are classified as those not being able to meet the minimum cost of basic needs. The food poverty line corresponds to the cost of the food basket as has been designated by the Central statistical Office is the extreme poverty line, while the basic needs baskets has been designated as the moderate poverty line. Therefore, households whose per adult equivalent expenditure is less than the extreme poverty line are classified as extremely poor, while households whose per adult equivalent expenditure is equal to the food poverty (extreme) line but falls below the moderate line are said to be moderately poor. Non-poor households are those whose adult equivalent expenditure is greater than but equal to the moderate line.

[20] We make use of the median distance of 401km from a constituency to the nearest mine.

[21]Kwacha is the official local currency used in Zambia.

Table 2.1- Summary Statistics[22]

Variables	Mean N=750	Standard Error
Household head		
% of literate household heads	82.9	0.4
Average age	41.9	0.1
% of female headed households	20.8	0.4
Household		
Income per capita	64784.2	45059.01
Poverty line (For the whole sample)	80872.3	45927.5
% of the population that living in extreme poverty	40.1	0.9
% of the population that are moderately poor	18.1	0.4
% of the population that is living in poverty	58.2	0.9
% non poor	41.6	0.9
% of population with access to electricity	35	1
% of population with access to clean water	77.2	0.6
Number of household members	5.4	0.03

[22] Summary statistics showing the time trends are presented in tables A2 to A6 in the appendix

Mining data		
Copper production	17216.1	1967.5
% of population employed by the mines	7.5	0.9
Mine level copper price	699.8	518.56
International copper price	4216.1	2713.7
Constituency data		
Distance to nearest mine(km)	419	12.2
Population	81350	3003.6
Government funding	32,200,000	58,200,000
Observations (Constituencies)	150	

Some interesting patterns should be noted from the descriptive statistics above. First, the average proportion of the population that can be considered rich is bigger than the proportion of those, who, on average, has access to electricity.[23] That shows that the data used for the research includes both urban and more rural areas with different levels of infrastructure, giving more validity to the research, after controlling for constituencies effects. In addition to that, the price of copper had experienced some significant volatility over the periods we are taking into account as well as the government spending.

Data on copper production is taken from Bank of Zambia (Zambia's' Central bank), an additional source was the Ministry of Mines and Minerals Development. All the different sources were combined to construct a time-series of annual copper production since 1994 for each large-scale mine. This data was compared and harmonized with data from the mining companies' annual reports. While data from the other measure of mining activity; employment was obtained from the LCMS. Lastly, data on the international copper prices was taken from the World Bank databank and Westmetall.

2.3.2 Other Influences

Using household statistics provided by the Living Conditions and Monitoring Surveys, the author computed the data on education, age, and household size, access to water and population density as well as data on percentage of female headed households. Lastly, Arc-GIS was used to compute data on distance, where distance was calculated from the centroid of each constituency to the mine closest to an individual constituency.

Administratively, Zambia consists of 10 provinces that are subdivided into districts. There were 72 districts consisting of 150 constituencies during the period the household surveys were conducted. Constituencies are at the lowest administrative level. Zambia had a population of 9.1million in 1996 and 13.2million in 2010 corresponding to an annual population growth rate of 3.2%. Per household survey data, poverty levels seem to have experienced some changes, with some areas with the presence of mines showing fluctuations

[23] Access to electricity only takes into consideration those that use hydro-electric power…others especially in the farms make use of solar energy.

in the levels of poverty. The North-western part of Zambia in which two mines begun production after the privatization of the mines, seems to have undergone reductions in poverty levels. The overall poverty rates for the North-western province marginally reduced from 89% in 1996 to 65% in 2010. These variations in the poverty levels make it ideal to determine whether copper production had an impact on standards of living in Zambia. Table 2 shows us the patterns of headcount poverty ratios during the survey period. Figure 2.2 also shows us the movements in real incomes for constituencies that are close to and far away from the mines. In this diagram, constituencies close to the nearest mine are classified as having a mine presence and the rest, those far away from the mines are without a mine presence.

Table 2.2- Headcount poverty during Survey Years

	Survey Years				
	1996	1998	2004	2006	2010
All Zambia	74	69	73	68	67
Rural/Urban					
Urban	46	56	53	29.7	27.5
Rural	92	82	83	80.3	77.9

Source: Authors' computations

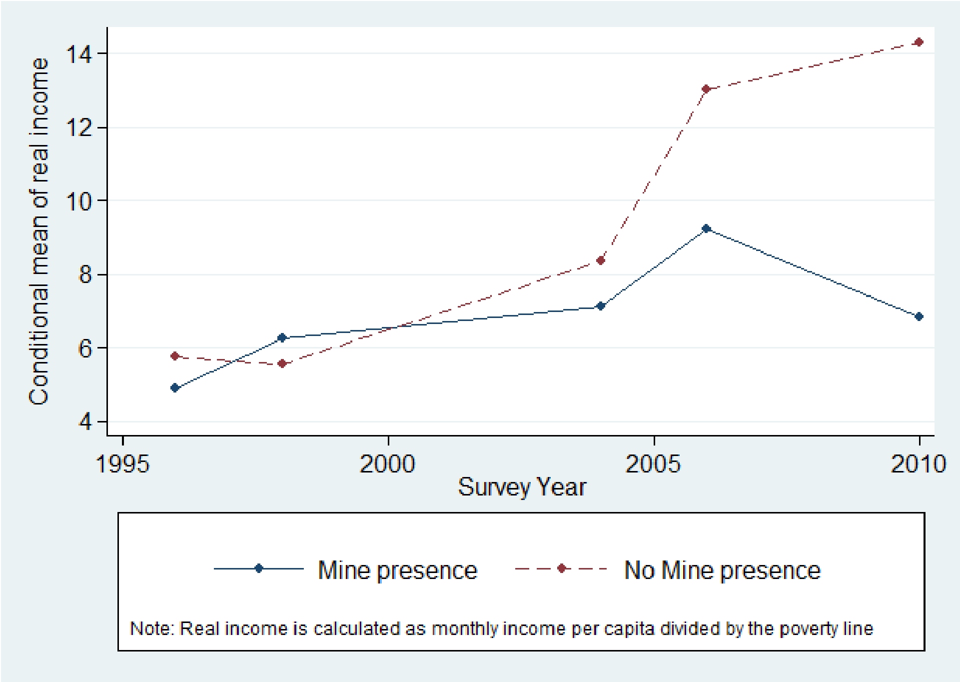

Figure 1.3: Conditional mean of real incomes by survey year

2.4 Identification Strategy and Estimation

The strategy ascertained the impact of per capita mine level copper output on real incomes of constituencies. The first attempt is to use the Ordinary Least Squares (OLS) estimation to determine the impact of per capita mine level copper output on real incomes of constituencies. Unfortunately, there is whole variety of problems of endogeneity when using the pooled OLS method on the panel data, starting from correlation of observed or unobserved time-invariant effects of constituencies that one should take into account, finishing with the endogeneity of natural resource extraction that has been previously identified in literature (omitted variable problem, reverse causality). There is also a likelihood of a measurement error in the per capita mine level copper output to be correlated with the error term. With the presence of the problems presented above, OLS is inconsistent (Wooldridge, 2009). Thus, the identification of the impact of per capita mine level copper output requires usage of the Panel Data Methods, for example, fixed effects (FE), and the Instrumental Variable (IV) that are exogenous and correlated with per capita mine level copper output but are uncorrelated with the error term.

2.4.1 Empirical Strategy

Thus, the objective in the empirical strategy is to understand the impact of per capita mine level copper output on local economies, particularly its effect on living standards at constituency level through the channel of real incomes. In this strategy, two major sources of variation are exploited; specifically, the mine level copper output and the real income. The specific estimation is as follows:

$$\boldsymbol{Ln}(\boldsymbol{y}_{ct}) = \boldsymbol{\alpha}_c + \boldsymbol{\gamma}_t + \boldsymbol{\delta Ln}(\boldsymbol{M}_{ct}) + \boldsymbol{\beta X}_{c\,t} + \boldsymbol{\varepsilon}_{ct} \qquad \textbf{(2.1)}$$

where $Ln(\boldsymbol{y}_{ct})$ denotes a natural logarithm of a constituency c socioeconomic outcome at year t (for example real incomes, employment and poverty measures), $\boldsymbol{Ln}(\boldsymbol{M}_{ct})$ indicates the per capita mine level copper output for constituency c at time t. The per capita mine level copper output represents the mine level copper output at constituency level. I take all constituencies within 401km to the nearest mine as having a mine presence. The reason for this assignment is that constituencies are smaller than districts and there are usually several them in a district. Most households that have links with the mines are not in constituencies were the mines are physically located. Therefore, leaving them out of the analysis I believe would not be carrying out a proper analysis. Moreover, there are only 10 constituencies were these mines are located meaning there would be no proper representation if households outside these constituencies but in the districts where the mines are located are not included in the analysis. In addition, using the median distance is more robust on the assumption that the distance in real life is not normally distributed. For this situation, using the median distance also takes into consideration the economic effects on mine employees who choose to live far away from the mines as a result of knowing the full repercussions of pollution if they lived close to the mining operations. The use of the distance of 401km which is the median distance in the sample is therefore more plausible for the analysis. While there was no copper output for all constituencies located more than 401km to the nearest mine. As such, the analysis of the heterogeneous effects of distance further compares the whole sample with sub-samples of constituencies located within 100km, 200km, 300km and 401km to the nearest mines.

$\boldsymbol{X_{c\,t}}$ is a vector of control variables, that include constituency characteristics that vary over time such as population density, $\boldsymbol{\alpha_c}$ is a constituency fixed effects, which are routinely removed by using the FE 2SLS estimation method (Within Transformation) in STATA statistical software, i.e. not estimated, $\boldsymbol{\gamma_t}$ is a year fixed effects and $\boldsymbol{\varepsilon_{ct}}$ is an idiosyncratic error of constituency *c* and period *t*. The government budgetary allocation to each constituency is also included as a control variable. Thus, $\boldsymbol{\delta}$ is the coefficient of interest.[24]

By removing fixed cross-country differences from the estimation of the effect of human capital or industrialization on copper output, I avoid the problem of correlation of the copper production with underlying physical copper endowments and other country-level characteristics (for example, geology, climate, and copper ore deposits and quality, inter alia) that are internal to each constituency and do not change over time. That is why, in all my specifications, I employ constituency fixed effects. In addition to that, the research

[24] This helps to resolve the problem of omitted variable bias as the expenditure on poverty alleviation projects can also affect constituency incomes, controlling for this expenditure is therefore vital.

concentrates on the in-country variations, rather than considering different countries is related to the following. Relying on cross-national variation (which is typically much larger than within-country variation) to assess the thesis would be exceedingly indirect, and critically misspecifying if the socioeconomic outcome-relevant (static or slow-moving) cross-national differences are not all correctly modelled.

The estimation approach used is the Two-Stage Least Squares with the fixed effects for panel data. The reason for using the 2SLS, as usual in many empirical studies (Card 1995, Caselli and Michaels (2013), or Monteiro and Ferraz (2012)), is a potential problem of endogeneity. Therefore, the first stage regression model (or a Reduced Form equation) is as follows:

$$\boldsymbol{Ln}(\boldsymbol{M_{ct}}) = \boldsymbol{\eta_c} + \boldsymbol{\theta_t} + \boldsymbol{\lambda_1 Ln}(\boldsymbol{IntCP_{t-1}}) + \boldsymbol{\beta X_{c\,t}} + \boldsymbol{\mu_{ct}} \qquad \textbf{(2.2)}$$

$\boldsymbol{Ln}(\boldsymbol{IntCP_{t-1}})$ denotes the natural logarithm international copper price at period $t-1$, the $\boldsymbol{\eta_c}$ and $\boldsymbol{\theta_t}$ represent the constituency and time fixed effects, the former are also routinely removed by the Within Transformation in STATA, $\boldsymbol{\mu_{ct}}$ represents the idiosyncratic error term. Lastly, $\boldsymbol{X_{c\,t}}$ includes all the exogenous explanatory variables that were used as controls in the second stage regression.

As mentioned above, per capita mine level copper output is not exogenous to local economies because it depends not only on the time-invariant characteristics of constituencies, such as availability of copper deposits, population and the geographic characteristics of the mines, but also on the time-varying variables directly related to the socioeconomic outcomes of the constituency, for example, level of development of the local infrastructure, local roads which with no doubt have impact on both, local population welfare and copper extraction (Lippert, 2014).[25] The main concern is related to the per capita mine level copper output which may vary over time and may not be perfectly observed. To deal

[25] The population affects the per capita mine level copper output as it is the main supply of labor to the mines.

with this potential problem, the strategies adopted by Caselli and Michaels (2013) and Monteiro and Ferraz (2012) are used. The two strategies applied an instrumental variable approach in their studies of natural resources and political outcomes.

Such an approach (2SLS FE) is a powerful tool in handling a whole set of endogeneity, with which, despite their popularity, OLS estimation cannot control. OLS are generally weak in dealing with the problems of endogeneity. The major sources of such problems identified from theory are simultaneity (e.g. reverse causality), omitted variable bias and measurement error (see Wooldridge, 2016, 405-437; or 2008: 506-536), (e.g. errors in variables). In addition to that, the Panel Data has the endogeneity that comes from the correlation of the observed or unobserved heterogeneous characteristics that are time-invariant.

2.4.1.1 Heterogeneous effects. The time-invariant effects inherent in the constituencies are routinely taken into account in STATA. The 2SLS FE estimation uses the within transformation, removing the time average for each constituency from each observation for that constituency removing all time-invariant effects, by doing so we remove any endogeneity from the potential correlation of the effects with the explanatory variables. Here we are following the approach of Chistaensen, Demery and Kühl (2011) and Heady (2014). The 2SLS RE were tested and the Hausman test supported the rejection of this approach. That is also enforced by the fact that such time-variant characteristics as, for example, geographical proximity to large copper deposits are correlated with the copper production levels and, potentially, with the social and economic outcomes of this constituency.

2.4.1.2 Simultaneity. There is a possibility of reverse causation from increased real incomes to higher per capita mine level copper output, for example, constituency changes in real incomes in part causing changes in copper output. The Instrumental Variable (IV) used in this work is correlated with the level of copper production but not with the other regressors included in the model. Thus, we assume that international copper prices influence the socioeconomic outcomes of the constituencies only through the level of copper production, i.e. $\boldsymbol{InIntCP_{t-1}}$, should have a significant impact on $\boldsymbol{InM_{ct}}$, and, at the same time, the excluded instrument must be distributed independently of the error process. In this study, the proposal is that the international copper price can provide a plausible source of variation in the real income levels. This, therefore, requires that $\boldsymbol{InIntCP_{t-1}}$ generates any direct effect on socioeconomic outcomes, through, in this case, the real incomes. This is supported by the fact that the international copper prices are determined specifically by the global market institutions such as the London Metal Exchange (LME). This means that the price ($\boldsymbol{InIntCP_{t-1}}$**)** is exogenous to the modelled relationship. When changes to the copper prices due to demand and supply factors take place at the global market level, this may lead to an increase in the international copper price. This increase is likely to boost copper production by the mining firms. This boost may be because of an increase in wages and other incentives such as production bonuses from the profits. This motivates the workers to increase their productive capacity ultimately leading to an increase in mine level copper output. The coefficient estimate, in this case, is expected to be positive.

The assumption of exogeneity of our IV can be considered to be plausible because close to seventy per cent of the copper production is done away from the major cities. Also, services and production plants that support copper production are concentrated in the north-western region of Zambia. While the International copper prices are determined by the supply and demand on the international market. Implying that the effect of a constituency in Zambia on the international prices can be assumed negligible, if not strictly zero. Although this assumption cannot be tested, there is evidence that copper production may not have any direct impact on local communities rather than through the central government. As there is a central collection of revenues in place, the assumption further supported. The validity of this assumption is further supported by the first stage regression results which show that the international copper price coefficient has the expected sign of coefficient. In this case, since the rise in the international copper prices is expected to lead to an increase in the per capita mine level copper output, there should be a positive correlation between the two variables and, as such, the coefficient should be positive. To prove this hypothesized relationship, the first stage results of the IV estimations are reported in panel 2 of each table.

Furthermore, the potential argument of endogeneity of $\boldsymbol{InIntCP_t}$ through the possibility that mining companies can try to influence the copper price influencing the copper output does not seem plausible here. I believe that this is highly unlikely to affect this study taking into account that there is no organisation of copper producers aiming at price regulation such as OPEC and Zambia does not account for a very large proportion of the global copper output.

2.4.1.3 Omitted Variable Bias. Using the same assumption on the exogeneity of the IV, it is natural to assume that our estimation method will help to mitigate any Omitted Variable Bias. Any omitted variable correlated with other explanatory variables should not be correlated with the exogenously determined international copper prices.

2.4.1.4 Error-in-variables Bias. The final source of endogeneity that the IV instrumental variable helps us mitigate here is the error-in-variables bias. In case if there are any potential errors in the way the data on the mine production levels are collected then our estimation approach should be able to handle it as well as the two biases explained above. The assumption that our IV variable – international copper prices – is uncorrelated with any type of error, makes sense due to the fact that the errors in data should, most probably, come from the subnational level (Birabi, 2016), while the international prices are determined on the international market as a result of the aggregate demand and supply for copper. Thus, the use of the international copper price as an instrument for the per capita mine level copper output is supported as the way to avoid a potential omitted variable bias; as the past prices are likely to later culminate into an increase in copper production, and, furthermore, be related to the real income only through the per capita mine level copper output.

To check the relevance and validity of the instrument used for per capita mine-level copper output, a number of diagnostics were employed. P-values for these tests are reported at the foot of the tables. As a rule of thumb, the F-statistic of a joint test should be greater than 10 in the case of a single endogenous regressor (Cameron and Trivedi, 2010).

In addition, a special control variable, government funding is used to help solve the problem of omitted variable bias. The argument is that the government spending, which may directly affect socioeconomic outcomes, in this case, may not necessarily be determined by mining activities. A higher international copper price may increase government revenues ultimately leading to increased revenues which the government can spend on the poor. This is the most effective way of the poor benefiting from the copper mining as decisions on the allocation of funding towards any poverty alleviation is determined at the national level. Even though EAZ (2011) and Manely (2015) observed that the management of such funds are quite ineffective and has not achieved its intended goal, it is believed that even the little expenditure by the government on projects targeted towards poverty alleviation can achieve the intended goal. The analysis thus controls for government spending (at constituency level) to solve the earlier stated problem of omitted variable bias. Government funding is a key control variable as there is a possibility that this in some cases may influence the real incomes at constituency level especially if the allocation is made according to the contribution of mining revenues to public funds. In the case of Zambia, as earlier highlighted, the government allocates what is known as Constituency Development Funds (CDF) which is uniform across all constituencies. This simply means that there is no favourable treatment for constituencies with a mine presence.

In the case of Zambia, constituencies with mineral deposits are not evenly distributed; they are mainly in the north-western part of the country.[26] This simply means that constituencies with copper deposits are systematically different from other Zambian constituencies. This may lead to potential biases if revenues from the mines were directly accruing to individual constituencies. But, in Zambia, revenues are collected centrally and decisions on expenditures are made by the central government through the national budget. Most of the results are thus later replicated with alternative subsamples as part of the robustness checks. The sample is separated by distance, which groups the constituencies into those located close to and far away from the mines. The sample is also divided into rural and urban constituencies. Findings from both these classifications show a non-sensitivity to sample selection.

From the above, it is not difficult to see a potential limitation of the current estimation approach. Any IV estimation is not without a bias in estimates to a certain degree. According to Wooldridge (2016) in small samples, a FE IV estimator can have a substantial bias that is why the large samples are preferred. In our case, the sample reaches 750 observations, which can be considered large enough and similar to the empirical studies carried out in the area of my research.

[26] Copper production is concentrated in a belt called the Copperbelt which extends to neighboring countries like the Democratic Republic of Congo.

2.4.2 Examination of the Identification Problems

In order to have the 2SLS FE model be properly identified, one must make sure that the following 2 conditions are satisfied:

1) Order Condition;
2) Rank Condition.

The first condition for the identification of the model is easy to check. It is necessary, although not sufficient. It states that we need at least as many excluded exogenous variables as there are included endogenous explanatory variables in the structural equation (Wooldridge 2016, p.479). In our case, the model is *just identified*. That is, there is one exogenous variable per one endogenous variable.

The second condition is more difficult to prove. Although it is sufficient for the identification. We omit using matrix algebra here for simplicity and reading easiness. To put it simply, it states that the IV should be sufficiently linearly related with the variable that we are using the IV for, and at the same time not correlated with the possible omitted variable, the way the error in variable is present, and should be related to the dependent variable (real incomes) only through the proposed channel.

The restriction is guaranteed to be valid by the external determination of the international copper price, specifically by the global market institutions such as the London Metal Exchange (LME) and vehicle of influence of prices on the levels of production of copper described above. The coefficient estimate in the reduced form equation is expected to be positive, and negative in the structural equation. This expectation is supported by the mainstream publications described in the Literature Review.

The foot of each table shows the first stage regressions used in this work. The F-statistics are greater than 10 for all samples confirming the significance of the instrument. This satisfies the rule of thumb stated by Cameron and Trivedi (2010).

Finally, the results tables in the next section provide additional diagnostic tests' p-values for the instrument used in the First-Stage regression. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null hypothesis of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null hypothesis that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid. In all regression estimations, we do not find any evidence with the problems related to under-identification or presence of weak instruments. In addition to that, we consider the sample size to be large enough to make sure that multicollinearity does not bring any problems to the estimation.

Thus, the current empirical approach used in this chapter differs from the one used by Lippert (2014) in a study on the spill-over effects of a resource boom in Zambia. Even though the same periods of time are used in our analyses, the focus of this chapter was more on the causal impact of copper production on real incomes in Zambia.

2.4.3 Final comments on the empirical approach. I routinely take into account such problems as non-normality of errors, heteroscedasticity and serial correlation. In all estimations we find the residuals being non-normal, so we must rely on asymptotical distributions of our estimators for the inference. The full sample size is 750 observations and the minimal subsample is 338, this can be considered large enough for the Law of Large Numbers and Central Limit Theorem to work, suggesting that all estimators should have the statistical distribution required for the correct inference.

It is important to control for heteroscedasticity and serial correlation in residuals as, nonetheless that such problems do not bring bias to the regression function, we still need to take them into account so that we follow the correct inference procedure and be sure that we do not make Types I, II errors (Wooldridge 2016). For each estimation, the Robust Standard Errors and their clustering based on the constituency are employed. Moreover, Wooldridge (2002) argues that clustering the standard errors at department level leads to standard errors that are completely robust to any kind of serial correlation and heteroscedasticity.

Finally, one should pay attention to the stationarity of the series included in the regression. However, in our case, we have insufficient observations to rely on the result of the unit root test. At the same time, the sample of 5 sets observations, taken with several year gaps can be considered safe and problems of non-stationarity can be considered irrelevant for our example.

2.5 Main Results

In this section, we report the main empirical results. Here the rise and fall in the international copper price acts as an instrumental variable and generates two effects on the local economy. First, it leads to an increase in the mine level copper output through the increase in production by the existing mines and the two reopened mines, Kansanshi and Lumwana in the north-western part of Zambia. Second, it leads to changes in the income of constituencies that are near mine deposits as the analysis is focused on the average constituency level effects.

2.5.1 Effect of mine activities on income

Table 2.3 reports the results from the OLS regressions of per capita mine level copper output on real incomes in column (1) using constituency real income per capita as the outcome variable. Column (2) shows results from the 2SLS FE regression.

Column 1 presents results using the per capita mine level copper output as the independent variable. The control variables included in the regression are the average household constituency characteristics and the population density of each constituency shows an insignificant negative impact of per capita mine level copper output on real incomes. Government spending is a variable that controls for any expenditure on projects meant for poverty alleviation in each constituency. But it is clear that the OLS regression is biased and inconsistent due to the endogeneity coming from the heterogeneous effects, potential simultaneity, omitted variable bias, or error-in-variables bias.

Thus, the results from the 2SLS FE are represented in column (2) of all the tables that follow. The 2SLS model shows per capita mine level copper output having a positive sign as is expected, thus, showing a positive impact of per capita mine level copper output on real incomes with a 1 per cent increase in per capita mine level copper output leading to a 0.124 per cent rise in real incomes, ceteris paribus (CP). The coefficient is not very large, but highly statistically significant. The difference in the results between the column (1) and (2) from the OLS regressions and the IV regressions just reveals the bias of the OLS results which can be attributed mostly to the panel data endogeneity and the reverse causation between constituency level real incomes and per capita mine level copper output.

In addition, the average age of the head of the household tends to increase the real income. This could be an indication that constituencies earning higher average real incomes tend to have smaller families partly due to spending more time getting educated. Higher levels of real incomes are documented in constituencies where the average age of the household is significantly high. Lastly, the higher the population density, the higher the average constituency real incomes as there seem to be more people living in a constituency as a result of the available economic opportunities such as employment and better development of such constituencies. It is clear that the urban areas having better economic and social opportunities also have higher population densities in comparison to the rural areas.

Lastly, one can note the highly significant coefficient for the government spending. It may seem small, although, from Table 2.1, it is evident, that the government spending is denominated in millions, thus the changes in policies can be very significant (as evident from Table 2.1), implying that the coefficient is not trivial, negative and statistically significant, as it is expected due to the public good being inefficient and not contributing to the real income, i.e. improvement in living standards.

Table 2.3- Effects of Ln(Copper output) on Ln(Real Incomes)

Panel 1	OLS	2SLS FE
Independent Variables	(1)	(2)
Ln(Per capita mine level copper output)	-0.015	0.124***
	(0.010)	(0.024)
Household size	-0.078	-0.114*
	(0.046)	(0.053)
Average age of household heads	0.023*	0.033*
	(0.011)	(0.017)
Population density	0.727**	0.001***
	(0.266)	(0.0001)
Female headed households	-0.003	-0.003
	(0.006)	(0.009)
Access to clean water	0.002	-0.003
	(0.004)	(0.003)
Government Spending	-0.0002*	-0.000001***
	(0.00008)	(0.0000001)
R-squared	0.346	0.753
Observations	703	703
Panel 2		
Instrumental Variable		
International Copper Price		*2.845****
		(0.354)
F-statistic		*64.58****
P-Value		*0.000*
R-Squared		*0.205*
Kleibergen-Papp		*0.000*
Anderson Rubin		*0.000*

Stock-Wright		*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

2.5.2 Heterogeneous Effects of Distance

In this section, we attempt a separate empirical exercise by exploring the aspect of distance to the nearest mine. This is conducted by analyzing how distance to the nearest mine affects the relationship between per capita mine level copper output and constituency level real incomes. The identification strategy relies on the effect of the mine activities declining with distance to the nearest mine. This feature is evaluated by running regressions on different groups of constituencies by distance to the nearest mine. This is achieved by getting a sample of constituencies. The other groups look at distances of 100km, 200km, 300km and 401km (which is the median distance).[27] The results are displayed in table 2.4. The commentary from here onwards concentrate on the 2SLS FE estimations due to the fact that OLS being biased and inconsistent and therefore unable to produce reliable results.

The estimations with the use of the 2SLS FE regressions show a positive and significant effect of log of per capita mine level copper output on log of real incomes.[28] Under the assumption that the evolution of real income in both groups of constituencies would have been similar in the absence of the mines, we can interpret these results as evidence that the positive externality of copper mine presence spreads further than the geographically closest mines but is stronger the closer a constituency is to the nearest mine.

A further assessment of the effect of mine level copper output on the real incomes of constituencies located within the highlighted distances singles out constituencies located within 100km and 401km to the nearest mine as the only ones showing a positive and significant effect of changes in copper output on living standards. Thus, the 1 per cent increase in per capita copper output is associated with approximately 0.169 per cent increase in real income CP for the 401km group of constituencies. The high significance of the coefficient in column (4) implies that living closer to a location where there is some copper mining does expose constituencies to improved living standards, maybe through better infrastructure or better employment opportunities. While there is weaker significance for constituencies located within 100km to the nearest mine. Constituencies significantly

[27] The authors' computed median distance is 401km.

[28] The IV 2sls approach was used to help resolve the potential endogeneity of natural resource extraction that has been observed from previous literature. These results are robust to the use of alternative measures of distance and non-linear effects of distance.

benefited from the presence of the mines even though there may not have been any revenue accruing to the local authorities.[29] In this case, there is a direct collection of any revenues from the mining activities by the central government and then distributed to the constituencies through central planning. Thus, one could propose that there is a multiplication effect from copper extraction. It requires various supporting services and industries, what gives more employment and higher income.

Examining constituencies that are located further than 401km to the nearest mine; we find evidence that the effect on populations is positive with the magnitude of the effect being economically significant: even though Lippert (2014) observed that areas located away from the copper mines and the copper transportation route did not benefit from the resource boom that took place during the survey period, the results shown in table (2.4) show that the boom in natural resources caused by an exogenous shock to the global copper price could have modestly affected the living standards in Zambia. The effect is smaller in magnitude than to the constituencies situated closer to the mines, the Chow test showed that the coefficients are statistically different for the two subsamples. Thus, 1 per cent increase in copper production on average increases the real income for these areas by 0.091 per cent (CP). Previous poverty studies by Ormande (2011), Simler (2012) and Lippert (2014) also found that poverty levels in Zambia had modestly changed during the survey years. Lastly, the positive results may be attributed to the reopening of two new mines in the north-western part of Zambia: Lumwana and Kansanshi mines. Thus, the results are contrary to previous findings by Sachs and Warner (1995 and 2001) that there is a negative relationship between the presence of natural resources and socio-economic outcomes. The results are robust to alternative samples.

The first-stage statistics associated with these results reported in panel 2 of the tables also indicate that our instrument, the international copper price is a strong predictor of copper intensity. In addition, the Kleibergen-Paap F statistic and the relevant Stock-Yogo both show statistical significance. While the overall F-statistic is greater than 10.

[29] Zambia follows a central planning type of economy which is the channel for any developmental projects.

Table 2.4- Effect of Ln(Copper Output) on Ln(Real Incomes) by distance

Panel 1					
Independent Variables	2SLS FE (1)	2SLS FE (2)	2SLS FE (3)	2SLS FE (4)	2SLS FE (5)
LN(Per capita mine level copper output)	0.152*	0.213	0.227	0.169***	0.124***
	(0.064)	(0.116)	(1.131)	(0.041)	(0.024)
Household size	-0.624	-0.954	-0.916	-0.101	-0.114*
	(0.732)	(1.011)	(0.985)	(0.067)	(0.053)
Average age of household heads	0.341	-0.402	-0.491	-0.007	0.033*
	(2.281)	(2.404)	(2.280)	(0.027)	(0.017)
Population density	1.684	0.68	0.543	0.001***	0.001***
	(1.325)	(2.005)	(2.229)	(0.0001)	(0.0001)
Female headed household	0.006*	0.003	0.00267	0.02	-0.003
	(0.002)	(0.002)	(0.002)	(0.012)	(0.009)
Access to clean water	-0.004	-0.012	-0.0119	-0.008	-0.003
	(0.005)	(0.009)	(0.010)	(0.005)	(0.0003)
Government spending	-0.00003	-0.000003	-0.000003	0.0000003	-0.000001***
	(0.000002)	(0.0000002)	(0.0000002)	(0.000000001)	(0.00000001)
Distance to the nearest mines	***Less than 100km***	***Less than 200km***	***Less than 300km***	***Less than 401km***	**Whole sample**
R-squared	0.147	0.360	0.383	0.22	0.753
Observations	*135*	195	239	338	750
Panel 2					
International Copper Price	*4.134***	*2.360*	*2.360*	*2.719***	*2.719****
	(1.689)	*(1.377)*	*(1.377)*	*(0.248)*	*(0.248)*

F-statistic	*5.99*	*3.34*	*2.94*	*119.93****	*119.93****
P-Value	*0.021*	*0.075*	*0.0000*	*0.000*	*0.000*
Kleibergen-Papp	*0.042*	*0.0933*	*0.108*	*0.000*	*0.000*
Anderson Rubin	***0.000***	*0.000*	*0.000*	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*	*0.000*	*0.002*	*0.002*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are **distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in** the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

2.5.3 Other measures of wellbeing— a main limitation of the previous analysis is that income may fail to fully capture the net effect of copper mining on constituency welfare, even in the short-run as people are not usually willing to disclose information of their incomes as well as their sources of income. To address this limitation, we replicate the baseline results using poverty as a measure of wellbeing. Table 2.5 displays the results using the different measures of poverty as outcome variables. In this instance, we use all the constituencies and obtain the headcount poverty ratios which are used as outcome variables. These poverty outcomes are classified into three different categories: those living in extreme poverty, those living in moderate poverty and the last category are of those that are regarded as non-poor. We find that the increase in copper production led to an increase in poverty levels for the moderately poor. This though shows some relative improvement in living standards.

From Table 2.5 it can be observed that there was a decreasing impact of the increase in per capita mine level of copper production on extreme poverty levels. According to CSO (2010), it is documented that 70 per cent of the population in Zambia lives in poverty and poverty levels increased particularly in rural constituencies which are usually located far away from the mines (Simler, 2007). Even though a slight increase in poverty levels has been documented during periods of the privatization of the mines, this was offset after the copper boom as observed by Fraser and Lungu (2007). These results are attributed to the privatization of the mines which led to a reduction in the labor force employed by the mines. In the table, results show that an increase in the per capita mine level copper output led to a reduction in the total population of the extremely poor, moreover, at the same time, the proportion of those not living in poverty increased. Results in column (1) of Table (5) show that a 1 per cent increase in copper production per capita led to 0.182 per cent decline in the proportion of the population in extreme poverty (CP). While the extreme poor significantly benefited from the increase in the per capita mine level copper output, the proportion of people in the moderately poor category increased, what seems to be natural move from one category to another. This shows that the mine level copper output positively impacted the poverty levels evidenced by the significant reduction in the proportion of the poor. Lastly, in column (3) of Table (2.5) an increase in the population of the non-poor is reported. This is an indication that on average, the population of Zambia benefited from the increase in the per capita mine level copper output as evidenced by the increase in the average real incomes of the constituencies.

Finally, the weak statistical significance of the population density along with the signs of the coefficients in all 3 estimations supports the initially proposed conclusion, that the areas with higher density, which tend to be urban areas, on average support the decrease of poverty holding everything else constant.

Table 2.5- Effect of Ln(Copper Output) on Ln(Poverty Levels)

Panel 1	2SLS FE	2SLS FE	2SLS FE
Independent Variables	(1)	(2)	(3)
	Extreme Poverty	Moderate Poverty	Non-poor
Ln(Per capita mine level copper output)	-0.182***	0.104***	0.087***
	(0.035)	(0.024)	(0.021)
Household size	0.095	-0.048	0.008
	(0.058)	(0.042)	(0.039)
Average age of household heads	-0.010	-0.003	-0.008
	(0.019)	(0.012)	(0.012)
Population density	-0.001**	-0.0002*	0.0001*
	(0.0002)	(0.0001)	(0.0001)
Female headed households	0.003	-0.010	-0.001
	(0.010)	(0.008)	(0.006)
Access to clean water	-0.001	-0.003	0.0003
	(0.003)	(0.002)	(0.003)
Government Spending	-0.000003*	-0.000001	-0.000001
	(0.000001)	(0.0000001)	(0.0000001)
R-squared	0.332	0.394	0.624
Observations	750	750	750
Panel 2			
Instrumental Variable			
International Copper Price	*2.540****	*2.540****	*2.550****
	(0.388)	*(0.388)*	*(0.390)*
F-statistic	*42.78****	*42.78****	*42.84****
P-Value	*0.000*	*0.000*	*0.000*
R-Squared	*0.184*	*0.184*	*0.185*

Kleibergen-Papp	*0.000*	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

2.5.4 Effects of per capita copper output on employment

Table 2.6 presents results from a regression that uses employment as a measure of wellbeing. Even the OLS results seem to be statistically significant and higher in magnitude than the IV regressions results; this cannot be relied on as the OLS are still inconsistent. The regressions for the constituencies near the copper mines indicated that there was an insignificant effect of per capita mine level copper output on employment.

This could have been a potential channel through which constituencies could have benefited from the increase in global copper prices which culminated into an increase in the copper output. It may not be very surprising to find that local communities were insignificantly impacted by the increase in the per capita mine level copper output. This may be attributed to the fact that there were some mine workers lost their jobs because of retrenchments. This is supported by Fraser and Lungu (2007) who document that most subsidiary companies previously run by ZCCM were shut down during the privatization of the mines which meant that there were some job losses.

The results in Table (2.6) are modest as it would be expected that employment by the mines would have increased with the increase in the global copper prices. The insignificant effect of mine level copper output on employment can further be attributed to the advanced and more efficient technology adopted by the mining investors after the privatization of the mines. This argument is partly supported by Hirschman (1958)'s observation that natural resources ventures in poor areas do not generate local positive effects as they tend to be capital intensive with almost no local employment, foreign-owned (i.e. profits distributed) and with almost no linkages to the economy.

Table 2.6- Effect of Ln(Copper Output) on Ln(Employment) by distance

Panel 1		
Independent Variables	2SLS FE (1)	2SLS FE (2)
Ln(Per capita mine level copper output)	0.015	-
	(0.043)	-
Household size	0.709*	0.402*
	(0.354)	(0.184)
Average age of household heads	-0.232	0.011
	(0.560)	(0.184)
Population density	0.428	0.166
	(0.519)	(0.188)
Female headed households	-0.026	-0.0004
	(0.023)	(0.009)
Access to clean water	0.002	-0.001
	(0.006)	(0.001)
Government Funding	0.000002	0.000001
	(0.000001)	(0.0000001)
Distance to the nearest mines	**Less than 401km**	***Whole Sample***
R-squared	0.185	0.067
Observations	338	750
Panel 2		
Instrumental Variable		
International Copper Price	*2.848****	*2.750****
	(0.798)	*(0.467)*
F-statistic	*12.73****	*34.71****
P-Value	*0.000*	*0.000*
Kleibergen-Papp	*0.001*	*0.000*

Anderson Rubin	*0.074*	*0.606*
Stock-Wright	*0.033*	*0.083*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

2.5.5 Separating the Sample

In Table 2.7, the sample is divided into two categories, urban and rural areas. Results for both urban and rural areas show that the changes in mine level copper output had a positive impact on the population. In this case, the impact of the per capita mines level of copper output is significant and positive on the real incomes of the whole population. The results show a greater and significant impact of the per capita mine level copper output on the real incomes of the rural constituencies located close to the mines. This could partly be attributed to the fact that rural areas are predominantly agriculture oriented which is mostly subsistence. This means that the interaction between the urban populations which are the main consumers of the agricultural products from the rural areas and the rural populations tends to affect the rural populations as well. Even though it has been evidenced by the poverty statistics documented by the Central Statics Office (CSO) in Zambia that rural poverty has been on the increase, for rural constituencies located close to the mines, this has not been the case. CSO further documents that poverty levels have declined in the north-western part of Zambia were two new mines were opened. This result is reliable as there are both urban and rural constituencies located near the mining deposits.

In addition, it is interesting to note that for the rural areas the female-headed households had a slightly higher real income, while for the urban areas there is no such discrepancy. For the urban areas, the age of the household head is statistically significant indicating that in the cities it is possible to make long career allowing people to earn a higher income.

Table 2.7- Effect of Ln(Copper Output) on Ln(Real Incomes) by locational Status

Panel 1	2SLS FE	2SLS FE
Independent Variables	(1)	(2)
Per capita mine level copper output	0.129***	0.136***
	(0.038)	(0.0319)
Household size	-0.120	-0.109
	(0.074)	(0.071)
Average age of household heads	-0.021	0.039***
	(0.041)	(0.018)
Population density	0.001**	0.007***
	(0.0001)	(0.005)
Female headed households	0.010***	-0.003
	(0.011)	(0.009)
Access to clean water	-0.005	0.00003
	(0.003)	(0.006)
Government Spending	-0.00002	-0.00003*
	(0.000001)	(0.00001)
Rural/Urban Status	**Rural**	**Urban**
R-squared	0.523	0.171
Observations	226	520
Panel 2		
Instrumental Variable		
International Copper Price	*2.352****	*2.714****
	(0.377)	*(1.724)*
F-statistic	*38.93****	*40.86****
P-Value	*0.000*	*0.000*
R-Squared	*0.199*	*0.240*
Kleibergen-Papp	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects.

The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

2.5.6. Effects of the mines on the economy

The pattern of structural change is one of the major reasons for the poor socio-economic performance in Zambia. This can be attributed to delayed industrialization because of the challenges in the implementation capacity the Zambian government faces as industrialization tends to be extremely capital intensive. This can be seen from the failure of the government to run the parastatal companies and reinvest in the mining sector. This led to the privatization of the mining conglomerate ZCCM. This challenge begun in the early 1970s' when the international copper price fell, and the government could not plan effectively for mining sector. This led to a collapse in the growth of Zambia's' economy.

The growth collapses of the late 1970s' and early 1980s', which also affected Zambia's economy, resulted from the backfiring of the resource-abundant countries' efforts to reduce the commodity dependence (Auty, 2001). This weakened Zambia's domestic policies meant to promote infant industries. Thereafter, international efforts to reverse the long-run decline in real commodity prices by establishing producer agreements triggered trade shocks in the 1970' that damaged Zambia's already weakened economy.

In addition, commodity exports sparked contests for rents that fostered factional or predatory political states. The government espoused infant industry policies that quickly degenerated into systems of transferring rents from the politically weak mining sector into a burgeoning non-tradeable sector characterized by slow-maturing manufacturing and an over-extended state bureaucracy. The relative decline of the mining sector accelerated the repression of incentives so that the investment efficiency deteriorated. This demonstrates how rapidly a growth collapse can occur, how easily potentially favorable diffuse socio-economic linkages are degraded and how protracted reform can become because of the erosion of all forms of capital (Paul Stevens, 2015). Therefore, while natural resources may provide low-income countries with a significant development opportunity, the prevailing extractives-led growth agenda is in urgent need of re-evaluation.

Another reason for Zambia's inferior performance: in spite of being a resource rich country, is being less likely to engender a 'developmental' political state. This is cardinal for good economic performance as it creates both the autonomy to pursue coherent and prudent economic policies and maximize social welfare. This means that Zambia has fallen well short of the mean growth of the group of resource rich countries. In addition, a contest over resource rents engendered the country thereby promoting sectional interests at the expense of a coherent welfare-maximizing economic policy. This gave rise to a developmental state. There are basically four main reasons that gave rise to developmental states in Zambia.

First, intense pressure on a mineral resource and the virtual absence of natural resource rents created a low tolerance by the poor, majority of rent extraction or an inadequate distribution of assets. This heightened the probability that the Zambian political state aligned its interests with low income majority and experimented with central planning. This though proved a disaster as the government entered an extreme debt crisis. This led to a political failure which culminated into shifting away from a one-party political state in 1991.

Second, due to experiencing minimal Dutch disease effects, Zambia had closed trade policies which it quickly abandoned. This also impacted the economy negatively.

Third, Zambia's manufacturing was very competitive. This competitiveness can be attributed to the transparency at a relatively low level of per capita income than the small size of the resource sector meaning that it could not support the slow-maturing infant industry or a bloated government bureaucracy (Auty, 1994). In addition, the emerging competitive manufacturing sector could not support such transfers because a fraction of rent within the sectors' revenue stream was less than in the case of the mining sector.[30]

In Zambia's case, its infant industry and public employment provided conduits for transferring the rents and strengthening protectionist interests, thereby making economic reform even more difficult to pursue. Consequently, this led to a severely distorted economy and compounded the inherent problems of the shift from resource-driven growth to skill-driven growth. This can be evidenced from the increase in the percentage of the literate and high unemployment levels.

[30] In Zambia's case, there were parastatal companies that were set up in the manufacturing sector. Unfortunately, these were only sustained by revenues from the mining sector as they were not self-sustaining.

There was also an increased competitiveness for state resources, namely those accessible through the political channel. In recent years, this has been seen through vote buying. In line with theoretical literature, Zambia's case can be attributed to the relative scarcity of resources because of inefficient allocation of state resources. Furthermore, competitive manufacturing could not afford the higher costs of inputs from protected infant industry.

Finally, there was market indiscipline due to the higher scope for cumulative policy errors because of abundant resource rents. Zambia also lacked strong pressure from a low level of per capita income to align interests of the political state with those of the majority poor. This contest for natural resource rents encouraged factional and predatory states that subverted prudent macroeconomic policies and tolerated cumulative policy error.

2.5.7 Fiscal Effects as on the living Standards

Unlike other resource rich countries like Chile, Brazil and Botswana were the fiscal management is decentralized; Zambia follows a centralized type of management. This means that any revenues from the mines must flow through the central government which sets all the national goals and implements national projects. Any poor living standards could thus be attributed to the central government. We thus endeavor to explain how this flow has taken place in the case of Zambia. First the shift from state ownership was both rapid and comprehensive; the sale of ZCCM improved the efficiency of mining operations and the long-run prospects for the sector. Unfortunately, it also effectively handed over entitlement to an overwhelming share of the future rents from the sector to foreign owners (Adam and Simpasa, 2009).

Second, the Zambia government faced an enormous pressure to privatize the mines due to the mounting losses. Because of this pressure, and having little bargaining power, the government was forced to enter Development agreements which gave the private investors more power to negotiate extremely favorable terms and tax concessions. In addition, the high liabilities accumulated by ZCCM posed a huge challenge at negotiation, such that the government had to settle the difference that could not be covered by the sales proceeds. (Craig, 2011).

With these two arguments, it implies that during the survey period, mining companies were enjoying a lower corporate tax in comparison to non-mining companies.[31] In addition, mining companies could also carry forward losses for up to 20 years, they were not required to pay import duties on capital inputs and capital expenditure could be deducted in full in the year it occurred. The royalty tax which could be a good and stable source of revenue was equally low. This stood at a rate of 0.6 percent of gross revenues which in magnitude is smaller than the international and average stability periods of 15 to 20 years guarantee those terms. Then together, these concessions imply that the mining companies enjoyed a marginal effective tax rate of around zero percent in the last decade (Dyfson, 2007). Consequently, the mining sectors' contribution to public finances has been negligibly small during increased copper prices.

Even though the copper price boom revealed the magnitude of this transfer of ownership of the mines into private hands, and with rising political opposition, prompted the government into a re-negotiation of the resource contacts to gain control over a larger share of the rents from the sector, this did not yield much fruit. It has been argued by (Adam and Simpasa, 2009) that the sharp fall in copper prices from mid-2008 neutralized the governments' attempt as taxable rents substantially reduced. As such some political opponents to the ruling government in Zambia have since described the copper price boom as a "cashless boom".[32] There is also an element of political dispensation to this argument as any attempts to shift the balance in favor of the state are likely to play an important role in the political economy of Zambia, that is make the ruling government unpopular and thus lead to its extinction.

In addition, even if it appears that the revenue situation has been improving this does not imply that the revenues are either adequate or reasonable (Conrad, 2012). This is because the number of mines paying tax is known to be relatively few. Moreover, during the period of study, there were expensing provisions were 100 percent of capital expenditure was set

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[31]Mining companies had a corporate tax rate of 25 percent while non-mining companies had a rate of 35 percent.

[32] A cashless boom is one in which the unfavorable terms of the privatization of the mines meant that the people of Zambia saw few of the benefits from the boom, either in terms of employment or other transfers, but bore the costs associated with the appreciation of the exchange rate-starkly illustrated how much the previous decades of mismanagement had forced the government's hand during the privatization process.

against the current year liability. This also led to serious hampering of revenue mainly through royalty tax which was very low after the privatization of the mines.[33]

Lastly, poverty levels showed a huge increase in constituencies close to the mines in the periods following the privatization of the mines (Fraser and Lungu, 2007). Even though the employment ratios seem to have increased over the study period, these can be attributed to the re-opening of two mines in different locations which still leaves the incomes of other mine workers low as there has been evidence of retrenchment and reduced incomes after the privatization of the mines (Ibid). Moreover, copper prices only begun to rise above trend in 2003 and returned to around the 2003 level in 2008 (Adam and Simpasa, 2009). This means that only three waves of the household surveys could capture any changes i.e. 2004, 2006 and 2010. This increase in copper prices was also unanticipated, so the reaction to the increase in copper prices was somehow not possible.[34]

In summary, huge challenges remain in Zambia. There are enormous challenges in overcoming the legacy of the past mismanagement of the economy, including deep poverty, substantial inequality and a badly depleted public infrastructure. All these are cardinal in improving living standards. There is equally a challenge of managing expectations about the future public spending capacity when needs are so high but rents from mining are likely to remain modest.

2.5.8. Alternative Explanations

We interpret the previous results as evidence that the local population did benefit from the increase in copper production that culminated from the exogenous shock of the international copper prices. This section explores whether alternative stories could explain the same results. We focus on using alternative measures and estimations. We also explore the use of restricting the sample to certain groups of the population.

[33] This kind of taxing system is a revenue system which is neither adequate in a dynamic system nor stable over the longer term.

[34] A witness to this unanticipated change was the example of Anglo Americas' decision to withdraw from copper mining. This led to changes in income levels as the new mine owners could not offer the mine workers the same conditions of service as offered by Anglo America. This also led to an exodus of highly skilled workers from the mining constituencies.

2.5.8.1. Additional Controls

Table 2.8 shows the 2SLS FE regressions of the effect of per capita mine level copper output on real incomes with additional control variables. The specific control variables are listed in the table. These include facilities and female-headed households in urban areas. These variables are important as they are likely to indirectly affect living standards. For example, controlling for female headed households in urban areas somehow disentangles the effects of mine level copper output as most mine workers tend to be male and also concentrates the analysis on the urban population where most of the copper production takes place. In addition, the sex of the household head can have a significant influence on the household expenditure behavior as well as the household incomes. Considering that the analysis is concentered on the effects of mining on living standards, this has serious implications for the study as females are less likely to be employed in the direct mining operations which take up a greater proportion of the workforce. Female headship is also typically expected to increase the likelihood of a household being found amongst the poor. While the presence of good facilities such as good sanitation and access to clean water is likely to have adverse effects on the living standards of communities. The findings on the effect of per capita copper output on real incomes clearly hold when there is an inclusion of more control variables even though the included variables are not statistically significant. It can also be noted that government spending maintains the same sign and level of significance. The first stage results are also clearly valid. The Kleibergen-Paap F-statistic is highly significant. In addition, the Angrist Pischke F-statistics for the interactions statistically significant, ruling out concerns regarding weak instrument. As shown in Table 2.8, the coefficient on per capita mine level copper output demonstrates that the positive relationship between natural resource price shocks and living standards still holds in the case of the regressions with additional controls.

Table 2.8- Effect of Ln(Copper Output) on Ln(Real Incomes) with additional control variables

Panel 1	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	0.094***
	(0.017)
Household size	-0.046
	(0.638)
Average age of household heads	1.457*
	(0.620)
Population density	0.506
	(0.313)
Female headed households	0.018
	(0.025)
Access to clean water	-0.006
	(0.006)
Government Spending	-0.00001***
	(0.000001)
Facilities	0.0001
	(0.0001)
Female headed households in urban areas	-0.004
	(0.004)
R-squared	0.450
Observations	703
Panel 2	
Instrumental Variable	
International Copper Price	*3.140****
	(0.496)

F-statistic	*40.09****
P-Value	*0.000*
R-Squared	*0.204*
Kleibergen-Papp	*0.000*
Anderson Rubin	*0.000*
Stock-Wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

2.5.8.2. Analyzing the Effect on poverty with additional control variables

In this section, an analysis of the effect of per capita mine level copper output on poverty levels with additional controls is made. We include other variables such as the facilities that a household has and the proportion of female-headed households in urban areas. The former is likely to be an important determinant of living standards as it will be affected by the employment rate in a particular constituency as households with stable incomes are likely to be surrounded by better living facilities. Thus, we try to disentangle the impact of per capita mine level copper output on poverty.

The results are given in Table 2.9. All columns in the table confirm the same result that one can observe in Table 2.5: the effect of copper production is highly significant. This just proves that poverty levels have undergone a positive transformation which from earlier results could also be attributed to the documented increase in the levels of employment by the mines; which could have been one of the major channels through which living standards have been impacted. Finally, we find that these relationships are stronger for the whole sample. The coefficients of interest have also kept the same magnitude throughout the whole analysis; this also supports the robustness of the obtained results.

Table 2.9- Effect of Ln(Copper Output) on Ln(Poverty) with additional control variables

Panel 1	2SLS FE	2SLS FE	2SLS FE
Independent Variables	(1)	(2)	(3)
	Extreme Poverty	Moderate Poverty	Non-poor
Ln(Per capita mine level copper output)	-0.152***	0.095***	0.073***
	(0.034)	(0.024)	(0.020)
Household size	0.009	0.436	0.491
	(0.629)	(0.524)	(0.419)
Average age of household heads	-0.230	-0.241*	-0.451
	(0.776)	(0.464)	(0.484)
Population density	-0.371	0.196	0.128
	(0.243)	(0.167)	(0.147)
Female headed households	-0.041	0.023	0.018
	(0.027)	(0.022)	(0.019)
Access to clean water	0.003	0.0005	-0.001
	(0.005)	(0.004)	(0.004)
Government Spending	-0.000003**	-0.000001*	-0.000001
	(0.0000001)	(0.0000001)	(0.0000001)
Facilities	-0.0002	-0.0001	0.0001
	(0.00001)	(0.00001)	(0.00001)
Female headed households in urban areas	0.003	-0.006	-0.003
	(0.004)	(0.003)	(0.003)
R-squared	0.575	0.755	0.389
Observations	750	750	750
Panel 2			
Instrumental Variable			
International Copper Price	*2.862****	*2.862****	*2.873****
	(0.491)	*(0.491)*	*(0.492)*

F-statistic	*34.04****	*34.04****	*34.10****
P-Value	*0.000*	*0.000*	*0.000*
R-Squared	*0.183*	*0.183*	*0.183*
Kleibergen-Papp	*0.000*	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

2.6. Conclusion

This chapter investigated the effects of the mining industry on living standards. We find robust evidence that the mines have generated a positive effect on real incomes of residents living close to the mines. These results can be attributed to some linkages between the mining industry and the local economy. Zambia did not experience poor socio-economic performance in the mining constituencies and as such the natural resource curse theory may not be applicable in this case. The slight increase in moderate poverty levels experienced in constituencies could therefore be attributed to the decrease in the number of people in the extreme poverty category and/or other factors that may be a subject of future research. This means that there was no collapse in the growth of the economy as hypothesized by the natural resource curse theory. As much as there may have been a relaxation of discipline through deployment of resource rents which is also a critical condition for a growth collapse, this did not negatively affect living standards in constituencies close to the mines. Moreover, there were incentives for directly productive investment as most new investors in the mines were given good tax incentives (World Bank, 2011 and Sikamo et al, 2016).

The main contribution of this chapter was to improve the understanding of the mechanisms through which natural resource extraction can impact local development and determine any possible reverse causation between copper mining and living standards. It shows that the rise in the production of copper can improve living conditions, especially if properly managed. Inspite of the documented case of mismanagement highlighted in Zambia’s mining industry which gave rise to increased corruption among government leaders; this did not affect the management of the mining companies (Craig, 2000).

The availability of natural resources in the developing world is often seen as a hindrance to economic development. In most cases, institutional failures such as conflict, mismanagement or corruption are often seen as the major contributions to the inability to transform natural wealth into better standards of living. This chapter suggests that despite the presence of such problems in Zambia, the copper mining industry was still able to contribute to the improvement in the living standards of the constituencies.

Chapter 3

The Impact of Privatization on a developing Economy:

The Copper Mines in Zambia

3.1 Introduction

Privatization is a worldwide phenomenon that began in industrialized countries but has extended to low-income developing economies. In recent years, there has been a decline in the role of the state and a growth in shifting economic activity from the public sector to the private sector. This shift in economic activity in developing countries has been exasperated by the failure of development planning in several Least Developed Countries (LDC's) and the problems of slow economic growth, budget deficits and inflation have forced many LDC's to increase the scope of private ownership and of the private sector (Safwat A, 2002). Privatization process is defined by Sargolzaei et al (2012) as an approach to gradually give access to the market mechanism in which the countries with government intervention allocate a part of public and governmental ownership to individuals and the private sector.

Privatization of the mines in Zambia like in most LDC's left unsolved (outstanding) problems confronting the government such as selling the debt of the public sector and the redundant labour displacement. These were brought about by the selling of less profitable companies. The Zambia Consolidated Copper Mines (ZCCM), the conglomerate running the mines on behalf of the government was no exception, as it had huge liabilities which had to be offset against the selling price; meaning that the proceeds from the sale of the mines were very small. The decision to privatize copper mining in Zambia, like in most developing countries came about as a result of the perceived inefficiencies.

Following on from chapter two, this chapter introduces a variable that may have been likely to change living standards by focusing on the effect of the per capita mine level copper output and of the privatization of the copper mines in a developing economy, in particular of the copper mines in Zambia. It specifically, analyzes the changes in the living standards at constituency level after the privatization of the copper mines. It also analyses how changes to the production of copper tend to affect living standards at constituency level.

Thus, a unique episode where there was an exogenous shock to the Zambian economy, in form of privatization is examined. It led to the loss of jobs in Zambia as most parastatal companies could no longer manage to sustain a large work-force while other companies were shut down due to inefficiencies. The chapter relies on this change to test whether and to what extent the privatization of the copper mines as well as how changes to the per capita mine level copper output had impacted the living standards in Zambia. The work also separates the constituencies by the distance to the closest mine, by the type of the constituency (rural vs urban), and by type of mines (open-pit vs underground). [35]

Results from the analysis suggest that the privatization of the state-owned copper mines has had a significantly positive impact on the economic outcomes of people living in all constituencies. Thus, there is a relationship between the privatization of key sectors in an economy such as the mining sector and living standards. In addition, privatization had a generally positive effect on the moderate poverty indicators, interestingly including rural areas. The magnitude of the effect is more substantial in urban constituencies.

In addition, changes in the levels of per capita mine level production always showed a positive and significant effect on real incomes. On the other hand, privatization seemed not to have led to any significant changes to the levels of employment. This effect on the levels of employment could be attributed to the laying off of a substantial number of mine workers by the private investors, what was later offset by the requalifying to the growing copper mining supporting industries. This provides empirical suggestive evidence of the positive effect that the changes in per capita mine level copper output after the privatization of the previously state-owned copper mines has had on Zambia's living standards. The results are generally robust to partitions of the sample.

This chapter makes four contributions to the strand of literature in development economics. The most important contribution is towards the empirical literature on divestiture and the effect that natural resources have on local economies by showing that there is some reverse causality that exists between the presence of natural resources and living standards. Secondly, it sheds light on the extent to which the process of privatization influences socio-

[35] A constituency is regarded as being close to a mine if it is located within 401km to the nearest mine. Where 401km is the median distance from each constituency to the nearest mine and this obtained from the data.

economic outcomes. Furthermore, it fills an existing gap in the literature for instance by focusing on the sub-national level making this study different from the already existing wide literature on cross-country studies. In addition, the examination of historic periods that had exogenous shocks, such as privatization through Structural Adjustment Programs (SAP) by using a novel panel dataset that was particularly constructed for this study provides another contribution towards the literature on natural resource curse. The last contribution made is towards the few empirical studies at the post-privatization level through using an identification strategy that allows for the comparison of living standards in constituencies before and after privatization of the mines; allowing for the estimation of the impact of the privatization of copper production on all constituencies at the post-privatization period. Least developed countries (LDCs) have not studied the impact of privatization on welfare as observed by Mahmoud (2003). In addition, Buchs (2002) also identified a limitation in the few empirical studies at the level of post-privatization performance and at the welfare analysis level. This is because of the experiences in Sub-Saharan Africa which shows that issues and pitfalls had not fundamentally changed between 1991 and 2001.

The study particularly analysed one prescription under SAP which was privatization. This provided an enabling environment for the analysis and comparison of two different periods of time, which is before and after the privatization of the copper mining industry. Most studies have focused on the effect of privatizing utility companies which are believed to directly affect the wellbeing of people, but the focus of this study is on an economic sector that is believed to have an indirect impact on socioeconomic outcomes.

The privatization has been a recipe of International Financial Institutions (IFI's) such as the World Bank and International Monetary Fund (IMF) who coined it as "reform". Yet this has injured the poor in the case of utilities such as water as they do not have any experience of participating in the market. This means the rich, who have the experience of participating in the market are at an advantage and thereby tend to benefit more from the privatization. This widens the gap between the few rich and the masses of poor people, meaning that there may be no improvement in the standards of living for most of the population in developing economies.

Whereas privatization has been most encouraged in utility companies, this chapter provides another dimension which is focusing on the mining sector and what effect privatization and the changes to the levels of copper production have had on the living standards. It focuses on a single developing country, Zambia, located in the sub-Saharan region of Africa. As much as there are possible losers from privatization of the mines in the short-term, this should be measured against the favorable long-term effect of the privatization process on efficiency and growth.[36] The fact that individual workers might have been harmed should not be a case to quash the process, but rather encourage the design of appropriate compensation and social safety measures to support the adoption of labor market reforms necessary to ensure that displaced workers can quickly find employment.

The rest of the chapter is structured as follows. Section 3.2 looks at the detailed review of existing literature. This is broken down into a review of previous literature and a review of background information on Zambia. The subsequent section describes the data in detail. Section 4 introduces the empirical methodology, particularly the identification strategy used. Results corresponding to the baseline model appear in section 5. Lastly, section 6 provides an overall interpretation of the findings and concludes.

3.1.1 Background

Zambia is a country that is located in sub-Saharan Africa. Like most developing countries, the country went through the privatization of its major companies as they were believed to be running inefficiently and therefore deemed unprofitable. The mining conglomerate Zambia Consolidated Copper Mines (ZCCM) was no exception to privatization.

3.1.1.1 Economic history

The performance of Zambia's economy from independence in 1964 to 1991 is seen to have shifted from a growing economy up to 1975, and later a declining economy. Yet through this shift from 1975 to a collapse of the economy, the government was reluctant to embark on any economic reforms. There was some consolation from international forecasters like the World Bank that copper prices would increase at some point. As such this may have provided some hope for the government which consequently encouraged it to postpone reforming of the economy.

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[36] This is a potential area for future research

3.1.1.2 Economic Reforms

For a long time, despite the collapsing economy, the government rejected reform. This rejection led the country to be termed a chronic non-reformer. Over the period 1976- 1991, the government led by then President Kaunda adopted seven donor supported adjustment programs (McPherson, 1995). Yet none of these were ever successful and worst of all carried on to the end. Each of the programs was designed to reduce internal and external balances and restore the conditions for sustainable growth, as revealed by the policy measures they comprised of. Unfortunately, they were all abandoned and this reinforced a decline in the economy.

The first attempt at economic reform with international support was in 1978. With a second attempt being made in 1980 and immediately after that, another set of economic reforms was embarked on in 1981. Later on, 1984 and 1985 are the other two years that witnessed further attempts at reform. The 1985 reform was as a result of the governments' realization that there was no other way of recovery as the copper prices had stayed low for a decade by then. These reforms ran for almost two years, with the central feature of these reforms being the imposition of controls on the exchange rate, interest rate and consumer prices. During the same year, the government abandoned its earlier policies and shifted to liberalization with the central feature being the introduction of an auction for foreign exchange. Two years down the line, the government re-imposed controls on markets for commodities, credit and foreign exchange. This shift in policy meant breaking off the ties with IMF consequently leading to the suspension of credit from the World Bank and most donor countries. But, in 1989, the government switched back to market oriented economic policies.

A major landmark of the reforms was to reduce the role of the state in state-owned enterprises. This was to be a reversal of the previous governments' policy of nationalization. This came out of a realization that the governments' role in most companies was limiting their efficiency and as such the government was now expected to privatize the companies it owned. Moreover, the government was being forced to bail out these companies in times of financial crises, consequently leading to huge expenditures. This privatization process meant that the mining sector also had to be privatized.

3.1.1.3 The cycle of nationalizing and privatizing the copper Mines

From independence, the mining companies were run by two foreign companies which are the Roan Selection Trust and Anglo-American Corporation. In 1991, the country underwent its first democratic elections which saw a new government being ushered into power. The new government agreed to implement the previously cancelled reform package which included the general liberalization of the economy. This also included the privatization program which saw the privatization of the mining conglomerate, ZCCM. This process of privatizing the mines begun in 1997 and ended around 2000 as ZCCM had to be broken up into small units for it to be sold. Due to the low value of the mines at privatization, the government signed development agreements with the new mine owners which entailed tax holidays for the mine owners. This meant that rents accruing to the government from the mines were modest. Even though Zambia was the largest contributor to transactions in privatization and subsequent proceeds from it, the masses perceive that the benefits from privatization have not been fully realized.

Six years after the privatization of the mines, copper prices begun rising on the international market. Consequently, the copper production output which went to as low as 255,000 metric tons at the time of privatization begun rising and at the end of 2014, Zambia's copper production was triple of what was produced at privatization. New mines have since been opened such as Lumwana Mine in Mwinilunga, Kansanshi and Kalumbila mines in Solwezi and Lubambe and Konkola Deep Mines in Chililabombwe.

The economy underwent a decline from 1975, with per capita GDP falling and subsequently mining's contribution to national GDP falling as well. Zambia was forced to turn to international lenders for relief, but as copper prices remained depressed, it became increasingly difficult to service its growing debt. Such that by mid-1990's, despite limited debt relief, Zambia's per capita foreign debt remained among the highest in the world. The country was forced to implement structural adjustment programs as a requirement for financial assistance. In 1997, as part of an agreement for assistance, the government began the privatization process of the mining conglomerate, ZCCM. This process subsequently ended and saw the country plunge further into problems of severe poverty. At this time, poverty levels reached as high as 80% in rural areas. The question at hand is whether the privatization of the copper mines has had any impact on living standards and if any, to what extent have living standards been impacted?

3.1.1.4 Poverty Profile in Zambia

Poverty, the problem at hand is not new to Zambia. The country's' economic decline has actually taken place in the context of political change since independence in 1964.This decline in some sense, begun as a result of the ruling governments' failure to forecast and make the necessary adjustments during resource booms and slumps during the first republic. This assertion is further supported by Milimo et al (2002) who alluded this decline to the economic difficulties of increased debt (which had to be repaid and serviced every year) and the Structural Adjustment Programs (SAP) the country underwent. These led to a big drop in the quality of life as the situation increasingly worsened. Within the period after the privatization of the mines, rural poverty rates remained stubbornly high at 80% whilst urban poverty rates were reported to have declined from 49% to 34% (Chapoto et al, 2011). This evidences the widespread consensus that poverty is a severe problem in Zambia, a view which is supported by recent empirical studies (Milimo et al, 2002; Kapungwe, 2004; Thurlow and Wobst, 2007; Simler, 2007; Masumbu and Mahrt, 2014 and Whitworth, 2014). Most households in extreme poverty are larger in number than the national average. The national average represents those headed by individuals with little or no education, who are predominantly self-employed and on average spend over 80 percent of their income on food.

With the decline in living standards at some time mostly affecting the urban areas, it remains a puzzle as to whether this can be attributed to the privatization of the mining sector. From a historical perspective, it can clearly be observed that the economic downturn which consequently led to declined living standards has in some way been following the performance pattern of the mining sector.

3.2 Review of Literature

Privatization has become a central feature of economic policy. Particularly in developing countries, divestiture is at the heart of adjustment programs being adopted under the supervision of the World Bank (Plane, 1997). It is generally believed that the private sector has a higher motivation for activity since it seeks to maximize benefit and in such a condition, limited resources of society are allocated optimally and efficiently (Sargolzaei et al, 2012). Privatization is expected to improve living standards through the elimination of any inefficiencies in the mining sector; hence the privatization of the mines is encouraged by proponents of liberalization.

In developed economies, privatization has been beneficial for efficiency. But, in developing economies, privatization seems to have injured the welfare of the poor populations and has only led to serious cases of income inequalities. Zambia is no exception; the country has after the privatization of its parastatals experienced the worst forms of inequalities; with the gap between the rich and the poor growing wider over the years. The difficulty of making money out of the poor is cited as the reason many global utility companies announced their intention to withdraw from or drastically scale down their "investments" in water and power services. This is against the notion that privatization has anything to do with reducing poverty: the poor are simply another (and not a very good) target group from which to make profits.

3.2.1 Theoretical Framework

Most theories on privatization are based on the fact that public companies are inefficient because of high exchange costs-the costs for protection and execution of ownership and goods rights. Higher motivation of private managers towards innovation is believed to lead to higher efficiency of most private firms as compared to public firms (Shleifer (1998). This is part of the agency theories which show that since firms have clear objectives, it is easier for its owners to audit managers' performance (Vicker and Yarrow, 1998; Dharwadker et al, 2000) and that managers perform better in private companies than in public companies.

The modern idea of privatization as an economic policy was pursued for the first time by the Federal Republic of Germany in 1957, when the government eventually sold majority stake of Volkswagen to private investors (Filipovic, 2005). It is important to note that theory generally predicts a positive correlation between privatization and economic growth, with (Filipovice, 2005) claiming that such a relationship shows that there is something possibly lacking from the model specifications that arrive at this conclusion. This, however, can provide powerful insights into the methodology of future studies. In fact, a World Bank analysis of the privatization in Eastern Europe suggests that the means through which privatization is implemented has played a significant part in the potential success of privatization in Eastern Europe (World Bank, 2002).

Understanding the concept of property rights has been viewed as the backbone of the major theoretical framework behind the idea of privatization. Scholars are generally of the view that an economy must be able to operate efficiently. This means that efficiency is key in the market system. Competitive markets, in which transactions are effectively handled by market prices, rely heavily on formal, well-defined property rights (Mankiw, 2001). In addition, De Soto (1996) further explains that, “To be exchanged in expanded markets, property rights must be ‘formalized’, in other words, embodied in universally obtainable, standardized instruments of exchange that are registered in a central system governed by legal rules”. In fact, de Soto (1996) argues that the lack of formal property rights is “the missing ingredient” that is keeping underdeveloped countries from sustaining long-term growth. Furthermore, the lack of property rights limits the amount of goods and services that can be exchanged in the market. An important implication of well-defined property rights is that it creates strong individual incentives, which, according to Easterly, is a significant factor in the quest for long term growth. By creating strong incentives, property rights lead to an increase in investment since people are certain and secure about the ownership of their property. Furthermore, individuals gain an access to credit since they can use their formal titles as a collateral for loans, ultimately leading to an increase in investment. Finally, property rights give people an incentive to pursue long-term rather than short term economic goals. In the case of land ownership, individuals who have secure and well-defined ownership will invest in their land instead of continuously draining new land (Soto, 1996).

Another fundamental aspect of privatization, which plays an essential part in the efficiency improvement associated with privatization, is embedded in the Coase Theorem. According to this theory developed by Ronald Coase, when conflicting property rights occur, bargaining between the parties involved will lead to an efficient outcome regardless of which party is ultimately awarded the property rights, as long as the transaction costs associated with bargaining are negligible. Since the most crucial objective of privatization is efficiency, it is definitely expected that that privatizing a firm will turn it around into a profitable one and keep in profitable. Meaning the transfer of property rights should lead to greater efficiency. Thus, in the case of Zambia, the Coase theorem fits in well with privatizing the mines. This is because copper production increased after privatization as a result of the mines being more profitable.

3.2.2 Methods of Privatization

Privatization can be looked at as a process which shifts economic activity from the public sector to the private sector in an economy; Ernst & Young (1994) identify 20 alternative methods of privatizing economic activity. These can be described based on ownership, organizational and operational characteristics of the enterprise. The case of Zambia's copper mines can be classified as a transfer of ownership, which is the most obvious form of privatization. One method of this is total "denationalization" where previously nationalized enterprises are sold in full to the private sector. Under this, a special share variant of denationalization occurred when the Zambian government, for national interest's sake retained a share of the privatized mines without performing any active management functions. The Zambia Consolidated Copper Mines- Investment Holdings (ZCCM-IH) currently manage this interest.

Unfortunately, privatization is not what the masses are meant to believe it is. In the real sense, it involves the abolishing or curtailing of public services (were private provision is expected to fill the gap), squeezing the resources of publicly-funded bodies to induce them to seek private funding, increasing the charges to users of public good-"user pays", promoting joint public/private (often foreign) production ventures, transferring public policy responsibilities to the private sector and encouraging private finance to build and operate public works. In addition, it takes the form of introducing private sector techniques into the public sector: creating a private sector "culture", facilitating private sector competition with the public sector by a policy of liberalization and deregulation, contracting out public services to private agents, selling subsidiaries belonging to nationalized or public industries/companies, capitalizing public companies through private sector investment and the partial or complete sale of public companies to the private sector.

3.2.3 Empirical Analysis Review

Studies on the impact of privatization seem to focus more on the impact at cross-country level. Unfortunately, there is a danger in drawing general conclusions from cross-country studies as all economies are at different stages of growth, have different institutions, privatized companies in different industries and may have implemented privatization at different timeframes and in different ways. For example, due to the highlighted differences Filipovice (2005) and Cook and Uchida (2003) concluded that privatization had negative and significant effects on an economy, while Plane (1997) and Barnett (2000) drew an opposite result. Drawing general conclusions thus poses a danger when it comes to policy recommendations as well as determining whether to adopt the policy of privatization or not. In order to avoid the loss of too much detail in the aggregation of data at country-level, Wallsten (1999) recommends the importance of conducting analyses on privatization at lower units of analyses such as at sub-national-level. This would provide much more a detailed and accurate view of the effects of privatization and its impact at a micro-level. This chapter will thus address this challenge by focusing on the impact of privatization on one single economy at a micro-level, particularly at a sub-national level.

An analysis into the effects of privatization on economic growth by Cook and Uchida (2001) showed that there is a robust partial correlation between privatization and economic growth, suggesting that privatization has contributed negatively to economic growth. This conclusion is contrary to the results obtained by Plane (1997) and Barnett (2000). Given the usual problems associated with regression analysis and the difficulties surrounding the determination of the direction of causality, and despite the attempt to be methodologically rigorous, the results must be treated with a fair degree of caution. To this effect, this paper attempts to examine the empirical relationship between privatization and living standards by using a fixed effects approach. The focus of this analysis is on a single country as there may be different economic shocks that countries may be going through at different times making it difficult to generalize the findings, particularly at cross-country level.

A further review of literature shows that different results have been yielded from privatization. Boubakri and Cosset (2002), who looked at privatizations in 16 different countries, found that profitability rose, and efficiency fell by slight percentages. Both these shifts were not statistically significant though a significant increase in capital expenditures divested into firms was observed. This is one of the few empirical studies that have been conducted thus showing a limit in the number of empirical studies. This study thus fills this gap by contributing to the empirical research into the area of privatization of mining and subsequent changes to copper production and its impact on developing economies.

An econometric examination on the effects of privatization, competition enhancement and regulation in telecommunications reform was also conducted in 30 countries consisting of 15 from Africa and the rest from Latin America. Wallston (1999) found a negative correlation with the number of lines which could arise because countries are likely to privatize their incumbent telecom provider when service is poor. On the contrary, it was observed that enhanced competition produces the clearest, most positive effects. Ownership change is assumed not to have generated many benefits.

Another study on Guinea's privatization of water resources by Menard and Clark (2002) concluded that despite evident problems of provision of water, all parties benefited from the reform. This is compared to what would have happened in the absence of private involvement, with an argument put forth of experiencing a worse situation if water management had been left in private hands. Similar conclusions of improved efficiency and quality were drawn in a study in Ivory Coast.

In countries like Tanzania, Temu and Due (1998) concluded that privatization increased government revenues, reduced subsidies in State-Owned and Operated Enterprises (SOEs) and forced firms to operate more efficiently. Unfortunately, the second studies in the same place revealed a decline in employment levels by 48% in 16 firms examined. This is evidence of a possible negative effect of privatization on the welfare of people due to the loss of jobs.

An analysis of 81 privatizations in Cote d'Ivoire by Jones, Jammal and Gokgar (1998) covering the electricity sector in infrastructure with the rest operating in competitive or potentially competitive markets found that firms performed better after privatization than they would have had under public ownership. It was found that privatization contributed positively to economic welfare with annual net welfare benefits stemming from increases in output, investment, labor productivity and intermediate input productivity. This highlights the welfare benefits of privatization through increased employment.

Privatization in Ghana according to Appiah-Kubi (2001) yielded positive results in terms of easing pressure on the balance of payments, increases in both allocative and x-efficiency, stimulation of local capital markets, enhancing the inflow of FDI, widespread quality gains for consumers and increased employment and remuneration post-scale (though increases in jobs after privatization had not yet matched the cuts in worker numbers made prior to divestiture). The lack of match between increased job opportunities and job cuts is a clear exhibition of the negative impact that privatization can bring on living standards. This contrasts what has been experienced for example in Cote d'Ivoire.

An assessment of privatization's impact on Mozambique and Tanzania by Andreasson (1998) found positive changes in operating the financial performance of the divested firms. Substantial productivity gains were also noted, due partly to reductions in the workforce but also because of improved utilization of capacity. The performance of privatized companies has met and even surpassed expectations in the overall conclusion.

In spite of these positive changes, little has been stated in terms of the impact privatization has had on social welfare of local communities. In addition, there is also a gap in literature in that there has been not much focus on privatizing the mining sector. This chapter therefore seeks to fill this gap in literature by examining the impact of privatization of the mining industry on living standards. It also attempts to add to the little existing empirical examinations thus contributing to the few studies on the role econometrics plays in examining the impact of privatizing the mining industry on welfare.

3.2.4 Privatization in Zambia

Privatization of the mines was a costly venture because the economy at the time was not capable of handling a higher volume of market transactions. There was no cost-benefit analysis before the process was begun, such that it has been concluded by theorists that the costs at the end of the process seemed to be more than the benefits. Yet this lacks a critical and empirical dimension of analysis, thus this paper fills this gap in literature by conducting an empirical analysis on the impact of the privatization of the copper mines. Privatization has been observed to be a tool through which economies can be able to function efficiently. This is because it allows for the market forces to freely run without any government interference.

I use a novel panel dataset which provides information on poverty from the Living Conditions and Monitoring Surveys (LCMS) conducted by Central Statistical Office CSO) in Zambia and the copper production and copper prices computed from the annual reports published by the mining companies. The national copper outputs and the international copper prices complement the dataset. The dataset covers a total of 150 constituencies (which are the lowest administrative level of government in Zambia) and nine different mining locations some of which have been in operation for over three decades. All this data is compiled over a period of five years following the periods in which the household surveys were conducted. Information on the distance between each constituency and the nearest mine to that constituency is also utilized. This is used to distinguish constituencies close to the mines from those far away from the mines.

A further contribution this paper seeks to make to existing literature is the investigation of the relationship between living standards and the mining sector in an economy exposed to structural changes. The pieces of work that are closely related to this study are the work of Lippert (2014) who analyses the spill-over effects of a resource boom, with evidence from Zambia and Aragon and Rud (2013) who analyze the impact of mining on local communities in Peru. The study adds on to this literature by examining the impact of privatization on living standards, which has never been explored on Zambia at a sub-national level.

Critics allege that firstly, privatization had been imposed and micromanaged by the IFIs without sufficient attention to requisite policy or regulatory frameworks, and with minimal involvement of Zambian citizens. Secondly, it is alleged that privatization resulted in the closure of many firms previously run by Zambians with a particular resentment that many that continued or reopened are in the hands of foreigners, particularly South Africans. Thirdly, privatization is believed to have added greatly to unemployment and thus poverty and inequality at a time when job opportunities were declining drastically. Thirdly, privatization was alleged to have increased the incidence of corruption with widespread suspicion that the proceeds from the sales were unreported and misused. Lastly, in general, it is alleged that privatization in Zambia benefited the rich, the foreign, the agile and politically well-connected at the expense of the poor, domestic, the honest and the unaffiliated-as illustrated by the allegation that new and private owners extracted subsidies and tax concessions from the government (Craig, 2002).

Furthermore, Zambians claim that the IFIs were originally uninterested in assisting them to deal with the negative social effects of privatization for example severance packages, retraining schemes and monitoring contractual obligations on new owners. This encapsulates the views prevalent in Zambia and widespread Africa as a whole, that the privatization that was forced upon Zambia by the IFIs' has not produced the economic benefits it was supposed to deliver and indeed imposed substantial costs and increased the level of corruption. This huge problem led to the loss of 7000 jobs reflecting an increase in unemployment in the mining sector of 20% which could have been avoided had the process been conducted differently (Fraser and Lungu, 2007)

The case of Zambia is probably a reflection of some other developing countries. Yet the results from privatization cannot be generalized as Zambia privatized its core sources of revenues at low prices due to the liabilities ZCCM had accrued over the period copper prices had declined to their lowest level in history. This calls for an analysis that is specific to the mining industry as a major contribution to the existing literature on privatization and its impact on developing economies.

Zambia's privatization of the mining industry which also brings on board issues regarding the loss of employment which may ultimately affect living standards is a unique case. At the same time, a nagging doubt could equally be raised on whether the problem was "institutional" or "political" in nature. Zambia faced what can be termed as "institutional shortcomings" resulting from what is argued by Nellis (2005) to be poor or corrupt political decisions. This decision bordered on the major problem of deciding on the removal of sales of the mining firms from the purview of the agency that oversaw privatization; a decision that was political in nature. With this evidence in view, it may be necessary to focus on a single economy at a sub-national level when it comes to analyzing the impact of privatization on the welfare of the local communities as each country's decisions would lead to different outcomes.

Since the principle and motivation for privatization in probably most developing economies has been to placate the International Financial Institutions (IFIs), it is extremely important to determine whether this policy recommendation has benefited the developing countries or not. It is to some extent believed that privatization has led to many hardships in developing countries due to inherent problems such as the management of the privatization process. This has led to a negative perception of the whole process, with pressure, in the case of Zambia being mounted at some point on the government to rethink the policy.

3.3 Data and Summary Statistics

3.3.1 Description of data

The focus of this study is the impact of the changes in the mine level copper output ant the privatization of the copper mines on the living standards of Zambia's 150 constituencies. Ascertaining the relationship between living standards and policy changes, particularly privatization of a major sector on a developing economy requires datasets that focus on all the constituencies through time. Thus, to enable the futility of this exercise, data for this chapter are drawn from a variety of sources which include the Central Statistical Office (CSO), the Ministry of Mines and Minerals Development, Bank of Zambia (BoZ), the World Bank, Westmetall and various annual reports from the mining companies with an established presence in Zambia.

These sources are combined to construct a novel panel data set at constituency level comprising of 750 observations observed at five different points in time. The dataset covers 150 constituencies for the periods 1996, 1998, 2004, 2006 and 2010.

The LCMS cover all the population residing in Zambia at the time of the survey. Each survey round is relatively large, covering roughly 1 in every 113 households. In 1996 - 11,788 households comprising of 61,455 individuals were surveyed, in 1998- 16,718 households comprising of 93,471 individuals, in 2002- 54,100 individuals from 9,741 households, in 2006 97,738 individuals from 18,662 households and in 2010- 102,882 individuals from 19,398 households.

The headcount poverty ratios in Table 2.2 show that there had been an increase in urban poverty by 10 per cent from 1996 to 1998 which coincided with the privatization of the mines.[37] Furthermore, it has been documented that urban areas seem to have been hit hard as a result of job losses on the Copperbelt province whose economic mainstay is through copper mining.

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[37] The headcount poverty was computed by taking the average poverty ratios for each survey year for the whole country. This was further broken down into rural and urban areas by grouping the constituencies into the two classifications of either being an urban or rural constituency. The poverty line used is different for each survey year and is adjusted for inflation.

Other Influences

Data on population density, age, access to clean water, the percentage of female-headed households and household size was computed by the author using household statistics provided by the Living Conditions and Monitoring Surveys While data on government funding was obtained from the Economics Association of Zambia (EAZ). Lastly, data on distance was computed by the author using Arc-GIS, where distance was calculated from the centroid of each constituency to the mine closest to an individual constituency.

3.3.2 Descriptive Statistics

Administratively, Zambia consists of 10 provinces that are subdivided into districts. There were 72 districts consisting of 150 constituencies during the period the household surveys were conducted. Constituencies are at the lowest administrative level. Zambia had a population of 9.1million in 1996 and 13.2million in 2010 corresponding to an annual population growth rate of 3.2%. According to household survey data, poverty levels seem to have experienced some changes, with some areas with the presence of mines showing fluctuations in the levels of poverty. The North-western part of Zambia in which two mines began production after the privatization of the mines seems to have undergone reductions in poverty levels. The overall poverty rates for the North-western province reduced from 89% in 1996 to 65% in 2010. These variations in the poverty levels make it ideal to study whether privatization has had an impact on standards of living in Zambia.

Since the focus of my analysis is the effect of privatization on real incomes, household survey data is aggregated at constituency level. Where the existing 150 constituencies were observed over five different waves of household surveys, the total number of observations was 750. Table 3.1 gives a summary of the statistics of the panel-level poverty levels.

As it is deeper explained further, the demographics of the constituencies show that even though people have moved away from extreme poverty, they remain relatively poor. The results are consistent with Ravallion and Chen (2012) who observed that even though the incidence of both absolute and weakly relative poverty has been falling in the developing world since the 1990s, this fall has been very slow for the moderate measure.

Table 3.1-Summary Statistics

Variables	Observations	Mean	Standard Dev.	Min	Max
Avg HH size: Close to a mine	375	5.56	0.744	3.6	8.4
Far away from a mine	375	5.48	0.85	3.5	10.0
Avg age of HH head: Close to a mine	375	41.90	2.82	33	52
Far away from a mine	375	42.33	3.43	25	60
% of the Educated: Close to a mine	375	83.91	9.82	59	99
Far away from a mine	375	78.54	11.30	6	98
Extreme Headcount Poverty: Close to a mine	375	37.85	21.65	1	93
Far away from a mine	375	48.77	18.63	2	90
Moderate Headcount Poverty: Close to a mine	375	17.38	8.21	1	55
Far away from a mine	375	17.69	8.53	2	70
Total Headcount Poverty: Close to a mine	375	55.23	21.95	5	100
Far away from a mine	375	66.45	16.22	14	99
Non Poor at Headcount level: Close to a mine	375	44.47	21.49	0	95
Far away from a mine	375	33.59	16.17	1	86
Population: Close to a mine	375	78451.50	55491.11	17932	514147
Far away from a mine	375	70433.31	65431.96	17923	1204763
% of female headed HHs: Close to a mine	375	19.62	9.17	6	43
Far away from a mine	375	20.64	9.15	6	43
% with access to electricity: Close to a mine	375	39.99	26.15	2.3	96.7
Far away from a mine	375	23.78	12.90	2.3	80.7
% with access to clean water: Close to a mine	375	77.01	13.09	1.1	99
Far away from a mine	375	76.65	13.87	1.1	99
Population density: Close to a mine	375	434.89	1103.33	2.01	7092.70
Far away from a mine	375	25.30	30.39	1.97	294.56

Notes: Table 3.2 shows a summary of descriptive statistics by groups of constituencies. The groups are categorized as those living close to and far away from the mines. HH(s) stands for household

3.4 Empirical Methodology

This section discusses the chosen empirical methods for estimating the relationship between natural resource extraction and living standards in the presence of exogenous shocks such as privatization. It further provides a detailed description of the empirical strategy that is used to analyze the impact of the privatization of the copper mines on living standards at constituency level in Zambia.

3.4.1 Baseline Model

This section provides the empirical methodology for the study of the impact of changes in the mine level copper output and the privatization of the copper mines on living standards. To formally evaluate the effect of privatization of the mines on living standards, the following baseline model is estimated:

$$y_{ct} = \alpha_c + \beta_t + \gamma_1 Priv_t + \gamma_2 LnM_{ct} + \gamma_3 Priv_t * LnM_{ct} + \delta X_{ct} + \varepsilon_{ct} \quad (3.1)$$

Equation (1) is estimated using Pooled Ordinary Least Squares (OLS, without time and constituency fixed effects) and Two-stage Least Squares with Fixed Effects, where:

y_{ct} - The natural log of the real income in constituency c, at period t;

α_c - Constituency fixed effects;

β_t - Year fixed effects;

$c = 1,2, \ldots.. N$ refers to the cross-section of units (constituencies in this case) for time period $t = 1,2, \ldots.. T$. $\boldsymbol{Priv_t}$ captures the effect of the privatization of the mines and takes the value of one after privatization and zero before.[38] $\boldsymbol{LnM_{ct}}$ measures the natural log of the per capita mine level copper output which is computed as the mine level copper output divided by the constituency population. This variable is used as defined in the previous chapter; where distance is used to determine whether there is any copper output in a constituency or not. This means that there was copper production only in constituencies located within the median distance of 401km to the nearest mine. The interaction term $\boldsymbol{Priv_t * LnM_{ct}}$ measures the post-privatization effects of per capita mine level copper output after the privatization of the mines**.** Finally, $\boldsymbol{X}$ is a vector of control variables, $\boldsymbol{\varepsilon_{ct}}$ is the error term for constituency *c* and period *t*.

Vector $\boldsymbol{X}$ contains various factors which influence constituency level living standards in line with the literature.[39] The main control variables are the constituency characteristics that may be correlated with the variables of interest (privation and copper output), the average age of the household head is an important determinant of household income.

Age is taken to be the natural log of the average age of the household heads. This is used to ascertain how the age at which people become household heads impacts on the living standards. This is an important factor affecting living standards as older household heads might have more experience and advantages enabling them to sustain their households and

[38] Real income is the average household income in each constituency deflated by the poverty line.

[39] The control variables in this case are briefly explained with a more detailed explanation being provided in the preceding chapter.

hedge them from poor living standards. The average age of the household head tends to determine the level of income gained. The older the household head is the more years of working experience they have and the higher income they are likely to earn. In terms of average age of the heads of the households, this is also an indication of the levels of education attained (Flores, Fernandez and Pena-Bouquet (2014) and Rinz and Voorhes (2018)).

$Household\ Size$ is measured as the average household size for each constituency. Constituencies with a larger household size are likely to have poor living standards as the income gained may not be able to be stretched out to meet the needs of the households. $Population\ \ Density$ is also an important aspect in determining living standards as constituencies with a lower population density have more resources to cater for the population than those with a high population density. Finally, $Government\ Expenditure$ which is measured by the funds allocated for constituency development projects aimed at poverty reduction is also an important variable. This variable captures the impact of government efforts to improve living standards. Controlling for government funding enables us to control for any effects on living standards that may arise as a result of government direct efforts to improve living standards, thus independently analyzing privatization and its effects on living standards. Even though EAZ (2011) and Manely (2015) observed that the management of such funds is quite ineffective and has not achieved its intended goal, it is believed that even the little expenditure by the government on projects targeted towards poverty alleviation can achieve the intended goal. The analysis thus controls for government spending (at constituency level) to solve the earlier stated problem of omitted variable bias. Government funding is a key control variable as there is a possibility that this in some cases may influence the real incomes at constituency level especially if the allocation is made according to the contribution of mining revenues to public funds. In the case of Zambia, as earlier highlighted, the government allocates what is known as Constituency Development Funds (CDF) which is uniform across all constituencies. This simply means that there is no favorable treatment for constituencies with a mine presence.

In the case of Zambia, constituencies with mineral deposits are not evenly distributed; they are mainly in the north-western part of the country.[40] This simply means

[40] Copper production is concentrated in a belt called the Copperbelt which extends to neighboring countries like the Democratic Republic of Congo.

that constituencies with copper deposits are systematically different from other Zambian constituencies. This may lead to potential biases if revenues from the mines were directly accruing to individual constituencies. But, in Zambia, revenues are collected centrally and decisions on expenditures are made by the central government through the national budget. Most of the results are thus later replicated with alternative subsamples as part of the robustness checks. The sample is separated by distance, which groups the constituencies into those located close to and far away from the mines. The sample is also divided into rural and urban constituencies. Findings from both these classifications show a non-sensitivity to sample selection.

3.4.2 Empirical Method

The objective of this section is to estimate the relationship between privatization of the copper mines ($lnCopper$) in a constituency (c) in a given time period (t)[41] and the living standards ($y_{c,t}$) or the parameter β_1:

$$\boldsymbol{y_{ct} = \gamma_1 Priv_t + \gamma_2 LnM_{ct} + + \gamma_3 Priv_t * LnM_{ct}\, \delta\, X_{ct} + \varepsilon_{ct}} \qquad \textbf{(3.2)}$$

There are many reasons for believing the identification assumption:$\mathbb{E}(Ln(M)_{c,t}, \varepsilon_{c,t}) =$ 0, does not hold in this case. For example, areas with high levels of per capita mine level copper output may be richer regardless of the availability of copper ore deposits. Such endogeneity is causing the Pooled OLS estimations to be biased and inconsistent for the Panel Data. The problem is coming from the fact that there are unobserved or observed heterogeneous or time effects are correlated with the variables of interest. For example, the fact that a particular constituency is geographically situated next to a copper mine makes such fixed effect correlated with the copper output per capita in this constituency. An example of time fixed effect would be a change in the environmental policies of Zambia that would regulate the copper output and, thus, would be correlated with the variable of interest.

Fortunately, due to the nature of the Panel Data there is a method to solve such endogeneity problem would be to include heterogeneous effects for time and constituency, thus accounting for some characteristics that were either present in one period and influenced all constituencies or were always present for each constituency individually and independently from other constituencies but did not change over time. This can be seen in equation **(3.1)** earlier presented**.** Where α_c and β_t are the fixed cross section and time effects respectively. Since these coefficients are not of research interest, they are not estimated, being removed routinely in STATA using the Within Transformation method with time fixed

[41] Year in this case represent the various survey years. Theses survey years follow the trend of the available data from the Living Conditions and Monitoring Surveys (LCMS) conducted in Zambia between 1996 and 2010

effects. This model represents a substantial improvement over the standard pooled OLS regression.

However, there are other sources of endogeneity and bias remaining. For example, Omitted Variable bias (OV), Error-in-variables bias, and simultaneity bias. The OV bias is one of the main concerns. In order to at least mitigate this problem, the whole set of control variables are included in all regressions. They were covered above. At the same time, the Instrumental Variable (IV) approach helps to mitigate all three biases. Thus, the Two-stage Least Squares Fixed Effects (2SLS FE) estimation is the core method of estimation in this work (see Wooldridge, 2016, 405-437; or 2008: 506-536). This methodology is following the well-established approach by Caselli and Michaels (2013) and Monteiro and Ferraz (2012). The following section discusses it closely.

3.4.3 Instrumental Variables Framework

To estimate the causal effect of mining activity and its privatization on the living standards, there is a need to overcome the main bias of simultaneity; that mine production could be affected by changes in real income. In other words, there is a risk of misinterpreting the effects if higher incomes lead to higher copper production, rather than higher copper production leading to higher incomes. To this effect, this thesis used an IV approach where copper production is instrumented with international copper prices. The idea is that production decisions are largely influenced by the exogenously determined possibility of profitability selling the copper on the international market. The exogeneity of international copper prices is motivated by the fact that demand elasticities are typically low since copper is generally an input in the industrial production and only constitutes a small share of the consumer price. At the same time, the income elasticity of demand is often high, and hence changes in economic activities in other countries where there are large manufacturers may have significant effects on mineral prices (Tolonen, 2016). Similar identification strategies have previously been used by, for example, Sanchez de la Sierra (2014) and Tolonen (2016). The main assumption is that international copper prices affect real incomes through copper production and not through any other channels (the exclusion restriction). There is no potential concern that real incomes in Zambia are directly affected by the international copper prices as Zambia's share of market power on the international market is relatively and therefore not able to influence the copper prices.

This section reminds about the instrumental variables strategy that is employed in the similar way as it is done in the previous Chapter. The method used is 2SLS FE estimation, thus, the first stage regression is as follows.

$$\boldsymbol{LnM_{ct} = \eta_c + \theta_t + \lambda_1 Ln(IntCP_{t-1}) + \gamma_3\, Ln(IntCP_{t-1}) * Priv_t + \psi X_{c\,t} + \mu_{ct}} \quad \textbf{(3.3)}$$

$$\boldsymbol{LnM_{ct} * Priv_t = \eta_c + \theta_t + \lambda_1 Ln(IntCP_{t-1}) + \gamma_3\, Ln(IntCP_{t-1}) * Priv_t + \psi X_{c\,t} + \mu_{ct}} \quad \textbf{(3.4)}$$

where $\boldsymbol{Ln(IntCP_{t-1})}$ denotes the natural logarithm international copper price in constituency c at period $t-1$, this is later interacted with the privatization dummy in order to enable the analysis of the effects of the mine level copper output on living standards after the privatization of the copper mines. The use of interacted endogenous regressor and ultimately interacted instrumental variable has previously been used by Esarey and Schwindt-Bayer (2015) in a study on women's representation, accountability, and corruption in democracies and Esarey (2015) in a study on the effects of corruption on economic development. The $\boldsymbol{\eta_c}$ and $\boldsymbol{\theta_t}$ represent the constituency and time fixed effects, the former are also routinely removed by the Within Transformation in STATA, $\boldsymbol{\mu_{ct}}$ represents the idiosyncratic error term. Lastly**,** $\boldsymbol{X_{c\,t}}$ includes all the exogenous explanatory variables that are used as controls in the second stage regression. [42]

As before, it is likely to minimize bias from the OV, simultaneity, and a classical measurement error (Error-in-variables bias) through the fact that the international copper prices are correlated with the average real income and other socio-economic outcomes of

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[42] In the vector, the full set of control variables includes: average household size, age, percentage of female headed households, percentage of literate heads of households, access to water, electricity and population density.

constituencies only through the level of copper mining in each mine. The arguments in detail are presented in the previous chapter.

However, for the sake of clear representation, several points should also be mentioned here. The instrumental variable (IV) is considered to be exogenous to our model as it is determined at the international market by international supply and demand, while copper production of Zambia is small relative to the world production. The order and the rank conditions seem to be satisfied; it is supported by the tests done routinely for each regression. The tests can be seen in the second panel of each estimation. Among them, there is an F-statistic (always more than 10 as expected), Kleibergen-Paap test, The Anderson Rubin and Stock-Wright LM. In the case of using two different instruments, there is only significance in reporting the results in panel 2 as they are the joint results while the other test results are for each individual instrument.

As before, such potential problems as non-normality of errors, heteroscedasticity and serial correlation and stationarity of variables are taken into account.

In all estimations we find the residuals being non-normal, so we must rely on asymptotical distributions of our estimators for the inference. The full sample size is 750 observations and the minimal subsample is 338, this can be considered large enough for the Law of Large Numbers and Central Limit Theorem to work, suggesting that all estimators should have the statistical distribution required for the correct inference.

In addition, for each estimation the standard errors are clustered at constituency level as the observations over time may be correlated within the constituencies. That, as according to Wooldridge (2002) leads to standard errors that are completely robust to any kind of serial correlation and heteroscedasticity. [43] Nevertheless, the option robust is always used in order to take any heteroscedasticity into account.

Stationarity cannot be tested with confidence for 5 observations per constituency, although it is supported by the Dickey-Fuller test. At the same time, a spurious regression should not be a problem here due to the nature of the dataset and the theoretical model behind the estimations.

[43] Gomez-Arceo, Hanna Rema and Olivia Paulina (2015) observed that results obtained by clustering standard errors at either department level such as constituency level or at period (year) level usually turn out to be somewhat identical.

Finally, the 2SLS Random Effects were used for the sake of testing the approach against the 2SLS FE. The Hausman test supported the rejection of this approach. That is also enforced by the fact that such time-variant characteristics as, for example, geographical proximity to large copper deposits are correlated with the copper production levels and, potentially, with the social and economic outcomes of this constituency, what makes employment of RE inefficient and irrelevant for our model.

3.5 Results

This section presents the main empirical results from the regression analysis. This examines whether the increase in per capita mine level copper output and the privatization of the copper mines has had any effects on living standards in post-privatization years.

3.5.1 Effects of the privatization of the mines on living standards

In this section, the results on the effect of the increase in per capita mine level copper output and privatization of the copper mines on living standards are presented. The outcome variable is a natural log of real income at the constituency level. For comparison purposes, a pooled OLS regression results are presented. Next to it, the results of the 2SLS FE estimation are presented due to the reasons mentioned above.

Table 3.2 looks at the effect of per capita mine level copper output and privatization of the mines on real incomes. The results in the columns (1) of the table show that per capita mine level copper output had a negative impact on real incomes while privatization had an insignificantly effect on real incomes. Though the coefficient on per capita mine level copper output is statistically significant, inconsistent and biased. The commentary further concentrates on the 2SLS FE estimations. For the interaction between the per capita mine level copper output and privatization of the copper mines on the other hand shows a positive and significant increase in real incomes. This change from the from insignificant in the pooled OLS model to a positive, significant and higher magnitude of the coefficient in 2SLS FE model might be due to the aforementioned reverse causality between per capita mine level copper output and real incomes. It can be seen that one per cent increase in copper output after the privatization of the copper mines is associated with 0.107 per cent increase in average real income of a constituency ceteris paribus (CP). It has equally been observed that the constituencies' average real income significantly increases when the mine that is situated close to it is privatized (Privatization =1) keeping all other variables constant, what supports the initial conjecture that the private capital can be more efficient than public. In addition to that, one can think about the vehicle of such efficiency as reinvesting the profits into the higher production levels and better infrastructure around a mine. What, in turn, increases the local employment level, giving a positive push to the average income in the constituency.

The argument is also supported by what has previously been observed by Lungu (2008) that there were inefficiencies in running the mines just before their privatization, and as such poverty levels had increased on the Copperbelt province where most of the mines are located. While CSO (2010) documents a decline in poverty levels a few years after the privatization of the mines. This is supported by the economic theory that an economy needs to make adjustments over a period of time before any changes can be observed.

Table 3.2- Effects of Ln(Copper Output) on Ln(Real Incomes)

Panel 1	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.035
	(0.034)
Privatization	0.035
	(0.124)
Ln(per capita mine level copper output)* Privatization	0.107***
	(0.026)
Household size	0.233
	(0.639)
Average age of household head	1.340*
	(0.647)
Population density	0.154
	(0.232)
Female	-0.014
	(0.025)
Access to clean water	-0.002
	(0.004)
Government Spending	-0.0000003***
	(0.00000001)
R-squared	0.247
Observations	750
Panel 2	
Kleibergen-Papp	*0.000*
Anderson Rubin	*0.000*
Stock-Wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the Null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the

over-identifying restrictions are valid

The other significant variable of interest is the government funding which controls for any government programs meant at poverty alleviation that could impact living standards significantly. The negative and statistically significant impact of government funding on real incomes could be attributed to the lack of implementing projects that are meant at reducing poverty in local communities. This, therefore, eliminates any possibility of attributing the improvement in living standards directly to the government. The other control variables are insignificant. In addition, it is interesting to notice that the coefficient for the mine level copper output lost its significance in comparison to the previous chapter results that is obviously related to the omitted variable bias present in the previous chapter.

3.5.2.1 Accounting for distance to the nearest mine

Since all constituencies are not expected to be equally affected by the adversities of the divestiture of the copper mines, constituency heterogeneity is taken into account. The aim of this analysis is to determine whether per capita mine level copper output, privatization of the copper mines and distance to the nearest mine[44] had an impact on the real incomes. The median distance of 401km is used to determine whether a constituency is located close to or far away from a mine.

Figure 3.1 shows that the conditional average of the average real income outcomes before and after privatization. It can be seen that the average real income was in general higher after privatization than before, though the real income after privatization did not follow the pre-privatization pattern. The average real income of constituencies after privatization also followed the expected pattern of declining with the distance to a mining operation. Additional support is provided in figure A1 in appendix A. As such the next section further explores these differences by discussing results from the model estimations.

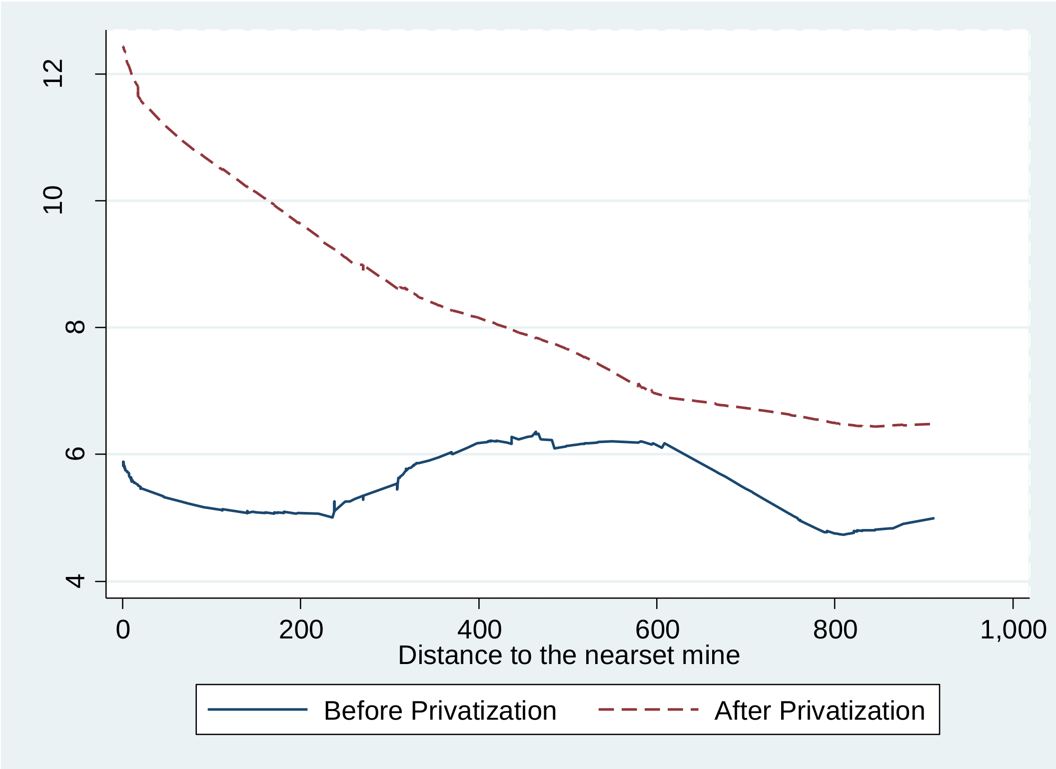

Figure 3.1: Movement of real incomes by distance

3.5.2.2 Accounting for the distance

This section explores the link between per capita mine level copper output, privatization of the copper mines and real incomes while categorizing constituencies into close to a mine and far away from the mine. The median distance is used as a threshold for separating the sample. It further analyses the impact of the changes in copper output after the privatization of the mines.

Table 3.2 reports the results of the effect per capita mine level copper output on real incomes for constituencies close to the mines. The results indicate that the copper production had an insignificant impact on that is constituencies located within 401km to the nearest min. Similar results are observed for the whole sample.

In terms of the effect of privatization of the copper mines on real incomes, this seems to also have an insignificant impact on constituencies located close to the mines even though it is interesting to observe a positive significant impact from the interaction. This positive impact could be attributed to the higher wages and more attractive incentives offered to the new workers who were mostly skilled workers (Fraser and Lungu, 2007). With an increase of 0.067 per cent in the average real income of constituencies close to a mine being observed after the privatization of it ceteris paribus. This effect tends to be higher with a decline in the distance to the nearest mine as shown in column (3) were a percentage increase in per capita mine level copper output increases real incomes by 0.067per cent.[45] This result tends to be higher for the whole sample due to the opening up of business to individual contractors rather than the old system of having subsidiary companies run by the former ZCCM to support the mining industry.

A further assessment of the effect of mine level copper output on the real incomes of constituencies located less than 401km to the nearest mine evidences that there is a statistical effect of copper output or privatization as well as a significant interaction between them. This supports the fact that mine activities play an important role in people's socioeconomic outcomes in Zambia and that the constituencies that are closer to such activities could benefit from them when there mines are privately run. One can note again that the coefficient of the Government Funding is significant and negative, suggesting the same inefficiency of spending, that can be related to the mismanagement, corruption, or general inefficiency of the public capital (Steven, et al, 2015).

Such outcome is partly in line with the study by Simler (2007), who found that even though mining constituencies experienced increasing poverty levels as a result of the job losses after the privatization of the mines, there has been some changes to this after the reopening of the two new mines, Kansanshi and Lumwana mines in the north-western part of the country.

[45]The IV 2sls approach was used to help resolve the potential endogeneity of natural resource extraction that has been observed from previous literature.

The findings further lend support to evidence provided by Cook and Uchida (2001) who found that there is a robust partial correlation between privatization and economic growth, suggesting that privatization has contributed positively to economic growth by improving the living standards of constituencies that are considered to be located close to the mines.

Finally, it is interesting to note that the statistical tests in Panel 2 of Table 3.2 provide evidence that International Copper Prices are an appropriate instrument for the copper production for the constituencies that are located closer to the mines. That is as expected as the copper production for these constituencies is correlated with the international copper price even for constituencies that are closer to the mines.

Table 3.2- Effects of Ln(Copper Output) on Ln(Real Incomes) by distance

Panel 1	Ln (Real Income)	
Independent Variables	2SLS FE (1)	2SLS FE (2)
Ln(Per capita mine level copper output)	0.052	-0.035
	(0.036)	(0.034)
Privatization	0.174	0.035
	(0.117)	(0.124)
Ln(Per capita mine level copper output)*Privatization	0.067***	0.107***
	(0.020)	(0.026)
Household size	0.819	0.233
	(0.542)	(0.639)
Average age of household heads	-0.141	1.340
	(0.819)	(0.647)
Population density	0.312	0.154
	(0.369)	(0.232)
Female headed households	0.026	-0.014
	(0.038)	(0.025)
Access to clean water	-0.003	-0.002
	(0.007)	(0.004)
Government Funding	-0.0000001	-0.0000003***
	(0.000001)	(0.0000001)
Distance to the nearest mines	***Less than 401km***	***Whole Sample***
R-squared	0.825	0.247
Observations	338	750
Panel 2		
Kleibergen-Papp	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

3.5.3 Using poverty status as an outcome variable

In table 3.3, another measure of wellbeing, in this case, headcount poverty is used to test the validity of the main findings.[46] The poverty outcomes are classified into three main categories, namely the extreme poor- who are taken as those living below the cost of basic needs food basket as defined by the Central Statistical Office (CSO). Secondly, the moderately poor comprise the section of the population living between the cost of basic needs food basket and the poverty line (CSO, 2010) and lastly the non-poor are those living above the poverty line as given by the central statistical office in Zambia. Results show that the privatization of the copper mines led to a significant increase in the proportion of the population of the non-poor while reducing the proportion of both the extreme poor. However, the population of moderately poor has increased, implying that people moved from the category “extremely poor” to both “moderately poor” and “non-poor”.

Table 3.3 shows these results, suggesting a general improvement in living standards. According to CSO (2010), it is documented that 70 percent of the population in Zambia lives in poverty and poverty levels increased particularly in rural constituencies which are usually located far away from the mines. Even though a slight increase in poverty levels has been documented during periods of the privatization of the mines, this was offset after the copper

[46] The headcount poverty levels are divided into 3 different categories. Extreme represents the percentage of poor people living in extreme poverty in each constituency. Extreme poverty represents the percentage of the constituency population living below the lowest threshold of the poverty datum line. In this case, the poverty lines used are national.

boom as observed by Fraser and Lungu (2007).[47] These results are attributed to the privatization of the mines which led to the temporal reduction in the labor-force employed by the mines just after the privatization of the mines but later on increased after the reopening of Kansanshi and Lumwana mines.[48]

Thus, Table 3.3 shows that privatization had rather different results. The column (1) shows that there was a jump of 0.394 per cent in the population of extremely poor due to the privatization. At the same time, the coefficient of privatization in column (2) shows that the proportion of moderately poor decreased by 0.071 per cent holding everything else fixed. The coefficient is statistically weak. Further, the privatization coefficient in column (3) is insignificant. That supports the Fraser and Lungu, showing that privatization here had an opposite effect to the increase in copper production, keeping people in poverty while at the same slightly improving their wellbeing through the moderate and significant increase in the moderately poor population. That is, probably, due to the laying off of workers after the privatization of the copper mines.

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[47] During the privatization exercise of the mines, there were some job losses that took place in the mining sector as the new mine owners were unable to absorb all the labor force from the state-owned ZCCM.

[48] The increase in the number of employees is the mining sector means that mine level copper output required for an increase in the mining sector workforce. Thus, the positive results in the chapter on employment.

Table 3.3-Regressions on the Effect of Ln(Copper Output) on Ln(Poverty Levels)

Panel 1	2SLS FE	2SLS FE	2SLS FE
Independent Variables	(1)	(2)	(3)
	Ln(Extreme Poverty)	Ln(Moderate Poverty)	Ln(Non-poor)
Ln(Per capita mine level copper output)	-0.072	0.071*	0.036
	(0.037)	(0.031)	(0.027)
Privatization	0.394**	-0.233**	-0.090
	(0.133)	(0.090)	(0.102)
Ln(Per capita mine level copper output)*Privatization	-0.099***	0.027	0.041
	(0.029)	(0.024)	(0.024)
Household size	0.339	0.215	0.436
	(0.646)	(0.543)	(0.419)
Average age of household heads	-0.687	-0.076	-0.345
	(0.640)	(0.456)	(0.396)
Population density	-0.432	0.247	0.097
	(0.251)	(0.164)	(0.134)
Female	0.004	0.019	0.008
	(0.028)	(0.024)	(0.020)
Access to clean water	-0.003	-0.001	0.001
	(0.004)	(0.002)	(0.003)
Female headed households	0.001	-0.005	-0.002
	(0.004)	(0.004)	(0.003)
Government Spending	0.0000002*	-0.000001*	-0.0000001
	(0.00000001)	(0.0000001)	(0.00000001)
R-squared	0.913	0.710	0.430
Observations	750	750	750
Panel 2			
Kleibergen-Papp	*0.000*	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

Interestingly, one could note the difference in coefficients of government spending. It seems that the effect of government spending is positive and statistically significant for the extremely poor population. While it is getting negative and weak for the other two categories. It is related to the fact that the governmental policy is mostly dedicated to eradicating extreme poverty (EAZ, 2011).

3.5.4 Impact on Living Standards

Allowing the mines to be run by the private sector may lead to improved living standards through the increase in real incomes. Our results suggest that the gains from the privatization of the mines had an effect on real income for those constituencies that are located close to the mining concentrations. The effect is positive and is higher for the constituencies situated closer to the mines.

Related literature suggests that even though living standards in constituencies with a mine concentration drastically declined during the period the mines were being privatized, the situation changed after that. In fact, while there is no evidence that the privatization of the mines affected living standards of the people living around the mining concentrations during the survey periods, CSO (2010) observed a reduction in poverty levels especially in the urban constituencies located close to the mines, what contradicts the results in Table 3.3, but at the same time is in line with the results from Table 3.2.[49] This can be attributed to the

[49] Table 3.3 can be seen on the previous page (page 87)

fact that the average real income is different from the poverty indicators used. One possible solution can be attributed to the general significant increase in pay to the skillful workers, while unskilled workers were laid off. With poverty levels reaching a record high in several years and an increase in death rates which was attributed to depression as a result of the loss of jobs. Moreover, there is evidence that the new mine owners were willing to have a reduced labour force and at the same time offer good conditions of service to those that qualified to work in the mines (Lungu, 2007). Finally, the results suggest that the privatization variable is insensitive to different samples.

Though many may support the privatization in developing countries, Samuel (2010) observed that there also seems to be a gap between the expectations and the reality of privatization in terms of its benefits. The general belief is that foreign investors tend to benefit more than the local investors and the process is pro-rich which is highly associated with corruption. This has been the general populist perception in Zambia in regard to the privatization of the mines. With evidence showing that there has been an increase in foreign investments in the mines most of which are directly linked to contracts with the mining companies. This could be but one of the few reasons why privatization has not been supported in Zambia. The results further just show a modest improvement in living standards in urban areas meaning that the rural poor are not necessarily beneficiaries of the privatization of the mines.

3.5.5 Effect of Privatization of the mines on real incomes by mine type

This section looks at the effect of privatization of the mines on real incomes by mine type.[50] The observation that underground mines tend to incur higher operational costs than open-pit mines and therefore assumed to be less profitable than open-pit mines, thus the two types of mines may have had an economically different effect on living standards.

Findings in column 1 of table 3.4 show that privatization had a non-trivial but statistically weak effect of privatization. According to our estimation the effect is as large as 61.7 per cent rise in average real incomes of the constituencies located close to the open-pit

[50] Mine type in this case refers to whether a mine is an open-pit mine or an underground mine.

mines ceteris paribus. This could be attributed to technology changes and capital investments that took place after the privatization of the mines, which meant that the mining industry became more capital intensive as observed by Simubali and Chileshe (2013). On contrary, the results presented in this column reveal findings of insignificant coefficients for both per capita mine level copper output and the interaction term. In this case, the other significant variables are only the controls; namely average household size, the gender, proportion of female-headed households and the government expenditure (all very weakly). This can be attributed to the fact that the two subsamples in this section are very different to each other, even though 136 observations in statistical tables are considered large enough, for our case there is a suspicion that it is not enough to get reliable estimates. This cannot be improved due to the nature of data. There are less open-pit mines in Zambia than the underground ones.

Results in column 2 of table 3.4 also show that neither of the first three coefficients of interest show significant effect on real incomes in constituencies located close to the underground mines ceteris paribus. As earlier stated, this could be attributed to the mines becoming more capital intensive and as a result requiring less unskilled and more skilled labor which tends to attract higher wages.

The negative and insignificant coefficients of copper per capita output and privatization reported in column (1) of table 3.4 may be also attributed to the lack of improvement in living standards in constituencies located near open-pit mines due to the cost of the high levels of pollution. High levels of pollution that people are prone to as a result of open-pit mining could lead to poor health and as increase the expenditures on health-related problems. This topic is discussed in detail in Chapter 4.

Paying some attention to the coefficients that are significant in this regression one can see that household size and female-headed household had a negative impact on the constituencies close to the open-pit copper mines. The possible explanation is that the larger is the number of people in a household the more difficult it is to provide for all of them for the working members of the household, especially taking into account that such mines are situated mostly in rural areas. The similar reasoning can be applied to the female-headed households, as it can be more problematic for the working members of such households to raise money in a rural area in the proximity of an open-pit mine. Government spending seems to be quite ineffective here as it was in the earlier regressions. These arguments still should be taken with caution taking into account relatively smaller subsample size with open-pit mines.

Underground mine type subsample is relatively large and shows a slightly different pattern. The coefficient for the household size is positive but statistically weak, suggesting that as such mines are usually close to urban areas the higher number of members in a household leads to higher average real income due to better employment possibilities.

Table 3.4- Effects of Ln(Copper Output) on Ln(Real Incomes) by mine Type

Panel 1	2SLS FE	2SLS FE
Independent Variables	(1)	(2)
Ln(Per capita mine level copper output)	-0.022	0.013
	(0.033)	(0.150)
Privatization	0.617**	-0.421
	(0.262)	(0.938)
Ln(Per capita mine level copper output)*Privatization	0.041	0.125
	(0.016)	(0.143)
Household size	-3.090*	1.171*
	(1.800)	(0.547)
Average age of household heads	1.356	0.202
	(1.018)	(0.805)
Population density	-0.033	0.272
	(1.342)	(0.202)
Female-headed households	0.022*	-0.004
	(0.011)	(0.003)
Access to clean water	0.004	-0.001
	(0.003)	(0.004)
Government Spending	-0.0000001	-0.000001
	(0.00000003)	(0.0000001)
Mine Type	**Open-pit Mine**	**Underground Mine**
R-squared	0.196	0.121
Observations	134	569
Panel 2		
Kleibergen-Papp	*0.011*	*0.001*
Anderson Rubin	*0.024*	*0.000*
Stock-Wright	*0.006*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density. Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

3.5.6 Effect of Privatization of the mines on Employment

Table 3.5 shows that there was an insignificant impact of the divestiture of the mines on the levels of employment. It equally shows that the increase per capita mine level copper output as a result of the increasing global copper prices only modestly increased the levels of employment in the mines (the impact is statistically weak). This effect is explained by the history of the mining sector in Zambia and situations that have evolved after the privatization of the mines.

The destruction of jobs is one of the most common features associated with privatization which was the case during the privatization of Zambia's copper mines. It has been generally observed that employment has been adversely affected mainly in the period leading up to privatization or in the case of liquidation. In the case of Zambia, the workforce in the privatized mines diminished in relative terms with massive layoffs in absolute terms. In the case of the privatization of Zambia's mining sector, employment declined by about 20%. According to Buchs (2003), although the layoffs were largely concentrated in the earlier years, there was a decline in employment on a continuous basis until 2001. With evidence of the best-known failure in attempts at imposing employment guarantees being evidenced at the Luanshya and Baluba mines. Although it was assessed in 1998 that up to 3000 workers would become redundant under any reasonable business plan, the private company RAMCOZ agreed to take over the mines and not to dismiss any of the 7000 workers. Shortly after the deal, RAMCOZ laid off 3000 workers and failed to make termination payments. When the company went out of business in 1999, the remaining 4000 workers joined the unemployed. Eventually, the Zambian government had to pay partial compensation to the workers, but the case was still not finalized as of mid-2003.

In addition, there has been a continuous decline in employment levels for the unskilled over time, especially with the temporal closure of the Luanshya mine. This reflects the pre-scale "cleaning up" of parastatals where overstaffing and the redundant labour force was a major issue. The results of the estimation of the coefficient for the interaction term for both columns indicate this process, when the additional per cent of per capita copper production is adding only 0.083-0.058=0.025 per cent in employment ceteris paribus for the subsample and only 0.003 per cent for the whole sample. That can be attributed also to the fact that after privatization the owners made improvements increasing the efficiency of the mines, making them less labor intensive and more capital intensive by introducing new technology.

This makes Zambia an exception to the general scenario of postponing the impact of privatization on employment and falling on the list of countries with an increase in poverty rates as a result of privatization. However, our estimations show a positive statistical effect on the employment rates; potentially suggesting that the workers laid off must have found employment elsewhere, for example, in the industries servicing the copper mines, which developed more after privatization.

Table 3.5- Effects of Ln(Copper Output) on Ln(Employment)

Panel 1		
Independent Variables	2SLS FE	2SLS FE

	(1)	(2)
Ln(Per capita mine level copper output)	0.083*	0.040*
	(0.036)	(0.021)
Privatization	0.148	0.101
	(0.150)	(0.073)
Ln(Per capita mine level copper output)*Privatization	-0.058*	-0.037*
	(0.027)	(0.017)
Household size	0.792	0.480
	(0.430)	(0.251)
Average age of household heads	-0.290	-0.062
	(0.673)	(0.272)
Population density	0.484	0.209
	(0.514)	(0.206)
Access to clean water	0.001	-0.001
	(0.005)	(0.001)
Female headed household	-0.001	-0.002
	(0.004)	(0.002)
Government Funding	0.000001	0.000001
	(0.000001	(0.000001)
Distance to the nearest mines	**Less than 401km**	***Whole Sample***
R-squared	0.090	0.036
Observations	375	750
Panel 2		
Kleibergen-Papp	*0.000*	*0.000*
Anderson Rubin	*0.020*	*0.030*
Stock-Wright	*0.001*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

3. 5.7 Separating the Sample into Urban and Rural Areas

In Table 3.6, the sample is divided into two categories, urban and rural areas. Results for both urban and rural areas show that the changes in mine level copper output had a positive impact on the real incomes of the corresponding population. Although the coefficient for Urban areas is statistically stronger than the one for the rural areas. This can be due to the difference in relative sizes of subsamples.

Privatizing the mines also seems to improve the living standards of urban constituencies mainly as a result of these constituencies being either close to the mining operations or the mining operations being located in these urban constituencies. Thus, privatization increased the average real income in the urban areas on average by 0.122 per cent ceteris paribus. In this case, holding everything else constant, the per capita mines level copper output significantly increased the real incomes in rural areas by 0.097 percent.

Supporting the above, it has been evidenced by the poverty statistics documented by the Central Statistics Office (CSO, 2010) in Zambia that rural poverty has been on the increase, however, for the rural constituencies located close to the mines, this has not been the case. CSO further documents that poverty levels have declined in the north-western part of Zambia where two new mines were opened. Furthermore, privatization of the copper mines only improved living standards of urban constituencies as most gainers from the privatization process were mostly from urban areas.

To sum up, the findings in this section are in according to the previous studies on poverty in Zambia by Simler (2010) and CSO (2010), rural poverty tends to be higher than urban poverty and according to Lippert (2014) the rural populations benefit less from the mining industry as they are located away from the mines and its transportation routes.

Table 3.6- Effects of Ln(Copper Output) on Ln(Real Incomes) by Rural and Urban Status

Panel 1	2SLS FE	2SLS FE
Independent Variables	(1)	(2)
Ln(Per capita mine level copper output)	-0.029	-0.041
	(0.068)	(0.046)
Privatization	-0.216	0.132
	(0.304)	(0.152)
Ln(Per capita mine level copper output)*	0.097*	0.122**
Privatization	(0.046)	(0.039)
Household size	0.617	0.217
	(1.1023)	(0.863)
Average age of household heads	1.440	1.323
	(1.1.284)	(0.836)
Population density	0.440	-0.056
	(0.280)	(0.343)
Female-headed households	0.029	-0.024
	(0.044)	(0.033)
Access to clean water	0.0004	-0.002
	(0.004)	(0.005)
Government Spending	-0.000001	-0.000004***
	(0.0000001)	(0.0000001)
Rural/Urban Status	**Rural**	**Urban**
R-squared	0.045	0.357
Observations	226	477
Panel 2		
Kleibergen-Papp	*0.007*	*0.001*
Anderson Rubin	*0.000*	*0.000*
Stock-Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

3.5.8 Using an alternative measure of well-being – facilities availability

In this section, another measure of wellbeing, facilities, is used. This represents the percentage of the constituency's population that has access to both good sanitation and clean water. Results from tables 3.7 and 3.8 both show some benefits accruing to local communities in the form of improved living standards as a result of the resource boom and the privatization of the copper mines and per capita copper production. Privatizing of the mines improved access to clean water and also led to better sanitary facilities. Thus, Table 3.7 shows that privatization increased the percentage of people with access to better facilities by 0.257 per cent, while an additional per cent increase in per capita copper production on average rises this share by 0.060 per cent, both effects are valid ceteris paribus.

Table 3.7- Effects of Ln(Copper Output) on Ln(Facilities)

Panel 1	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	0.060**
	(0.023)
Privatization	0.257***
	(0.071)
Ln(Per capita mine level copper output)*Privatization	-0.027
	(0.015
Household size	0.491
	(0.338)
Average age of household heads	-0.195
	(0.362)
Population density	-0.353
	(0.461)
Female	0.019
	(0.020)
Female headed households	-0.003
	(0.003)
Government Spending	0.000002*
	(0.0000002)
R-squared	0.0012
Observations	750
Panel 2	
Kleibergen-Papp	*0.000*
Anderson Rubin	*0.004*
Stock-Wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

The results seem to be valid even with different subsamples, for instance with partitioning the whole sample by the mine type, there still seems to be a positive and significant improvement in living standards brought about by an increase in per capita mine level copper output and the privatization of the copper mines. Increased competitiveness, especially for better housing facilities, due to the liberalization of the economy which coincided with the privatization of the mines could be another leading cause of an improvement in living standards.

Table 3.8 further validates the earlier findings in this chapter by showing that the observed results are to some extent insensitive to changes in the mine type. Thus, one can still observe similar estimations to those in Table 3.7. However, statistically, the estimations for the open-pit mines subsample seem to be weaker than for the underground mines, this can be attributed to the difference in sample sizes as previously stated. Privatization of the mines also led to a significant improvement in Living standards proving the finding by CSO (2010) that living standards in constituencies endowed with Copper deposits seem to have improved over the survey period due to increased economic activity in mining concentrations. This improvement in economic activities can equally be attributed to the involvement of local people through direct business activities with the mines.

Table 3.8- Effects of Ln(Copper Output) on Ln(Facilities) by Mine Type

Panel 1		
Independent Variables	2SLS FE	2SLS FE
	(1)	(2)
Ln(Per capita mine level copper output)	0.021*	0.184*
	(0.020)	(0.104)
Privatization	0.007*	1.076*
	(0.0233)	(0.527)
Ln(Per capita mine level copper output)*Privatization	-0.019	-0.133
	(0.021)	(0.075)
Household size	1.417	0.421
	(0.811)	(0.468)
Average age of household heads	-0.290	-0.757
	(0.479)	(0.484)
Population density	0.103	-0.391
	(0.409)	(0.487)
Female	0.051	-0.0001
	(0.037)	(0.022)
Female headed households	-0.007*	-0.001
	(0.005)	(0.004)
Government Funding	*0.0000002*	*0.000002****
	(0.000002)	*(0.000001)*
Mine Type	***Open-pit***	***Underground***
R-squared	0.179	0.100
Observations	165	585
Panel 2		
Kleibergen-Papp	*0.012*	*0.001*
Anderson Rubin	*0.011*	*0.012*
Stock-Wright	*0.001*	*0.001*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

3.6. Conclusion

This paper examines the evidence of the effect of the copper boom and Zambia's privatization of the copper mines on living standards. While living standards moderately improved in both areas with a mine presence and in those with no mine presence in proximity after the privatization of the mines, urban constituencies in which mining was concentrated experienced marginally better living standards, than relatively rural constituencies with no mine presence. This finding is robust across a range of alternative samples. The magnitude of this effect is substantial.

As a result of this work, it becomes evident that there is a relationship between per capita mine level copper output, privatization of the copper mines and real incomes. The per capita copper output seems to have a generally positive effect on the economic and social outcomes of the constituencies in Zambia. Privatization, however, had mixed results, while generally increasing average real income of constituencies; it had a harmful effect increasing poverty via mainly the initial decreases in employment, which were offset later making no statistical difference. The offset is potentially due to requalifying of workers to the servicing industries growing around the newly privatized copper industries. The poverty levels of the poorest and those living in rural areas were hit disproportionately by privatization. Unfortunately, the poorest people tend to live mostly in rural areas far away from the mines. These findings confirm the results of Lungu (2008) and are in line with other literature that finds evidence of a privatization-living standards link.

It can be stressed that the methodology of this paper precludes making any conclusions on whether privatization of the mines in Zambia, in aggregate, causes higher or lower income growth or faster or slower poverty reduction. Rather, this paper shows that privatization of natural resources may have heterogeneous effects, with different areas and segments of the population experiencing markedly different gains (or losses) than other segments depending on how they respond to changes that take place because of either privatization or nationalization of key sectors like mining in an economy. In addition, it shows that there is a causal relationship between natural resources and living standards in Zambia.

The findings in this study are important from a policy perspective. An increasing number of developing countries are pursuing the privatization of SOEs to achieve faster economic growth, increased living standards and poverty reduction. However, the paper demonstrates that in Zambia, areas that were more exposed to the mines through their employment mix did not reap many benefits from privatization. Institutional characteristics also mattered. The way the privatization process was handled seems to have exacerbated the adjustment costs of the structural reform. The implementation of additional policies to redistribute some of the gains of privatization from winners to losers may both mitigate the effects on living standards and the economy at large that is at a macroeconomic level. Finally, creating a flexible institutional environment will likely minimize the need for additional interventions.

Chapter 4

The effects of Mining on Health: Copper Mining in Zambia

4.1 Introduction

The global market has been hit by a surge in mineral prices which has resulted into an increase in mining activities culminating into economic growth for low-income and middle-income, mineral rich countries (McMahon and Moreira, 2014). Although few, multinational mining companies that are earning billion-dollar profits in Zambia have had a massive impact on its environment and people. For almost 100 years, Zambia has been highly dependent on copper and the mining industry, and the country is a living proof that progress leaves its mark on both the environment and peoples' health. Land degradation, increased deforestation and water and air pollution from particles of sulphuric acid, which affects those residing near the mines are some of the main concerns by the environmental authorities. The lifecycle of mining consists of exploration, mine development, mine operation, decommissioning and land rehabilitation. There could, however, also be some negative spillovers from this. Often, the start of an extractive industry, say, the opening of a mine, will attract workers from other districts. This could temper the rise in wages; put a strain on local services such as health and education (World Bank, 2015). All types of mining can pollute and cause environmental damage unless carefully managed. But even when carefully managed, there are still substantial risks to local communities.

Studies have been conducted to analyse the effects of mining on Zambias' economy and most developing economies. However, the available evidence on the effects of copper mining tells us very little on the consequences at local level such as pollution. The major borne of contention in developing countries such as Zambia especially after the privatization of the mines is whether there is a trade-off between the benefits from copper mining and the health of the communities living around the mines. This chapter filled this gap by investigating whether copper mining affects health outcomes by exploring the mechanisms for this to happen. The case of Zambia, a large copper mining country, is used as a testing ground and further evaluate the effects of copper mining on health outcomes of the local population. In contrast to the existing literature, it also focuses on the effects of copper mining on health outcomes for constituencies located close to the mines after the privatization of the copper mines.

Although copper mining yields huge revenues for both the mining companies in form of profits and the government in form of revenue from taxes, it often results in water and air pollution that affects the health of the surrounding population. It is known that the main channel of copper exposure is through the sulphuric acid that is released as a by-product of copper production and mainly affects those that are directly involved in the production process. However, there is scant evidence on the magnitude and extent of the effect of copper production on the health of the surrounding populations, and whether the benefits of copper mining could compensate for any damage. Most copper mining operations in Zambia are large polluters and are at risk of weak environmental regulation and enforcement because they are very important sources of revenue, foreign exchange and employment. It should be however noted that there is atleast no indication that ill health is caused by deprivation as living in mining communities is assumed to lead to economic gains which are generally expected to outweigh the cost of health impacts. Some copper mines are however, located in the vicinity of urban centres were the population is not sparse and the circulation of air is compromised.

A main empirical challenge in such a study was the possibility of the endogeneity of natural resources extraction. The production of copper in this case may have exposed the populations to negative externalities such as pollution. To overcome this concern, a 2SLS approach was used; exploiting two sources of variation: health outcomes and changes in copper production. The main identification assumption is that the change in health outcomes is affected by the pollution of the mines. This followed the strategy used by Arceo-Gomez et al (2015), which is the closest study to this chapter. Unlike Arceo-Gomez et al (2015), this chapter uses the international copper price to instrument for the mine level copper production. The main dependent variable is whether the general health of people has changed and if there has been an increase in respiratory infections highly related with mining, both aspects which capture the possibility of a low life expectancy. A rich dataset with all infections and types of diseases by gender and age was used; this was constructed from the Living Conditions and Monitoring Surveys (LCMS).

This chapter therefore seeks to make the following contributions. The most notable contribution made is to the empirical literature on reverse causality; where it is assumed that higher levels of copper production may lead to higher levels of pollution which can negatively affect health outcomes and when there is generally poor health among the labour force in the mine, this is likely to lead to lower levels of coper production. Secondly, it contributes to the rare literature in developing countries on mining and health by presenting a micro-data study of the comparative health effects of an important industry in a single developing country. Lastly, a contribution is made to the growing body of literature on the effects and externalities of mining, specifically to the literature on mining in developing countries and its effects on health outcomes. Although there has been an active literature on the health effects of pollution, most of it has been using developed countries' data (Greenstone and Jack, 2015), it therefore seeks to add on to the scant literature in developing economies.

The observed results show evidence of a significant but modest decline in general health outcomes with, especially, diarrhoea cases increasing as a result of pollution. The potential vehicle of such relationship is through air and soil pollution the quality of food is deteriorating, while, at the same time, the general health and immunity of the people in the constituencies is deteriorating leading to the higher number of diarrhoea cases. Results also show a significant increase in chest infections and the prevalence of anaemia shows a reduction after the privatization of the copper mines. Chest infection and anaemia one can easily name among the straightforward results of the air pollution. In terms of mine type, there seems to be an improvement in the general health of populations living close to open-pit mines in comparison with those living near underground mines, however. The estimates suggest that a one per cent increase in the copper production measure is associated with a 0.136 percent increase in the prevalence of chest infections for constituencies located close to underground mines. This can be attributed that the effects of the pollution are much stronger for the workers of the underground mines. They are under the direct influence of the pollution for most of the time of their day, while in an open-pit mine there is more air circulation, reducing the concentration of pollutants increasing chest infections. On the other hand, the underground mines are located closer to the urban areas rather than open-pit types, suggesting that the health problems are coming from the urban life-style as well. The results tend to be insignificant when the observations are restricted to constituencies located closer to open pit mines. Lastly, including the real income to the regressions reduces a potential omitted variable bias and validates the results showing that changes in incomes have a significant impact on health outcomes as well.

The chapter proceeds as follows. Section 4.2 reviews the existing literature and describes the relationship between health and mining. Section 4.3 describes the data used for the study. Section 4.4 presents the econometric specification. Section 4.5 presents the results. Lastly, it concludes with section 4.6.

4.1.1 Background

The empirical analysis followed in this paper pertains to the case of copper mining in Zambia. Most of the copper is extracted by modern large-scale mines located in the north-western part of Zambia. These mines, similar to other modern mines in the world, are capital intensive, highly mechanised operations. They are located within urban vicinities though with somehow elusive interactions with the local economies; they hire few locals especially in the top positions, buy few local products, their profits are not distributed among local residents and there is no fraction of the fiscal revenue that is allocated to local authorities (Aryeetey et al, 2007).

Due to data availability, the focus for this chapter was on five years: 1996, 1998, 2004, 2006 and 2010. As shown in figure 1, copper production was increasing before 2003 after the privatization of the mines. This was mostly driven by the re-opening of two new mines, Kansanshi and Lumwana mines. After 2003, copper production continued to increase but at a higher level. The aggregate cumulative copper production was almost tripled between 1996 and 2010 and there is a substantial variation across mines. It therefore exploited these differences in copper production in the empirical analysis.

People living near and around mining constituencies in Zambia are exposed to a variety of pollutants some of which undermine the right to their health and livelihoods (Tanimowo 2000). Air pollutants, such as SO_2 (sulphuric acid) being released into the atmosphere during copper smelting and subsequent production of sulphuric acid is associated with respiratory problems. Children, the elderly and those already suffering from respiratory ailments, such as asthmatics are especially at risk. Although there has been a substantial decline in the concentration of SO_2 in the vicinity of the emissions source compared to what the smelter discharges into the atmosphere, Ncube et al, 2012 found that the air pollution measurements in most cases exceeded the Zambia's annual ambient SO2 value of 50 μg/m^3.

Since there is no data on the concentration of pollutants around the mining operations, we borrowed from Aragon and Rud (2016) and used the cumulation of mine-level copper output over the relevant period as a proxy for the generation of pollutants that accumulate in the environment over time.

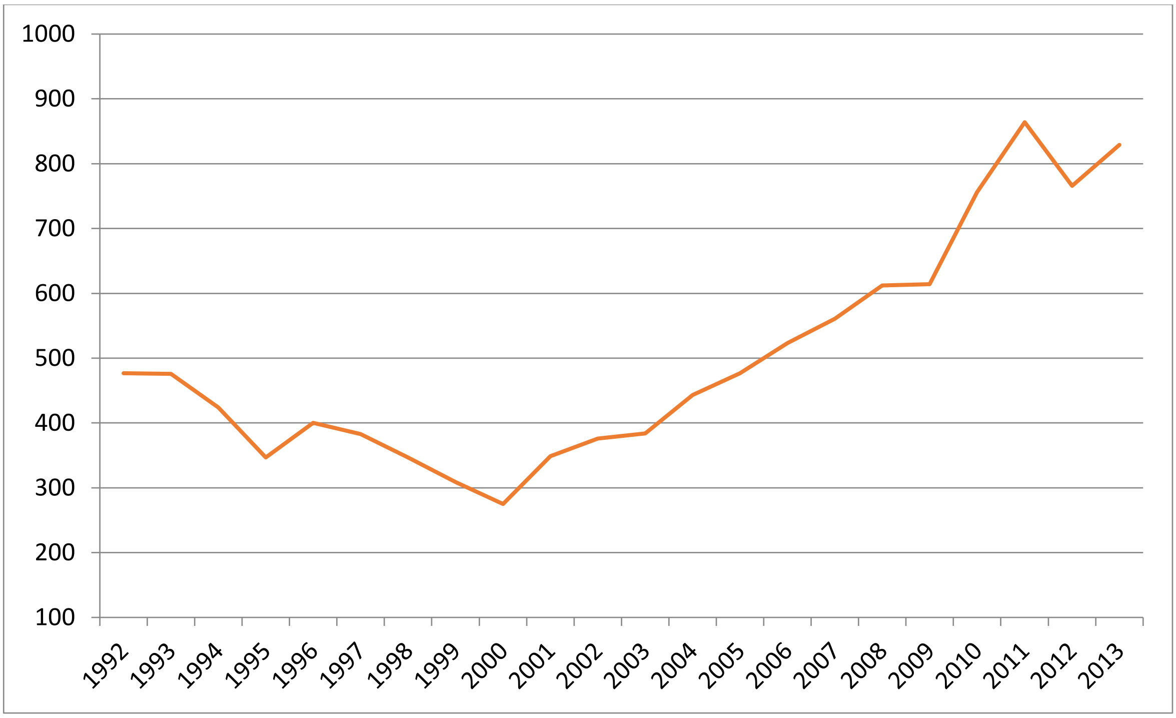

Figure 4.1: Total copper production (in metric tons), by Year

4.2 Review of Literature

The evaluation of environmental impacts of mining and smelting is a very difficult task because of the complexity of factors that should be submitted to assessment as well as lack of uniform methodology, which may lead to conflicting results (Baker and Bowers, 1998; Dutkiewiez, 1993). Nevertheless, in some situations it is evident that harmful health effects are usually caused by emissions from mining/smelting industries. Copper mining is especially a heavy burden on the environment because it generates more than half of all the mine wastes and tailings produced in metal mining. Although mines are classified on the basis of their predominant products, they produce large quantities of other elements as coproducts. As a result, metal ore processing usually leads to multi-elemental contamination of the environment. Copper smelting is regarded as one of the major manmade sources of sulphuric acid which contributes to acid rain. The gaseous, dust liquid and solid wastes discharged into the environment from the mines and smelters cause soil and water acidification, air, water, soil and plant contamination by trace element, deterioration of soil biology and fertility and soil erosion. Primary metal smelters are the main sources of atmospheric emissions.

A body of literature has been documented from research and studies on the effects the mining industry has on human health. Goltz and Barnwal (2012) observed that there is limited work in economics on the issue of health and mining. In their study on the trade-off between wealth and mining in developing countries it was concluded that there is actually a trade-off between wealth and health in mining areas with asset wealth increasing and so did the anaemia in women and stunted growth in young children. Other studies on developing countries include those showing the relationship between sexual behaviour and wealth.

In a study on the relationship between health indictors and residential proximity to coal mining in West Virginia, Hendryx and Ahem (2008) observed that there was an increase in the rates of cardiopulmonary disease, lung disease and hypertension among coal workers. These health problems have been associated with an increase in coal production. This is clear evidence of poor health status and incidence of chronic illnesses in areas near mining operations. This risk is associated with an increase in exposure to mineral by-products.

In terms of the effects of pollution from mining operations on health, this has been studied in large and well-identified studies (for example Curie et al, 2013). Yet most of these investigate developed countries with studies in developing countries still remaining rare. Hanna and Oliva (2015) describe reductions in air pollution from the closure of a large refinery in Mexico City, and an associated increase in labour demand. Yet this does not touch on the intermediate health outcomes. Ebenstein (2012) assesses the effect of water pollution on gastro-intestinal cancer rates in China, another study focussing on China by Chen et al (2013) focussed on reduced life expectancy from air pollution due to power generation in China. Other related but not industry specific studies include Greenstone and Hanna (2011) and Arceo-Gomez et al (2015) who study the effects of overall urban pollution.

Aragón and Rud (2013) also show that the pollution associated with gold mining in Ghana has had a negative impact on income from agriculture. They estimate an agricultural production function and analyze the effect of mining on the residuals of productivity, which is shown to correspond to an 18 percent increase in rural poverty. The empirical strategy relies on geo-referenced data on the location of mines and satellite imagery to measure air pollution (nitrogen dioxide).

Indirect effects have been documented through productivity and health using a difference in difference strategy, with additional variation in exposure from seasonal wind patterns, Hanna and Oliva (2015) examine the effect of a decrease in pollution resulting from the closure of a refinery in Mexico City. They find that a one percent decrease in sulphur dioxide concentrations increased labor supply by 0.61 hours per week. They present suggestive evidence that the effects are driven by child health, which affects parental labor supply. Pitt, Rosenzweig, and Hassan (2012) find evidence that arsenic exposure lowers cognition and results in lower schooling attainment using biological measures of arsenic (i.e., toenail clippings) and variation associated with genetic predisposition to store arsenic in the body. Kremer et al. (2011) also measure the effect of pollution on productivity in their study of springs in Kenya and find that improvements to water did not increase school attendance among primary-school children. Taken as a whole, these papers indicate that the health burden of air and water pollution in developing countries is substantial and that the productivity and income effects may also be important.

Greenstone and Jack (2015) observe that here is still a great deal to learn about dose-response functions, the distribution of impacts, and the non-health outcomes. All of these are promising areas for future research, with the greatest contribution likely to come from studies that go beyond quantifying the health impacts to investigate both economic consequences and underlying mechanisms.

Exposure to environmental pollutants increases risks for heart, respiratory and kidney disease. For example, low levels of environmental lead exposure accelerate progressive renal insufficiency in patients with chronic kidney disease (Lin et al. 2006), and environmental lead increases cardiovascular mortality in the general population (Menke et al. 2006). Mercury from industrial activity has been linked to kidney disease mortality (Hodgson et al. 2007). Arsenic in drinking water increases mortality from cardiovascular and kidney disease (Meliker et al. 2007). Cadmium exposure increases risk of renal dysfunction (Nishijo et al. 2006; Noonan et al. 2002). In addition to toxic agents, particulate matter (PM) from fossil fuel combustion increases risks for cardiovascular and respiratory disease morbidity and mortality (Barnett et al. 2006; Miller et al. 2007; Pope et al. 2002; Sarnat et al. 2006; Wellenius et al. 2006).

In a further study on the effects of gold mining on local communities, the World Bank (2015) observed a marginally statistically significant reduction in the prevalence of cough, fever, and diarrhoea. The significant drop in diarrheal incidence of children in mining communities in Mali was taken as a welcome development, since diarrhoea remains a serious threat to children in developing countries, even though it is a disease that is easy to cure and prevent. This reduction was attributed to access to safe water and sanitation which is an important development in fighting diarrheal diseases and could be a way in which a mine affects diarrheal incidence. The results further showed that households in Mali are 6.5 percentage points less likely to spend more than 10 minutes fetching water, although this suggests little about the quality of that water. There was some further evidence that access to a private toilet facility, which might be important to stop the spread of diarrheal diseases, and access to flush toilets, increase in mining communities. The overall results tend to differ from country to country; it is therefore very important to conduct studies focussing on a single country.

4.2.1 Health and Mining

Local communities can be exposed to pollution through a number of channels which include the following: dust from mining, handling and processing; mine waste water, direct exposure to abandoned mine spoils and tailings; metals leached from tailings into soil and water; and particulate gaseous emissions from roasting and smelting. Sometimes the material extracted is itself of concern, such as in copper, lead, uranium and asbestos mining. At other times, pollutants are used in processing, such as in the case of cyanide leaching of gold, or gold and silver extraction by mercury amalgamation. Finally, sometimes the concern is with toxicants co-located with the mineral mined and released either in processing or weathering of mine spoils, such as in the case of heavy metals in non-ferrous metal mining which was the focus of this chapter.

4.2.1.1 Copper mining and human health

There is documented literature that has identified a strong correlation between mining and adverse environmental and health outcomes. Radon daughter exposure in underground mining has for example increased the risk of lung cancer but is now generally controlled by mine ventilation. This is a typical example of the pollution levels from mining.

4.2.1.2 Sulphuric acid and copper mining

The mining industry uses sulphuric acid in the extraction and treatment of copper. The extraction processes are called heap and situ leaching; during these processes, particles react with each other to create acidic mists that not only harm peoples' skin, eyes and lungs, but also destroy crops, deteriorate the quality of the land and damage nearby buildings. The acid dust both smells and tastes bad. An observation from the International Agency for Research on Cancer (IARC) concludes that occupational exposure to strong inorganic mists containing sulphuric acid is carcinogenic for humans. Nevertheless, sulphuric acid is still used with little concern for the people affected through air and water pollution, and the environment and animal life continue to be severely affected by copper extraction in Zambia. This problem led to the suing of one of the mining giants in Zambia in August 2015 by 1,800 local residents from a village who claimed that the mining company was polluting the local waterways and causing catastrophic damage to their health and livelihoods. Furthermore, according to the Blacksmith Institute, an American research centre, industrial waste is yearly produced and dumped in Kafue River. This pollution constitutes a direct and imminent health risk for both human and animal life and could lead to outbreaks of cholera if not halted. Other effects could include chest infections and anaemia in adult women.

Employment in copper mining also increased substantially over this period, despite the relative capital intensity of large-scale copper mining. Wilson (2012) observed that annual employment in copper mining from 1999-2008 increased from 20,000 to 60,000. Employment in copper mining grew by over 180 percent during the copper boom which occurred after the privatization of the copper mines. Notably, the largest increase in employment in copper mining occurred in 2005, the same year in which output at the non-depleting mines increased most rapidly. By the end of the boom, roughly one in five adult males in copper mining cities was employed in copper mining. Similarly, the copper boom after the privatization of the mines was associated with a large increase in aggregate output in Zambia. This increase in copper production could have come at a cost as there is a likely increase in levels of pollution which may lead to increases in the numbers of people suffering from illnesses related to mining.

4.2.1.3 Lead, Copper and Hematologic toxicity

There is a possibility of some traces of lead being found in mining discharges during the copper mining process. The exposure to lead may lead to the depression of haemoglobin levels in blood. This tends to shorten the life spans of the red blood cells and thereby interfering with enzymes that are essential to the synthesis of the heme component in haemoglobin. Grandjean et al (1989) argue that even when lead exposure is too low to reduce the haemoglobin levels in adults, “increased demand in the formation of blood following blood loss could result in delayed blood regeneration in individuals exposed to lead”. In addition, this leads to a decrease in iron absorption, thereby leading to iron-deficiency anaemia. This is mainly as a result of the environmental exposure from the automobile exhaust emitted during the mining process.

In places where there is a presence of copper mining operations, there is likelihood of some traces of lead being found. Copper, just like lead is classified in everyday semantics as a heavy meal and thus linked to characteristics of highly toxic pollutants and most prominently found in sulphide rock. According to Salomons (1995) minerals such as copper when exposed to water and air tend to generate sulphuric acid, which in turn leaches metals from the mines tailings with the resulting acid mine drainage posing severe health and environmental concerns. The leachate from mining complexes and waste rock deposits may drain into nearby aquatic ecosystems. Once in the streams the heavy metals can be transported to considerable distances downstream (Axtmann and Luoma, I991). There are several physical and chemical processes operating in a stream which can give rise, directly or indirectly, to attenuation of pollutants.

4.2.1.4 Other Health hazards of mining

Other metal ores, including those of lead, cadmium, manganese, platinum and cobalt, present health hazards. The risks are usually greatest during metallurgical processing, when air concentrations exceed those experienced during mining of the ore.

The risk of tropical diseases such as malaria and dengue fever is substantial at some remote mining locations. Leptospirosis and ankylostomiasis were common in mines, but eradication of rats and improved sanitation has controlled these hazards effectively in the developed world but may still pose some challenges in the developing world.

Crystalline silica has long been a serious hazard in mining, with the risk of silicosis at its worst during dry drilling late in the nineteenth century. Silicosis has been subject to considerable investigation. Axial water-fed rock drills, wet techniques, ventilation, enclosed cabins and respiratory protection have largely controlled silicosis in developed nations. However, silicosis remains a problem in developing nations and silico-tuberculosis is important in Africa, where the high prevalence of HIV infection among miners increases the risk. Prolonged exposure to crystalline silica can also cause chronic obstructive pulmonary disease. There is some evidence for accelerated silicosis in rheumatoid arthritis and of renal disease following prolonged silica exposure. There is also now good evidence that prolonged exposure to crystalline silica increases the risk of lung cancer. In addition, Arsenic is sometimes a contaminant of metal ores and has been commercially extracted during copper smelting with an accompanying risk of lung cancer.

Exposure to the dust of copper acetate has been previously observed to produce sneezing, coughing, digestive disorders and fever. Metal workers exposed to complex copper slats in dust form have in the past been reported to have complained of metallic taste with irritation of nasal and oral mucosa; atrophic changes in mucous membranes were noted in subjects exposed for long periods of time. On ingestion, copper salts act as irritants and cause nausia, vommitting, abdominal pain, hemorragic gastritis and diarrhoea. Copper salts splashed in the eyes cause conjictivitis, cornealulceration and turbidity and may produce palpebral edema. Copper slats embedded in the eye result in pronounced foreign-body reaction with characterristic discoloration of ocular tissue. Although copper is an essential element for health, excessive amounts can produce harmful effects.

4.3. Data

4.3.1 Socio-economic and health data

The socio-economic and health data for this chapter are obtained from the Living Conditions and Monitoring Surveys (LCMS) from Zambia available at the time of writing this chapter. The number of households and individuals captured differs in each survey year. Due to the unavailability of panel data on socio-economic and health data in Zambia, the obtained data was aggregated at constituency level to form a panel dataset. This helped to capture the same constituencies' health outcomes for all the survey years.

The LCMS data has some notable strengths: it covers a very broad range of households and individuals; surveys have been conducted for nearly 15 years; individual surveys are fairly comparable and there is strong data on the specific health outcomes such as chest infections and anaemia. In addition, the data also captures the socioeconomic status and provides information on health outcomes. These currently make the LCMS an obvious choice to study health and development at a micro level in a single country.

However, the data also has some important limitations with implications for my work. Firstly, there is inadequate information on wages and expenditures on health. I therefore discuss employment in passing in order to cover for wages. Secondly, because the surveys have kept changing and improving, very few indicators of relevance for this study were collected in the surveys. Indeed, working with the largest set of observations for which all indicators are available is impractical because the number of observations is very small. Finally, the data are cross-sectional and compared by years. Unlike other studies that have constructed pooled cross-section pseudo panels, this strategy is avoided in this chapter as the data was not collected from the same individuals in all the survey years. A balance is thus struck by instead resorting to aggregating the data at constituency level as earlier stated.

The detailed data on health from all the households surveyed was obtained from the LCMS. The core indicators are the proportion of the population that suffered from any chest infections which include tuberculosis. In addition to the core outcomes, data is collected on a range of health outcomes, employment and occupation. The range of health outcomes includes the proportion of the population that suffered from anaemia and diarrhoea in each constituency. The proportion of the population that suffered from any other general illnesses which represent levels of poor health outcomes is also taken into consideration.

4.3.2 Mining data

Information on the location and characteristics of mine and mineral production was drawn from three main data sources for. These include data collected from the mine annual reports, the Ministry of Mines and Minerals Development and Westmetall. In total, all the 10 large copper mines were observed in the cross-section. All the mines are located in the north-western part of Zambia. Even though issues may be raised on selection bias, this is not a limitation for this study as copper mining in Zambia is concentrated in the north-western part of the country which is largely endowed with copper deposits as all the 10 mines were taken into account.

Table 4.1- Summary Statistics for Health Outcomes

Variables	Mean N=750	Standard Error
Household head		
% of literate household heads	81.22	10.91
Average age	42.12	3.15
% of female headed households	20.13	9.17
Household		
% of the population that had chest infections	17.5	0.8
% of the population that had diarrhea	39.03	19.77
% of the population that had anemia	4.322	2.09
% of population that were generally sick	60.84	20.08
% of population with access to electricity	35	1
% of population with access to clean water	77.2	0.6
Number of household members	5.4	0.03
Mining data		
Per capita Copper production	3881.33	7314.50
% of population living close to the mines	26.67	44.25

Constituency data		
Distance to nearest mine(km)	419	12.2
Population	81350	3003.6
Observations (Constituencies)	150	

4.3.2 Summary Statistics

Table 4.1 reports the summary statistics with column 1 showing the mean values of each variable for the whole sample while column 2 reports the corresponding standard errors.

The variables are reported in different categories, firstly at household head level. Secondly, there is a focus on the average outcomes at household level. The third category reports statistics from the mining data and lastly statistics on constituency data are presented. The number of observations in this case (which represents the constituencies is 150). A striking feature to note from the summary statistics of the per capita mine level copper output is that the mean in this case seems to be much lower that the corresponding standard error. This unique result could be attributed to the manner in which the copper output is assigned to each constituency. The assignment of copper output values in this case is based on the distance between a constituency and a mine. Constituencies located within a distance of 200km to the nearest mine are in this case taken to be close to a mine while those farther than 200km to the nearest mine are regarded as being far away from mining operations and therefore considered as having no mine presence. With this assumption as borrowed from previous literature, it is imperative to only assign copper output values to constituencies considered as having a mine presence while those with no mine presence are assigned a zero copper output value. Further summary statistics for all the data can be found in the appendix.

Overall, the summary statistics indicate two main points. Firstly, some constituencies faced higher percentages of general sickness leading to a higher mean, while there was generally lower prevalence of anemia which has also been observed in the regression estimations. Secondly, diarrhea cases seem to also be on a higher side. The results section further provides formal regressions tests on the relationship between health outcomes and copper output during the survey period.

4.4. Econometric Specification

Coming back to the research question, it is at least plausibly the case that the copper wealth accruing to a constituency is not entirely a gift of nature but rather amenable to change based on public policies—affecting industrialization, human capital formation, and the like—it remains to consider a strategy that can connect this insight to an examination of impact of the extraction of this wealth on health outcomes. The basic question that frames this discussion—does natural resource wealth tend to promote poor health outcomes? —is quite simple. But successive efforts to examine the question empirically, and the prevailing dissensus that appears in the literature, make clear that adequately specifying and examining this relationship is anything but simple. As much as it is common practice to find the probabilities of an outcome in health economics, making it necessary to use probability models, this may not be possible with this study. This is because probability models require the use of binary data and in our case the unit of analysis, which is the constituency cannot provide that binary data. It would have been possible to make use of a probit model if the unit of analysis was either the household or individual. As such, this chapter makes use of the 2SLS IV model with the international copper price being used an instrumental variable.[51]

4.4.1 Baseline model

In the baseline investigation of health impacts, there was no distinction between different types of mines. As such the main concern was with the health consequences of environmental contamination with heavy metals, precisely, copper and traces of lead that may be found in the mining operation process.

The baseline model (the Structural Equation) is as follows.

[51] Not being able to use a probability model is one of the major limitations of this chapter.

$$\boldsymbol{ln}(\boldsymbol{y}_{c,t}) = \boldsymbol{\alpha}_c + \boldsymbol{\beta}_t + \boldsymbol{\beta}_1 \boldsymbol{lnM}_{c,t} + \boldsymbol{\beta}_2 \boldsymbol{X}_{c,t} + \boldsymbol{\varepsilon}_{c,t} \quad \textbf{(4.1)}$$

Where $\boldsymbol{ln}(\boldsymbol{y}_{c,t})$ denotes the natural logarithm of constituency *c* health outcomes at year t (for example, ln of the proportion of the population that suffer from general sicknesses, anaemia, chest infections and diarrhoea), $\boldsymbol{lnM}_{c,t}$ represents the natural log of the effect of per capita mine level copper output on health outcomes in constituency *c* at time t, $\boldsymbol{X}_{c,t}$ is a vector of exogenously determined constituency *c* characteristics that vary over time such as population density at time t, $\boldsymbol{\alpha}_c$ is a constituency fixed effect, $\boldsymbol{\beta}_t$ is a year fixed effect.[52] All fixed effects are missing in the estimation results presented further as they are removed routinely with the Two-Stage Least Squares Fixed Effects (2SLS FE) estimation in STATA statistical software. Finally, $\boldsymbol{\varepsilon}_{ct}$ denotes the error term for constituency *c* at time *t*. The functional form chosen to be the full elasticity model in order to make the data observations smooth and additionally mitigate any potential problem of heteroscedasticity in the data, furthermore the full elasticity model has a very useful feature of interpreting the causal relationship in terms of the 1 percentage change leading to the $\boldsymbol{\beta}_1$ percentage change ceteris paribus.

By removing fixed cross-country differences from the estimation of the effect of human capital or industrialization on copper output, I avoid the problem of correlation of the copper production with underlying physical copper endowments and other country-level characteristics (for example, geology, climate, and copper ore deposits and quality, inter alia). In all my specifications, I employ constituency fixed effects. The principal reason is that one should take into account the inherent characteristics of the constituencies that do not change over time. In addition to that, the research concentrates on the in-country variations, rather than taking into account different countries is related to the following. The claims of the resource-curse literature are about changes in health outcomes that are driven by changes in natural resource output at the constituency level. Relying on cross-national variation (which is typically much larger than within-country variation) to assess the thesis

[52] Per capita mine level copper output was used as proxy for pollution due to the unavailability of data on pollution.

would be exceedingly indirect, and critically misspecified if the health outcome-relevant (static or slow-moving) cross-national differences are not all correctly modelled. There is a wide agreement on such a specification in recent work—strong supporters and opponents of the resource curse thesis alike have come to focus on within-country temporal variation.[53]

The estimation approach used is the Two-Stage Least Squares with fixed effects for panel data. The reason for using the 2SLS, as usual in many empirical studies (Card (1995), Caselli and Michaels (2013), Monteiro and Ferraz (2012), or Arceo-Gomez et al (2015)), is a potential problem of endogeneity. Therefore, the first stage regression model (or a Reduced Form equation) is as follows:

$$lnM_{c,t} = \gamma_c + \tau_t + \delta lnIntCP_{t-1} + \beta_2 X_{c,t} + u_{c,t} \quad \textbf{(4.2)}$$

Where $lnIntCP_{t-1}$ is the natural log of the international copper price in period *t-1*. $X_{c,t}$ denotes a vector of all the exogenous explanatory (control) variables in the second stage for constituency *c* at time *t*, while $u_{c,t}$ is the error term for constituency *c* at time *t*.

I define exposure to mining as being geographically close to a mine. This choice is immediate for the study of economic impacts. Previous studies e.g. Goltz and Barnwal (2014) have used distances of between 40-200km, using similar distances in this study takes into account the effects of the use of water that has been polluted by mine discharges into the nearby rivers, mostly the Kafue river and the air pollution (WHO, 1999).[54] I select the distance of 200km to the nearest mine in order to take into consideration the effects of the pollutants from the mines that are located in the rural areas (away from residential housing), yet discharge their waste effluents into the water deposits that are used to supply water to residents in nearby constituencies. It can therefore be argued that the use of such a range of distance is reasonable as it will enable me to effectively study the impact of mining on health.

[53] See Andersen and Ross 2014; and Haber and Menaldo 2011, respectively.

[54] Disease outbreaks such as cholera which killed close to 500 people on the Copperbelt town of Kitwe in 1992 have previously been linked to the pollution of the mines.

Shorter distances such as those employed by Goltz and Barnwal (2014) may not be able to adequately capture all the affected constituencies.

The per capita mine level copper output represents the output of the mine assigned for the nearest constituency (located within 200km). While the output for constituencies located further than 200km away was assigned to be zero for all years. Extracting minerals from the ground, breaking them up, and processing them generates a flow of pollution. At the same time though, the stock of tailings dumped after processing will in many cases continue to pollute. This will, therefore, have an impact on the health of people living around the vicinity of a mine or a mine dumpsite (WHO, 1999).[55] It is therefore more plausible to go up to a distance of 200km because the effects of pollution as reported in past literature may extend to such distances, as the pollution may spread over a 200km radius.

The controls always include some appropriate socio-economic measures such as the age of the respondent or the household head. As a result of the LCMS being repeated cross-sections (CSO, 2010), my model allows for repeated measurements of effects near the same mine, while accounting for year-specific and constituency effects in each round of measurements. I account for the residual serial correlation by clustering errors at the constituency level and using the Robust Standard Errors for estimates at both stages.

Identifying assumptions would be violated if mining constituencies differed from neighboring communities in geography, institutions or other characteristics in ways that correlate with potential outcomes. However, differences would have to arise even compared to locations very close by, because I restrict the “control” locations to those more than 200km away from the nearest mine, despite that we control for that using the constituency fixed effects so that should not be a problem in our estimations. Identification is also only affected by such differences if they are not in some way due to the presence of the mine in a long-run equilibrium. For instance, infrastructure is likely to be affected by mining. Companies may build railroads; mining consumes water and may make mining communities water scarce. Similarly, mining might have some impacts-

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[55] Mines in most cases dump their waste from extraction or processing of copper very near their operating site.

whether good or bad-on local governance and public goods. Yet, this does not affect the validity of my reduced-form estimates. Rather, it requires me to show further evidence before I make claims about the mechanisms-crucially pollution-by which mines affect local communities.

4.4.2 Empirical Strategy – Two Stage Least Squares (2SLS)

OLS estimates are the workhouse of empirical research. Researchers see a number of advantages in these estimations. Most notably under certain simple assumptions, they are BLUE (best linear unbiased estimators) or at least the most efficient estimators (see Wooldridge 2016, p. 90). OLS are easy to implement and the results they generate are easy to replicate. Another appealing feature of OLS estimates is that they easily accommodate the inclusion of individual (i.e. time, household, and constituency) idiosyncratic effects. Despite their popularity, however, OLS estimations are weak in dealing with the problems of endogeneity. The major sources of such problems identified from theory are simultaneity (e.g. reverse causality), omitted variable bias and measurement error (see Wooldridge, 2016, 405-437; or 2008: 506-536), (e.g. errors in variables). A look at the previous literature on natural resources (such as Caselli and Michaels (2013), Monteiro and Ferraz (2012), or Arceo-Gomez et al (2015)) provides an indication that could inform us about the inherent possible sources of such endogeneity.

To resolve this problem, following the most influential papers of the field (Caselli and Michaels (2013), Monteiro and Ferraz (2012) and Arceo-Gomez et al (2015) and well-established books on econometrics (e.g. Wooldridge 2016) the use of IV-type estimators in this chapter is proposed. This approach handles the endogeneity bias that may arise through the following vehicle.

It is commonplace in the resource curse literature to view natural resources as more or less fixed and exogenously-given endowment – or “manna from heaven” (Dunning, 2008). Some constituencies are assumed to have natural capital in abundance, and others not. I seek to join a small but important literature that challenges this conventional understanding by recognizing that there may be a critical endogeneity in the development of natural resource wealth that serves to deepen the differences between the positive and negative resource-induced equilibria (e.g., David and Wright 1997; Stijns 2006). Rather than being a 'gift of nature' from which states obtain substantial revenue, effective resource endowments may be endogenous to the technology used to detect and extract them. Only copper that is both discovered and extracted can become a developmental resource, and both conditions are heavily shaped by the technology of exploitation that is available and locally employed. Such technology, in turn, should be related to domestic industrial capacity and human capital investments in the country. Domestic human capital thus should be associated with a higher likelihood of identifying natural resource endowments and employing them in economically developmental ways.

To give a particular example, the copper mine production can have a direct impact on the health of the individuals living nearby through pollution of various sorts, what was explained in the previous chapters, while at the same time, bad health consequences can have negative impact on the further development of the mines, since, for example, some staff employed at these mines might consider it to be unbearable for them and/or their families to continue their presence around a polluting mine, and vice versa. Through such channel, the further expansion of mine production can be deteriorated, even to the extent of contraction or seizure. This can be especially significant if those individuals are valuable decision makers, or higher or medium level professionals.

Thus, adoption of the 2SLS FE estimation is justified by the current trend in the related literature and proposed direct vehicle, bringing endogeneity of the main explanatory variable determination. The Fixed Effects estimation method is useful to incorporate and use the properties of the panel data, having two "dimensions": cross-sectional and time. Thus, by using the within estimation the endogeneity coming from correlation of the individual time-invariant characteristics of the constituencies with one or more explanatory variables is avoided. For example, it is impossible to imagine that such characteristic as the geographical distance from the copper deposits must be correlated with the access to clean water, population density, or even government spending.

The second channel of endogeneity that can be related to the current study is an omitted variable bias, which is possible in this case as the model may not be able to adequately control for the inherent variations at the lower administrative levels of the mines, related to the cultural dimension (such as at ward level and other cultural patterns). That can be correlated to the production levels of the mines and, thus, could seemingly pose empirical challenges. Instrumental variables may help to overcome such bias. The argument, in this case, is that the previous periods' international copper prices are correlated with the per capita mine level copper output but not correlated to any mine management problems. δ in equation (2) represents the per capita mine level copper output response to exogenous international copper price changes.

The final source of endogeneity that the IV instrumental variable helps us mitigate here is the error-in-variables bias. In case if there are any potential errors in the way the data on the mine production levels are collected then our estimation approach in this chapter should be able to handle it as well as the two biases explained above. The assumption that the IV variable – international copper prices – is uncorrelated with any type of error, makes sense since the errors in data should, most probably, come from the subnational level (CSO, 2010), while the international prices are determined on the international market as a result of the aggregate demand and supply for copper. Thus, the use of the international copper price as an instrument for the per capita mine level copper output is supported as the way to avoid a potential omitted variable bias; as the past prices are likely to later culminate into an increase in copper production, and, furthermore, be related to the health outcomes only through the per capita mine level copper output.

From the above, it is not difficult to see a potential limitation of the current estimation approach. Any IV estimation is not without a bias in estimates to a certain degree. According to Wooldridge (2016) in small samples, a FE IV estimator can have a substantial bias that is why the large samples are preferred. In our case, the sample reaches 750 observations, which can be considered large enough and similar to the empirical studies carried out in the area of my research *(Dube ad Vargas, (2013), Lippert, 2014 and Aragon and Rud, (2013)).*

4.4.3 The Examination of Instrumental Variable

I take as given that copper wealth is at least in part related to industrial strategy and human capital formation, which can themselves be connected to health outcomes, as an ample body of research suggests. But this raises the possibility of a potential (at least indirect) endogeneity between the health outcomes and the actual level of copper output. If good higher wages lead to better health outcomes, ceteris paribus, and this, in turn, helps make copper mining more viable, then standard treatments of the relationship between copper wealth and health outcomes are potentially biased. I take two strategies to examine this potential endogeneity, with an eye to producing a more appropriate estimate of the actual effect of copper wealth on health outcomes.

My main strategy for examining the causal linkage between natural resources (copper output) and the health outcomes net of the effect of endogeneity in this relationship is to employ an instrumental variable to purge the copper output measure of its endogenous component. Of course, such strategies can themselves cause difficulties if the quality of the instrument is not high. In this case, my instrument for per capita mine level copper output, as earlier stated, is the natural log of the international copper price. The instrument needs to be exogenous—that is, have an effect on health outcomes that operates only through its association with mine level copper output per capita. Although it is comforting that my instrument is not correlated with the outcome at a bivariate level, exogeneity is itself essentially a theoretical matter—a claim about the exclusivity of the pathway of the effect of the instrumental variable.

The principal issue is whether I would have reason to believe that international copper price is itself associated with other causal pathways leading to health outcomes. There are good reasons to think not. First, the international copper price has not been commonly theoretically identified in any of the voluminous literature on resource curse itself. This literature has focused almost entirely on income or exports, not the prices. Moreover, there is no theoretical reason to believe that international copper price would have any connection either to health outcomes or to any of the commonly identified correlates or causes of poor health outcomes. Another way is to account for the possibility of copper entering into the prices of all electrical medical equipment and computers. Meaning that higher international copper prices might be correlated with the health outcomes but very little, like in the case of the sample used for this study. Even the literature on country-size effects focuses on population, not geographic area.

If the claims of resource-curse scholars are accurate, then higher levels of copper output should be associated with changes in the health outcomes in a more positive direction, regardless of the starting point.

There may be possible issues with the health expenditure in each constituency. This is not likely to cause any omitted variable bias as health expenditures allocated to government health facilities are not dependent on whether a constituency has any mining operations in place or not. Instead, government budgetary allocations to each constituency are centrally distributed by the Ministry of health on the basis of the size and number of health facilities in an area. In addition, some mining companies also run their own health facilities which are not funded by the government.

4.4.4 Examination of the Identification Problems

In order to have the 2SLS FE model be properly identified, one must make sure that the following 2 conditions are satisfied:

1) Order Condition;
2) Rank Condition.

The first condition for the identification of the model is easy to check. It is necessary, although not sufficient. It states that we need at least as many excluded exogenous variables as there are included endogenous explanatory variables in the structural equation (Wooldridge 2016, p.479). In our case, the model is *just identified*. That is, there is one exogenous variable per one endogenous variable.

The second condition is more difficult to prove. Although it is sufficient for the identification. We omit using matrix algebra here for simplicity and reading easiness. To put it simply, it states that the IV should be sufficiently linearly related with the variable that we are using the IV for, and at the same time not correlated with the possible omitted variable, the way the error in variable is present, and should be related to the dependent variable (health outcomes) only through the proposed channel.

The restriction is guaranteed to be valid by the external determination of the international copper price, specifically by the global market institutions such as the London Metal Exchange (LME). This means that the price $\boldsymbol{lnIntCP_{t-1}}$ is exogenous to the analysis. When changes to the copper prices due to demand and supply factors take place at the global market level, this may lead to an increase in the international copper price. This increase is likely to boost copper production by the mining firms. This boost may be because of an increase in wages and other incentives such as production bonuses from the profits. This motivates the workers to increase their productive capacity ultimately leading to an increase in mine level copper output. This increase in the levels of production may lead to high levels of pollution, which is a negative externality to the local economies. Since this is a negative externality, it is hypothesised to lead to poor health outcomes especially for populations living very close to the mines. The coefficient estimate in the reduced form equation is expected to be positive, and negative in the structural equation. This expectation is supported by the mainstream publications described in the Literature Review.

In terms of the variables, this theoretical vehicle translates into $\boldsymbol{lnIntCP_{t-1}}$, having a significant impact on $\boldsymbol{lnM_{c,t}}$, and that $\boldsymbol{lnIntCP_{t-1}}$ not generating any direct effect on health outcomes. The validity of this assumption is supported by the first stage regression results which show that the international copper price coefficient has the positive sign and is statistically significant (the first stage regression coefficient and its significance is reported in the results section below). The statistical significance also important to support the correlation coefficient in the proof that the instrument used is not weak.

In addition, a special control variable, government funding, is used to help to solve the problem of omitted variable bias. The argument is that the government spending, which may directly affect health outcomes, in this case, may not necessarily be determined by mining activities. A higher international copper price may increase government revenues ultimately leading to increased revenues which the government can spend on improved health facilities, drugs, infrastructure, more and better-paid health workers and medical machinery. This is the most effective way of the poor benefiting from the copper mining as decisions on the allocation of funding towards health expenditures is determined at national level. Even though it has been previously observed that the management of such funds is quite ineffective and is made and decided centrally through an annual budgetary allocation (EAZ, 2011).[56] The analysis thus controls for government spending (at constituency level) to solve the earlier stated problem of omitted variable bias. Government funding is a key control variable as there is a possibility that this in some cases may influence health outcomes at constituency level especially if the allocation is made according to the contribution of mining revenues to public funds. In the case of Zambia, as earlier highlighted, the allocation of funds to health facilities is not dependent on the presence of a mine near or in a constituency. This simply means that there is no favourable treatment for constituencies with a mine presence. Furthermore, mining companies also run their own health facilities which at times are self-funding and get extra income or funding from the respective mining companies that run them. In short, these are more or less like departments under different mining companies.

In the case of Zambia, constituencies with mineral deposits are not evenly distributed; they are mainly in the north-western part of the country. This simply means that constituencies with copper deposits are systematically different from other Zambian constituencies. This may lead to potential biases if revenues from the mines were directly accruing to individual constituencies. But, in Zambia, revenues are collected centrally and decisions on expenditures are made by the central government through the national budget. Most of the results are thus later replicated with alternative samples as part of the robustness checks. The sample is separated by distance, which groups the constituencies into those located close to and far away from the mines. The sample is also divided into rural and urban constituencies. Findings from both these classifications show a non-sensitivity to sample selection.

The main empirical specification thus employs a panel IV strategy, described by equations (1) and (2). Panel 2 of each table shows the statistical essence of the first stage regressions used in this work. The F-statistics are greater than 10 for all samples confirming that there is no evidence of the weak instrument problem. This satisfies the rule of thumb stated by Cameron and Trivedi (2010).

Finally, there is a possible concern related to the potential endogeneity of $\boldsymbol{InIntCP}$. It may be argued that mining companies can try to influence the copper price in order to influence the copper output, I believe that this is possibly highly unlikely to affect this study as Zambia does not account for a very large proportion of the global copper output.

Although the specification is presented in two stages, the estimation is always undertaken via a one-step procedure. The main specification uses 2SLS FE estimation following the approach of Chistaensen, Demery and Kühl (2011) and Heady (2014) who added fixed effects to their welfare regressions. Adding the constituency trend effects is potentially important because changes in health outcomes could be correlated with other unobserved health outcome relevant trends.

Finally, the results tables in the next section provide additional diagnostic tests' p-values for the instrument used in the First-Stage regression. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null hypothesis of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null hypothesis that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid. In all regression estimations, we do not find any evidence with the problems related to under-identification or presence of weak instruments. In addition to that, the possibility of multicollinearity is taken into account. The sample size in this case was large enough to make sure that multicollinearity does not bring any problems to the estimation.

4.4.5 Analysis of the residuals

It is important to control for several issues related to the residuals of the regression. The first one is the normality of the residuals. This is routinely tested after each regression. In all estimations the residuals are non-normal, so we rely on the asymptotic distribution of the estimators. The sample size is considered to be large enough (max 750 and min 165 observations) for the Law of Large Numbers and Central Limit Theorem to work, suggesting that all estimators should have the statistical distribution required for the correct inference.

The next two issues we routinely control for are the heteroscedasticity and serial correlation in the residuals. It is clear that the two problems do not bring bias to our estimation but can affect the inference through wrongly estimated Standard Errors of the coefficients (e.g. Wooldridge 2016). For each estimation, the Robust Standard Errors and their clustering based on the constituency are employed. The two solutions allow us to obtain efficient and unbiased estimates of the Standard Errors, making the inference correct. To support that, Baltagi (2008) argues that there is a likely violation of the assumption of serially uncorrelated disturbances resulting from the dynamic effect of shocks to the dependent variable over several periods of time. Moreover, Wooldridge (2002) argues that clustering the standard errors at department level leads to standard errors that are completely robust to any kind of serial correlation and heteroscedasticity.

Finally, one should pay attention to the stationarity of the series included in the regression. In case if the variables included have unit-root, then one may fall into a problem of a spurious regression, i.e. finding a relationship somewhere, where such relationship does not exist (e.g. such relationship can be through having similar time trends, see Wooldridge 2016 pp 510-512). Thus, before having estimations done, the Augmented Dickey-Fuller test for panel data is routinely employed in STATA, which showed no evidence of having a unit root in any of the variables employed in the regression, implying no possibility of spurious regression.

4.5. Main Results

This section provides evidence that the expansion (or presence) of mining activities is associated with a significant adverse effect on health outcomes. These health outcomes represent the proportion of those that have been suffering from each health outcome in each constituency over the survey period. The results were tested against different samples and showed at least qualitative robustness. While unable to measure mining-related pollution directly, I use copper production levels for people living close to the mines to show that pollution concentrates around mining areas.

4.5.1 Effect of copper production on Health Outcomes

Table 4.2 presents the main results. In column 1, I explore the relationship between living close to a mine and general sickness using the pooled Ordinary Least Squares (pooled OLS) method. I note that this relationship is negative and insignificant with the result changing with the use of the 2SLS FE with international copper price as an IV. This is as expected due to the bias that is highly likely to be present in the pooled OLS estimation for panel data because of not exploiting the benefits of such type of data (time and cross section dimensions) and not controlling for the time-invariant effects present for each constituency (what is done for each 2SLS FE estimation). As well as not controlling for the time effects that changed over time but are attributable to all constituencies and mines (e.g. changes in governmental policies). This common structure of the regressions is present for all the estimations shown below. Thus, the following commentaries concentrate mostly on the causal relationship between log of per capita copper output and the log of the health outcome.

Table 4.2 Effect of Ln(Copper Output) on Ln(General sickness)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.076***
	(0.019)
Household size	0.018
	(0.334)
Average age of household heads	-0.113
	(0.449)
Population density	-0.211
	(0.135)
Female headed households	-0.006
	(0.014)
Access to clean water	-0.001
	(0.002)
Distance	
Government Spending	0.000001
	(0.000001)
R-squared	0.218
Observations	750
Panel 2-First Sage	
Instrumental Variable	
International Copper Price	*2.750****
	(0.468)
F-statistic	*34.47****
P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*

Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significance at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification.
The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which
are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous
regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

The result from the Table 4.2 above shows, at first glance, the surprising decrease in general sickness associated with the growth of the production of copper. From the estimated coefficients it is clear that holding other factors fixed, one percent increase in copper production leads to the 0.076% decrease in the population with general sickness in an average constituency. That supports the claim stated before, suggesting that the increase in copper production may lead to the provision of better infrastructure, whose effect on the constituencies' habitants goes in the opposite direction with the usual negative impact on the them through the depreciation of the environment around.

Similar results are also obtained for anaemia and in Table 4.3, where the 2SLS FE estimation shows a statistically significant reduction in presence of anaemia. Thus, holding other factors fixed, a percentage increase in per capita mine level copper output leads to a 0.167 per cent decline in the proportion of the population that suffers from anaemia. This result is also not consistent with mining affecting specific health outcomes through pollution. This may be attributed to better employment possibilities, what makes people being able to afford food that may help improve their red blood cells levels. However, one should note that the effect is very small, and combined with statistical significance, it seems that the positive effect of infrastructure for both, general sickness and anaemia, in particular, is stronger than the negative externality expected, but only marginally.

The estimators for the other variables are not statistically different from zero, except for the government spending in Table 4.3 and 4.4. The coefficients are weak statistically and very small, suggesting that the effect is trivial and negligible in this case, what undermines the possible influence of the positive effect of governmental investment in public goods. It may rather be private investments that we do not and cannot account for in this study due to the availability of the data of that sort.

Table 4.3 Effect of Ln(Copper Output) on Ln(Anaemia)

Second Stage Estimation	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.167***
	(0.036)
Household size	-0.113
	(0.695)
Average age of household heads	-0.385
	(0.839)
Population density	-0.447
	(0.252)
Female headed households	-0.020
	(0.029)
Access to clean water	-0.002
	(0.004)
Distance	
Government Spending	0.000003**
	(0.000001)
R-squared	0.421
No of Observations	750
First Stage Estimation	
Instrumental Variable	
International Copper Price	*2.750****
	(0.468)
F-statistic	*34.47****
P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*

Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significance at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Second part of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

According to the estimation, the additional percent of production of copper on average results in 0.076 percent decrease in general sickness of the constituencies' inhabitants, ceteris paribus. On the other hand, as it can be observed in tables 4.3 and 4.4, the ceteris paribus effect of a slight increase in copper production is, as expected a priori, on average increase the chest infections and diarrheal cases ceteris paribus. The magnitude of the coefficients seems to be similar to the coefficient of interest in Table 4.2 (0.088% and 0.079% respectively).

Table 4.4 Effect of Ln(Copper Output) on Ln(chest infections)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Per capita mine level copper output	0.088***
	(0.023)
Household size	0.417
	(0.523)
Average age of household heads	-0.293
	(0.458)
Population density	0.158
	(0.151)
Female headed households	0.020
	(0.021)
Access to clean water	-0.002
	(0.002)
Distance	
Government Spending	-0.000001*
	(0.000001)
R-squared	0.642
Observations	750
Panel 2- First Sage	
Instrumental Variable	
International Copper Price	*2.746****
	(0.468)
F-statistic	*34.47****
P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*

Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significance at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

Table 4.5 Effect of Ln(Copper Output) on Ln(Diarrhoea)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Per capita mine level copper output	0.079***
	(0.021)
Household size	0.501
	(0.434)
Average age of household heads	-0.404
	(0.502)
Population density	0.161
	(0.148)
Female headed households	0.020
	(0.020)
Access to clean water	0.001
	(0.003)
Distance	
Government Spending	-0.000001
	(0.000001)
R-squared	0.482
Observations	750
Panel 2- First Sage	
Instrumental Variable	
International Copper Price	*2.756****
	(0.469)
F-statistic	*34.53****
P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*

Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significance at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

4.5.2 Effects of copper mining on health by mine type

In tables 4.6, 4.7, 4.8 and 4.9, I look at the effect that the mine type has on specific health outcomes. This basically analyses the effect that open pit mines and underground mines have on health outcomes respectively. Both mine types have their individual consequences with higher risks of chest infections expected in constituencies close to underground mines due to effects of dust that is released underground during the mining of the copper ore from the ground. Both types of mines are likely to be releasing effluents into the nearby rivers as well as sulphuric acid during the copper processing phase.

In respect to the results, it can be seen that after the partition done the results are similar in magnitude and sign to the results from a pooled sample presented above (Tables 4.6-4.9). Thus, the estimations show that one per cent increase in per capita copper production on average decrease the general sickness cases by 0.098% ceteris paribus for the underground subsample. The estimations on the open pit subsample show statistically significant estimates neither in Table 4.6 nor in the rest of estimations (Tables 4.6-4.9).

This could be attributed again to the fact that developing of a mine requires the appropriate infrastructure to be built around, increasing the level of life for inhabitants, while the open pit type of mines does not require such infrastructure. These improvements generally lead to better health facilities provided by the mining companies and the ability to afford a better lifestyle due to the increase in employment levels by the mines during the study period which may have culminated into higher wages and thereby improved living standards as observed in chapter one of this thesis. This is supported by the World Bank (2015) in their study on the local effects of gold mining. They observed that Higher income could improve household health by reducing the disease environment through making it possible for the household to buy better-quality housing with proper sanitation and clean water. Higher incomes can also directly buy better health care. This evidence further lends support to the results being significantly different between underground mines and open pit mines. In the case of Zambia, research by labour experts has proved that underground workers tend to get higher wages than open pit workers, so their health may be generally better as they can afford to consume more healthy food and also maintain a better and healthier lifestyle. The wages in underground mining tend to be higher due to the greater risk. In addition, some of the underground work is subcontracted to other firms like Atlas Copco and Sandvik that seem to pay their workers higher wages than what is paid out for example currently by most mining companies that originate in China. This is due to the fact that Chinese firms are globally known to use cheap labour in comparison to western firms whose countries of origin have a minimum wage law which requires decent wages to be paid to all employees. In A report for the Human Rights Watch (2011), Matt Wells observed that even though there has been substantial investment and job creation by Chinese-run copper mines, workers suffer from abusive employment conditions that fail to meet domestic and international standards and fall short of practices among copper mining industry elsewhere in Zambia. In addition, miners at several Chinese-run companies reported of poor health and safety standards, including poor ventilation that can lead to serious lung diseases, hours of work in excess of Zambian law, the failure to replace workers' protective equipment that is damaged while at work, and the threat of being fired should workers refuse to work in unsafe places. In general, injuries and negative health consequences are not uncommon.

However, one should take into account the asymmetric usage of different types of mines. Due to concentrating on Zambia only, the sample consists of only those mines that are present in the country. Thus, as the underground mining is more popular in the country, there are more underground mines present in the sample. While partitioning of the sample by the mine type can be interesting from policy maker's perspective, it produces not comparable results. There are only 165 constituencies that lie geographically close to the open pit mines, what restricts the degrees of freedom and available information for producing robust estimation results, implying that the cause of the insignificance of estimates (including the coefficient of interest) can also be due to the lack of observations apart from the case that open pit mines have no statistical effect on the health outcomes of the nearest constituencies. This is also supported by the dropping of the significance of the instrument

(F-stat) in the first stage regression estimation results. A similar situation can be seen in all regressions on the partitioned sample, that is considered as a limitation of the current research and discussed more in the limitation section below.

Table 4.6 Effect of Ln(Copper Output) on Ln(General sickness) by Mine Type

Panel 1-Second Sage		
Independent Variables	2SLS FE (1)	2SLS FE (2)
Per capita mine level copper output	-0.052	-0.098***
	(0.035)	(0.019)
Household size	0.207	-0.131
	(1.116)	(0.261)
Average age of household heads	0.029	0.382
	(0.879)	(0.306)
Population density	-0.272	-0.183
	(0.449)	(0.096)
Female headed households	-0.002	0.004
	(0.058)	(0.011)
Access to clean water	-0.003	-0.001
	(0.004)	(0.001)
Government Funding	0.000001	-0.000001***
	(0.0000001)	(0.0000001)
Mine Type	***Open pit***	***Underground***
R-squared	0.048	0.032
Observations	165	585
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*3.824***	*2.206****
	(0.1785)	*(0.240)*
F-statistic	*4.59***	*84.73****
P-Value	*0.040*	*0.000*
Kleibergen Papp	*0.040*	*0.000*
Anderson Rubin	*0.006*	*0.000*

Stock Wright	*0.003*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Similarly, in table 4.7, it can be observed that open pit mining does not have any significant effect on chest infections while underground mining has a significant effect on chest infections with a percentage increase in per capita mine level copper output leading to 0.136 percentage increase in the proportion of population that suffers from chest infections such as tuberculosis.

On the other hand, Table 4.8 shows that underground mining has a negative and significant effect on anaemia with anaemia cases reducing on average by -0.225 per cent for a per cent increase in per capita copper production holding everything else fixed. Results from Table 4.9 propose that a 1 per cent increase in copper production led to an average 0.088 per cent increase in diarrhoea cases, ceteris paribus.

Table 4.7 Effect of Ln(Copper Output) on Ln(chest infections) by Mine Type

Panel 1-Second Sage	Chest Infections	Chest Infections
Independent Variables	2SLS FE	2SLS FE
	(1)	(2)
Per capita mine level copper output	0.010	0.136***
	(0.041)	(0.026)
Household size	1.151	0.491
	(0.818)	(0.475)
Average age of household heads	-0.351	-1.193
	(0.602)	(0.611)
Population density	0.386	0.107
	(0.383)	(0.137)
Female headed households	0.018	0.006
	(0.035)	(0.020)
Access to clean water	-0.001	-0.001
	(0.002)	(0.002)
Government Funding	-0.000001	0.000001**
	(0.00001)	(0.000001)
Mine Type	***Open pit***	***Underground***
R-squared	0.170	0.126
Observations	165	585
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*3.824***	*2.206****
	(0.1785)	*(0.240)*
F-statistic	*4.59***	*84.73****
P-Value	*0.040*	*0.000*
Kleibergen Papp	*0.040*	*0.000*
Anderson Rubin	*0.003*	*0.000*

Stock Wright	*0.002*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.8 Effect of Ln(Copper Output) on Ln(Anaemia) by Mine Type

Panel 1-Second Sage	Anaemia	Anaemia
Independent Variables	2SLS FE	2SLS FE
	(1)	(2)
Per capita mine level copper output	-0.087	-0.225***
	(0.054)	(0.036)
Household size	0.063	-0.429
	(1.592)	(0.564)
Average age of household heads	-0.596	0.825
	(1.291)	(0.668)
Population density	-0.791	-0.358*
	(0.769)	(0.150)
Female headed households	0.004	-0.001
	(0.079)	(0.024)
Access to clean water	-0.007	-0.002
	(0.007)	(0.002)
Government Funding	0.000001	-0.000003***
	(0.000001)	(0.000001)
Mine Type	***Open pit***	***Underground***
R-squared	0.170	0.187
Observations	165	585
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*3.824***	*2.206****
	(0.1785)	*(0.240)*
F-statistic	*4.59***	*84.73****
P-Value	*0.040*	*0.000*
Kleibergen Papp	*0.040*	*0.000*
Anderson Rubin	*0.003*	*0.000*

Stock Wright	*0.002*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects.

The full set of control variables includes: constituency level age, average household size and population density. Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.9 Effect of Ln(Copper Output) on Ln(Diarrhoea) by Mine Type

Panel 1-Second Sage	Diarrhoea	Diarrhoea
Independent Variables	2SLS FE (1)	2SLS FE (2)
Per capita mine level copper output	0.072	0.088***
	(0.043)	(0.024)
Household size	0.933	0.417
	(1.347)	(0.395)
Average age of household heads	-0.535	-0.726
	(1.040)	(0.447)
Population density	0.479	0.118
	(0.606)	(0.114)
Female headed households	0.036	0.006
	(0.072)	(0.018)
Access to clean water	0.002	0.001
	(0.004)	(0.003)
Government Funding	-0.000001	0.000002***
	(0.000001)	(0.000001)
Mine Type	***Open pit***	***Underground***
R-squared	0.645	0.056
Observations	165	585
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*3.824***	*2.204****
	(0.1785)	*(0.240)*
F-statistic	*4.59***	*84.83****
P-Value	*0.040*	*0.000*
Kleibergen Papp	*0.040*	*0.000*
Anderson Rubin	*0.000*	*0.000*
Stock Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

4.5.3 Effects of copper mining by Rural/Urban Status

This section analyses the effect of copper mining on health outcomes by rural or urban status. This is an important classification as some mines in Zambia tend to be located nearer to rural areas where there seems to be more open land. In our sample there are mines that are close to both rural and urban areas, thus it is necessary to check if the effect of mines on the constituencies depends on the type of settlement.

Beginning with general sickness (Table 4.10), one can see that in both cases there is a significant positive effect on this health outcome (negative effect on cases of general sickness). The elasticity coefficients of interest are both negative for rural and urban areas (-.155 and -0.043), what is consistent with our previous estimates, but different in magnitude, implying that the effect of copper extraction on the general sickness in the rural areas can be higher than in the urban areas. This, potentially, suggests that the positive externalities through the infrastructure development are more efficient for the rural areas. On the other hand, this reduction could also be attributed to the lower levels of pollution found in rural areas as well as the fresh air that is created as a result of the presence of nature such as trees surrounding the rural areas. Further, both coefficients are statistically significant, and, despite the smaller subsample size for the rural areas (230 vs 520), the per capita copper production coefficient for rural areas has a bit higher T-statistic than a T-statistic for the same coefficient in the second subsample. At the same time, it is important to keep in mind that the effects are still small, less than one per cent decrease in general sickness cases per one per cent increase in the copper production. In addition, the asymmetry of the sample sizes should be mentioned as a limitation of the work. It is present in here for the same reasons that were described in the previous subsection.

Results in column (4) of table 4.11 show similar results and similar magnitude difference is present for the regressions of the anaemia cases. This could be attributed to the type of diet found in rural areas which most of the times seems to be richer in essential nutrients than that found in urban areas. Despite that difference, the effects are also larger in magnitude to the estimates in the previous regression (Table 4.10). Another point that requires attention is the occasional significance of the coefficient on the population density in the 2SLS FE regressions in Tables 4.10-4.11. The coefficients are weakly statistically significant and negative. The potential explanation for that can be that the higher population is correlated with the development of a settlement, thus higher development of infrastructure, what may lead to the better health outcomes. This sentiment is supported by Lippert (2014) who observed that constituencies located close to infrastructure such as transport links are likely to benefit from the linkages with the mining industry.

On the other hand, following the patterns from the previous subsection, the regressions of the other health outcomes show opposite results. The elasticities of chest infections (Table 4.12) are statistically significant in urban areas only; with a percentage increase in copper production leading to 0.145 per cent increase in chest infections on average, ceteris paribus (CP). This result could be attributed to fact that most mine workers (who are likely to be directly exposed to the mining processes) tend to live in urban areas (Fraser and Lungu, 2007). [57] Results in Table 4.13 further show a statistically non-zero increase in diarrheal cases in the urban areas with a percentage increase in copper production leading to a 0.071 per cent increase in the prevalence of the disease (CP), while the effect is even larger in the rural areas, 0.112 per cent (CP). Such difference in the estimates between rural and urban areas could be attributed to the lack of access to safe clean water in rural areas, as well as, to the poor sanitation that may be found in certain parts of the urban areas where people live in slums and may not afford to live in houses with flushable toilets. Access to clean flushable toilets has been previously found to affect the prevalence of diarrhea in developing countries (World Bank, 2015).

[57] Living in urban areas makes it easier to get to work as there is easier access to transport and better roads in urban areas.

Table 4.10: Effect of Ln (Copper output) on ln(General Sicknesses) by Rural/Urban status

Panel 1-Second Sage		
Independent Variables	2SLS FE (1)	2SLS FE (2)
Ln(Per capita mine level copper output)	-0.155**	-0.043**
	(0.049)	(0.016)
Household size	-0.676	-0.028
	(1.036)	(0.280)
Average age of household heads	1.670	0.218
	(1.193)	(0.383)
Population density	-0.688*	-0.029
	(0.323)	(0.105)
Female headed households	-0.027	-0.005
	(0.046)	(0.012)
Access to clean water	-0.007	-0.001
	(0.006)	(0.001)
Government Funding	0.000001	0.000004
	(0.000001)	(0.000001)
Rural/Urban status	***Rural***	***Urban***
R-squared	0.087	0.827
Observations	230	520
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*2.990****	*2.457****
	(0.743)	*(0.571)*
F-statistic	*16.17****	*18.48****
P-Value	*0.000*	*0.000*
Kleibergen Papp	*0.001*	*0.000*
Anderson Rubin	*0.000*	*0.000*

Stock Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.11: Effect of Ln(Copper output) on ln(Anaemia) by Rural/Urban status

Panel 1-Second Sage	Anaemia	Anaemia
Independent Variables	2SLS FE (1)	2SLS FE (2)
Ln(Per capita mine level copper output)	-0.293**	-0.120***
	(0.089)	(0.036)
Household size	-2.402	0.169
	(2.084)	(0.624)
Average age of household heads	3.046	-0.051
	(2.223)	(0.809)
Population density	-1.264*	-0.195*
	(0.549)	(0.252)
Female headed households	-0.101	-0.006
	(0.090)	(0.025)
Access to clean water	-0.016	-0.00005
	(0.011)	(0.003)
Government Funding	0.0000002	0.000002
	(0.000002)	(0.000001)
Rural/Urban status	***Rural***	***Urban***
R-squared	0.161	0.215
Observations	230	520
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*2.299****	*2.457****
	(0.743)	*(0.571)*
F-statistic	*16.17****	*18.48****
P-Value	*0.000*	*0.000*
Kleibergen Papp	*0.000*	*0.000*
Anderson Rubin	*0.000*	*0.000*

Stock Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.12: Effect of Ln(Copper output) on ln(chest infections) by Rural/Urban status

Panel 1-Second Sage	Chest Infections	Chest Infections
Independent Variables	2SLS FE	2SLS FE
	(1)	(2)
Ln(Per capita mine level copper output)	0.018	0.145***
	(0.034)	(0.041)
Household size	1.164	0.009
	(0.719)	(0.803)
Average age of household heads	-1.203	0.703
	(0.833)	(0.796)
Population density	0.116	0.289
	(0.249)	(0.279)
Female headed households	0.045	0.016
	(0.029)	(0.031)
Access to clean water	-0.004	-0.002
	(0.004)	(0.003)
Government Funding	0.000004	-0.000003**
	(0.00001)	(0.000001)
Rural/Urban status	***Rural***	***Urban***
R-squared	0.10	0.193
Observations	230	520
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*2.990****	*2.457****
	(0.743)	*(0.571)*
F-statistic	*16.17****	*18.48****
P-Value	*0.000*	*0.000*
Kleibergen Papp	*0.001*	*0.000*
Anderson Rubin	*0.632*	*0.000*

Stock Wright	*0.519*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.13: Effect of Ln(Copper output) on ln(Diarrhea) by Rural/Urban status

Panel 1-Second Sage	Diarrhoea	Diarrhoea
Independent Variables	2SLS FE (1)	2SLS FE (2)
Ln(Per capita mine level copper output)	0.112**	0.071*
	(0.035)	(0.027)
Household size	0.980	0.465
	(0.705)	(0.526)
Average age of household heads	-1.648	-0.428
	(0.959)	(0.610)
Population density	0.407	0.036
	(0.215)	(0.186)
Female headed households	0.040	0.018
	(0.034)	(0.023)
Access to clean water	0.003	0.001
	(0.005)	(0.003)
Government Funding	0.000004	-0.000002
	(0.000001)	(0.000001)
Rural/Urban status	***Rural***	***Urban***
R-squared	0.753	0.395
Observations	230	520
Panel 2-**First Sage**		
Instrumental Variable		
International Copper Price	*2.990****	*2.472****
	(0.743)	*(0.573)*
F-statistic	*16.17****	*18.58****
P-Value	*0.000*	*0.000*
Kleibergen Papp	*0.001*	*0.000*
Anderson Rubin	*0.000*	*0.000*
Stock Wright	*0.000*	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

4.5.4 Effects of copper mining and real income on health outcomes

In the following Tables 4.14, 4.15, 4.16 and 4.17, I look at the effect that copper mining has on specific health outcomes in relation to the real incomes. In this case; the variable real income represents the average per capita real income in each constituency. This, basically, analyses whether including real incomes to the baseline regressions has any influence on the various health outcomes. Results in the tables listed below lend support to the earlier findings with evidence of reverse causality being exhibited. The instrument-international copper price is still highly valid as observed in panel 2 of all the tables.

Table 4.14 shows similar patterns of elasticity to the per capita copper production that were evident for general sickness in the estimations above. The increase in such production leads to the decrease in the proportion of the population with general sickness on average and ceteris paribus. This improvement in the prevalence of general sicknesses could also be attributed to the quick and efficient response to curb such diseases in mining towns by the mining companies. In most mining companies, there are frequent programs laid down to deal with disease prevention at the community level through environmental health specialists. An example of this is the fumigation that takes place to control the spread of malaria, provision of mosquito nets and at times community health education to teach local communities how to prevent certain diseases. In addition to that, the coefficient of the natural log of the real income is highly significant and negative. Thus, according to the estimation with a one per cent increase in the real income, as expected, the cases of general sickness decrease by 0.147 per cent.

In the case of anaemia, results still show a reduction in the proportion of the population that suffer from anaemia. Even if the magnitudes of the coefficients on the per capita mine level copper output shows a decline, this remains significant. In addition, an increase in real incomes also reduces the proportion of the population that suffered from anaemia during the study period. As for chest infections, the impact of per capita mine level copper output on chest infections is still significant. On the other hand, the real income has an insignificant impact on chest infections.

Slightly unusual and unexpected results are present in Table 4.17. As usual, the increases in copper output seem to increase the prevalence of diarrhoea, however, the increase in real incomes also increases the proportion of the population that are affected by diarrhoea. This could partly be attributed to the fact that the higher incomes are reported in urban areas, where an increase in the population can lead to intense competition for limited good sanitation and clean water. This may, in turn, affect the provision of services and compromise their quality leading to an increase in diseases. Thus, the urban areas in Zambia have a higher prevalence of communicable diseases such as diarrhoea as was the case in the rainy season of 2017-2018 where there was a catastrophic cholera outbreak in mostly urban areas of Zambia such as Lusaka (Sladoje, M, 2018). Another example is the cholera outbreak that affected the mining towns on the Copperbelt after the contamination of their major sources of clean water. This outbreak led to several deaths, especially in Kitwe (WHO, 1999).

The above results validate the earlier findings that only levels of anaemia and general sickness experience an improvement from increases in copper mining. Similar results are observed in tables 4.18 and 4.19 when the measure of wellbeing is changed to poverty. The non-poor show resilience to anaemia and chest infections while the poor are more likely to suffer from such illnesses because of not being able to afford healthy food that can be used to prevent the diseases assessed in this chapter. In the most recent past, there has been a shift in the type of diseases affecting urban wage-earning populations. Diseases such as high blood pressure, arthritis, diabetes and conditions such as stroke and heart problems seem to be more prevalent in urban areas. This is an area for future research.

Table 4.14: Effect of Ln(Copper output) and Ln(Real Incomes) on ln(General Sicknesses)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.061***
	(0.013)
Ln(Real income per capita)	-0.147***
	(0.038)
Household size	0.091
	(0.251)
Average age of household heads	-0.074
	(0.362)
Population density	-0.117
	(0.113)
Female headed households	-0.0002
	(0.012)
Access to clean water	-0.001
	(0.002)
Distance	
Government Spending	0.000001
	(0.000003)
R-squared	0.467
Observations	750
Panel 2-First Sage	
Instrumental Variable	
International Copper Price	*3.367****
	(0.479)
F-statistic	*49.42****

P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

Table 4.15: Effect of Ln(Copper output) and Ln(Real Incomes) on ln(Anaemia)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.139***
	(0.026)
Ln(Real Income per capita)	-0.281***
	(0.078)
Household size	-0.015
	(0.567)
Average age of household heads	-0.268
	(0.688)
Population density	-0.257
	(0.215)
Female headed households	-0.011
	(0.025)
Access to clean water	-0.002
	(0.004)
Distance	
Government Spending	0.000001
	(0.000001)
R-squared	0.883
Observations	750
Panel 2-First Sage	
Instrumental Variable	
International Copper Price	*3.367****
	(0.479)
F-statistic	*49.42****
P-Value	*0.000*

Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density. Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.16: Effect of Ln(Copper output) and Ln(Real Incomes) on ln(chest infections)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	0.080***
	(0.018)
Ln(Real Income per capita)	0.095
	(0.054)
Household size	0.477
	(0.510)
Average age of household heads	-0.513
	(0.460)
Population density	0.079
	(0.157)
Female headed households	0.019
	(0.021)
Access to clean water	-0.003
	(0.002)
Distance	
Government Spending	-0.000001
	(0.0000005)
R-squared	0.396
Observations	750
Panel 2- First Sage	
Instrumental Variable	
International Copper Price	*3.367****
	(0.479)
F-statistic	*49.42****

P-Value	*0.000*
Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

Table 4.17: Effect of Ln(Copper output) and Ln(Real Incomes) on ln(Diarrhea)

Panel 1-Second Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	0.059***
	(0.016)
Ln(Real Income per capita)	0.137***
	(0.037)
Household size	0.448
	(0.368)
Average age of household heads	-0.595
	(0.433)
Population density	0.066
	(0.128)
Female headed households	0.014
	(0.017)
Access to clean water	0.002
	(0.003)
Distance	
Government Spending	0.0000001
	(0.0000004)
R-squared	0.491
Observations	750
Panel 2- First Sage	
Instrumental Variable	
International Copper Price	*3.373****
	(0.479)
F-statistic	*49.49****
P-Value	*0.000*

Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid.

Table 4.18: Effect of Ln(Copper output) and Poverty(poor) on ln(Anaemia)

Panel 1-First Sage	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	-0.115***
	(0.025)
Non-Poor	-0.653***
	(0.071)
Household size	0.221
	(0.519)
Average age of household heads	-0.651
	(0.561)
Population density	-0.342
	(0.177)
Female headed households	-0.007
	(0.021)
Access to clean water	-0.007
	(0.003)
Distance	
Government Spending	0.0000002***
	(0.0000001)
R-squared	0.547
Observations	750
Panel 2-First Sage	
Instrumental Variable	
International Copper Price	*2.786****
	(0.484)
F-statistic	*33.17****
P-Value	*0.000*

Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.

Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

Table 4.19: Effect of Ln(Copper output) and Poverty(poor) on ln(chest infections)

Panel 1	2SLS FE
Independent Variables	(1)
Ln(Per capita mine level copper output)	0.090***
	(0.024)
Non-Poor	0.0002
	(0.056)
Household size	0.437
	(0.531)
Average age of household heads	-0.299
	(0.462)
Population density	0.157
	(0.152)
Female headed households	0.021
	(0.021)
Access to clean water	-0.002
	(0.002)
Distance	
Government Spending	-0.000001*
	(0.000001)
R-squared	0.660
Observations	750
Panel 2- First Sage	
Instrumental Variable	
International Copper Price	*2.786****
	(0.484)
F-statistic	*33.17****
P-Value	*0.000*

Kleibergen-Paap	*0.000*
Anderson Rubin	*0.000*
Stock-wright	*0.000*

Notes: Robust standard errors in parenthesis. Standard errors are clustered at constituency level. *denotes significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include year and constituency fixed effects. The full set of control variables includes: constituency level age, average household size and population density.
Panel 2 of the table provides diagnostic tests for the IV regression model reported in Table 2. The Kleibergen-Paap is a test of under-identification distributed as chi-square under the null of under-identification. The Anderson Rubin and Stock-Wright LM statistic are weak instrument-robust inference tests, which are distributed as F-test and chi-square respectively, under the null that coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and the over-identifying restrictions are valid

4.6 Conclusion

Chapter 4 examined an important externality that polluting industries may impose on local communities, effects on health outcomes. It finds robust evidence that general health outcomes are better in constituencies located closer to the mining areas relative to areas in the same region but located at a greater distance from mining activities. In addition, general health outcomes became better for people living closer to open pit mines relative to those living in constituencies located closer to underground mines. It also documents a general reduction in anaemia cases for those living close to mines associated with an increase in copper production. The magnitude of these effects is however, specific to the Zambian case and should not be extrapolated to other contexts. Evidence from this chapter conclusively reveals that the real economic benefits generated in mining constituencies go hand in hand with reduced levels of anaemia and general sicknesses. This just shows significant evidence that all change in an economy brings costs and benefits; gainers and losers. But in most cases the national benefit tends to outweigh the costs.

Chapter 5: Conclusion

5.1 Outline

This thesis explores different studies on natural resources and their causal effects on local economies, the impact of divestiture as well as effects of externalities such as pollution in developing economies with special emphasis on country-level studies at a sub-national level. This thesis mainly focuses on three main areas of development economics: natural resources and their effects on local economies (chapter 2), divestiture in the mining sector and local economies (chapter 3) and finally, copper mining and local economies health outcomes. The conclusion of the thesis provides in detail the contribution of each chapter and consequently outlines the limitations, main implications and prospects of future research in this dissertation.

5.2 Contribution of each empirical chapter

In summary, the most important contribution this thesis makes is to the already existing literature on natural resources and local economies by focusing on the sub-national level. This fills the existing gap in literature where most studies on natural resources are at a cross-country level by providing detailed analyses on the mechanisms of how natural resources impact the economy within a single country. The use of a novel dataset which was specifically constructed for the research work in this thesis also enlists as a contribution made by the thesis. This data is mainly drawn from the Living Conditions and Monitoring Surveys (LCMS) in Zambia. The methodological approach used throughout the work can contribute to the number of publications that used international prices as an instrument allowing to control for potential reverse causality.

In addition, the thesis sheds light on the extent to which divestiture influences socio-economic outcomes. In this way, it makes a contribution towards the literature that examines historic periods that saw some structural changes, for example, through Structural Adjustment Programs (SAP) and to the few empirical studies at the post-privatization level. It is done by using an identification strategy that enables the comparison of the effect of the copper production on living standards in constituencies before and after privatization.

A contribution is made to the rare literature in developing countries on mining and health by presenting a micro-level data study of the comparative health effects of an important industry in a single developing country. This can be counted as a part of the growing body of literature on the effects of externalities of mining such as pollution, specifically to the literature on mining in developing countries and its effects on health outcomes. Especially, since the active literature on the health effects of pollution has been using developed countries' data (Greenstone and Jack, 2015).

5.3 Limitations

The availability of natural resources in developing countries has often been viewed as a 'divine curse' in the natural resource curse literature. However, this endowment is seen as providing bright hopes for a better lifestyle for the poor. This has at times provided both formal and informal employment, industrialization in some countries, as well as huge revenues for the government. Using socio-economic data in Zambia, this thesis explored whether there are any benefits accruing to the local communities. In chapter two (2), it explored whether copper mining is able to improve living standards in local communities. The LCMS data was merged with mining data enabling a highly localized analysis of the effects of the changes (particularly) increases in copper output or a resource boom on living standards. A 2SLS FE instrumental variables technique (or strategy) was used to assess these living standards.

The results show that truly increases in mine level copper output provide opportunities to better living standards. Even though it may be expected that the direct employment from the mines may lead to improved living standards, this may not have been the case from Zambia. Yet there may still be indirect ways in which real incomes in constituencies located close to the mines may be increased. This can be looked at as the secondary benefits of the resource boom. We also see a reduction in overall poverty levels, particularly a reduction in the proportion of the extremely poor people as well as an increase in the proportion of the nonpoor. Rural populations also seem to have benefited from the increase in the copper output; through probably their interactions with urban areas by supplying them with food from their agricultural produce. These effects of the resource boom are not systematically in line with employment. The insignificant effect of mine level copper output on employment just shows evidence of the effects the privatization of the copper mines.[58]

In chapter three (3), the aspects of privatization are included into the analysis. The privatization of the SOEs in Zambia which led to the privatization of the mines modestly changes the results in the preceding chapter. In this case the mine level coper output exhibits signs of weak significance implying that the privatization of the copper mines changes the economic relationship between the mining industry and living standards. Leading to a huge number of retrenchments especially with the mines being more capital intensive after privatization (Fraser and Lungu, 2007). This simply put, gives an indication that copper mining is a boom-bust economy and may be greatly affected by any changes whether upward or downward.

The results from chapters 2 and 3 are robust to some checks, such as separating the sample into urban and rural constituencies and using additional control variables. The results are therefore quantitatively important. We also observe that the reopening of two mines- Kansanshi and Lumwana mines led to the rise in the number of males employed in the mining sector. This rise though did not match with earlier figures when the mines were still state run. This makes it necessary to further assess the impact of the privatization of the copper mines had on living standards in constituencies with copper mining concentrations- this is discussed in chapter 3.

Though the results are not consistent with the 'natural resource curse hypothesis', they seem to be in line with within-country studies conducted on other developing countries like Brazil were Caselli and Michaels (2014) found a negative relationship between natural resource endowments and poor socio-economic outcomes.[59] The observations made by the duo show that municipalities tend to economically benefit from the oil production especially when they are located close to oil fields. Whether local communities have been hugely

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[58] Privatization of the copper mines is analyzed in detail in chapter three of this thesis

[59] Most natural resource curse literature focuses on cross-country studies as presented in the literature review.

benefited from Zambias' resource boom is a conclusion that can only be fully concluded through a full welfare analysis. This analysis would involve even direct links to the mines such as corporate social responsibility from the mining companies. Moreover, future analysis must seek to assess and compare what is happening across the mines through probably using data from natural experiments rather than observational data.

The question on whether local communities are negatively affected by the production of natural resources is not new to economic and medical research. To our knowledge this is one of the few papers that have assessed the impact of negative externalities from the mining industry such as pollution on health outcomes such as chest infections, anaemia and diarrhoea in mining vicinities of a developing country. This chapter explored the link between Zambias' mining industry and health outcomes. The question is of interest in this context as Zambia is an important mining country. Firstly, the countrys' economic mainstay is largely dependent on copper mining and the mining industry changed hands from being state-run to being run by private investors.[60] Most previous studies have seemed to focus on developed countries, and therefore not informative regarding the relationship between mining and health outcomes in developing countries.

This chapter explored the causal link between health outcomes and mining using different classifications of health outcomes such as anaemia, chest infections, diarrhoea and general sicknesses using an instrumental variables approach. With this strategy, this chapter explored how pollution affects the health of the populations living near the copper mines. To overcome concerns regarding reverse causality, were pollution levels increase because of increased copper production, mine level copper output was instrumented with the international copper price. In this chapter, the focus was restricted to specific health outcomes that seem to be directly related to the pollution in the mining industry: chest infections, diarrhoea, anaemia and general sickness.

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[60] Most economic activities in the north-western part of Zambia where all the large copper mining operations take place are largely dependent on the mines; that is the goods and services industry all dependent on the mining industry. This is the reason why CSO (2010) documents an increase in poverty levels after the privatization of the mines on the Copperbelt.

In line with conclusions drawn from previous literature, we find an overall negative and significant relationship between copper mining and health outcomes such as chest infections and diarrhoea. On the other hand, there seems to exist contrasting results from anaemia and general sickness. The prevalence of anaemia and general sicknesses significantly decreased by around 0.167 percent and 0.076 percent respectively per 1 percent increase in the levels of pollution ceteris paribus. However, the analysis shows that the populations living close to underground mines may be at a higher risk of suffering from chest infections when the levels of copper output increase. This indicates that the negative relationship that we see between underground mining and health outcomes especially chest infections could be driven by positive shocks on health outcomes that increased copper output could have.

Such an effect could be explained through an income opportunity channel for the mining companies and inadequate environmental regulation by the government. In the analysis, the two channels are further explored. When incomes from mining increase for the mining companies, this is likely to culminate into an increase in real incomes for the population living close to the mines. Findings show supportive evidence that increasing mine level copper output expands the mining sector leading to a possible increase in real incomes. This leads to higher levels of pollution and a substitution of incomes from being spent on other things such as savings with expenditures going more towards maintaining healthy lifestyles. This is in line with Goltz and Barnwal 92014) that health and wealth are interrelated. Results show that the prevalence of general sicknesses decreases by 0.147 percent with a 1 percent increase in real incomes ceteris paribus. The percentage for the prevalence anaemia seems to even be slightly higher at 0.281 percent.

Despite the overall negative relationship between mining and health outcomes, particularly chest infections and diarrhoea, it is important to highlight two caveats. First, in line with previous literature, it can be noted that there is a negative relationship between copper mining and some of the health outcomes (chest infections and diarrhoea). This is supported by evidence from Mali where health outcomes were affected by pollution (World Bank, 2015). Secondly, the dynamic relationship between health outcomes and copper mining needs further analysis as stated in the limitations of this research. Mining could lead to increased levels of pollution especially if there is no total enforcement of environmental regulations, which could result into an unhealthy population and thus lead to lower production in an economy. In the case copper mining in Zambia, it might be expected that the mining sector may cause increased levels of pollution as they are privately run and therefore not obligated to be stewards of public goods.

Another limitation one might notice is that it considers only the within-country data and data on copper production only. The results of this research can be only attributed to Zambia, what limits the generalisation of the results to this country only. Any generalisation to the other countries, even similar in size, the population should be done with caution, especially if they have different natural resources type of industry.

Limitations from the methodological side. The methodological approach used throughout the research tackles many problems of endogeneity, e.g. heterogeneity coming from the constituencies or potential reverse causality. However, usage of an Instrumental Variable is not without its flaws. Any IV estimation is not without a bias in estimates to a certain degree. According to Wooldridge (2016) in small samples, an FE IV estimator can have a substantial bias that is why the large samples are preferred. In our case, the sample reaches 750 observations, which can be considered large enough and similar to the empirical studies carried out in the area of my research. Despite the sample size, the results should be used with care. Furthermore, no regression model exists that has no omitted variable bias; I tried to minimize the probability of it, though, via usage of an IV and an extensive set of controls.

On the same side of IV problems lies the fact that only one variable is used as an instrument, what really limits the possibility of assessing its statistical properties, validity and strength. No overidentification tests could be done with only one instrument. The choice of more instruments can be a part of future research, however the theoretical belief that International Copper Prices are directly correlated with the copper output has a strong base of economic classic theory underneath (higher prices leading to higher production in the next period as Zambia can be considered as price taker for its small percentage in the world copper production).

Another methodological limitation is that while its commonplace for any health study to analyse the probabilities of suffering from certain health problems, this has not been possible in this thesis. This could be largely attributed to the fact that probability models require the use of binary variable. In the case of the data used in this thesis, this data is not binary and therefore makes it difficult to use probability models such as the Probit Instrumental Variable model.

Finally, no dynamic relationship between two periods of the dependent variables is taken into account. The strength of the intertemporal relationship is different depending on the variable of course. For example, for the real income, it can be strong, but the health outcomes can be much less dependent on the past. This can be an important limitation of the work; however, the nature of the data is such that the observations have several years between them. The gaps suggest that the intertemporal link in observations must be fading and become weaker. Thus, the current research should be treated with care. Despite that, it certainly has a potential for the future research.

5.4 Implications of research

This section emphasizes the potential policy implications. The first empirical chapter (chapter 2) provides evidence that the natural resource curse may not exist in all countries. It is therefore important, as suggested, to use the correct and most suitable policies for each economy. Some of the key policy implications of this chapter suggest that the mining industry is important to the local communities not only through government revenues but also through income increases. This, however, became the case only after privatization, implying that, from one point of view, more and more governmentally owned businesses, at least in natural resources sphere, should be privatized.

It is also equally important to plan for Zambia’s future economic development. Information gathered from this research as well as the findings can help the government formulate policies that could improve the countrys’ export diversification as well as incorporating the private sector into future economic plans and their implementation. Export diversification programs can include those meant at developing and growing the agricultural sector into a modern sector with more commercial farmers. These farmers can be supported through provision of inputs and support towards exporting their produce such as reduced taxes. In addition, the government with its cooperating partners and other stake holders such as the private sector can liase on how to translate macroeconomic prosperity into improvements in the livelihoods of ordinary citizens. This can be done by encouraging the opening up of new manufacturing industries that would be supported and protected by the government. Support can include facilitation of finance and making sure this is readily available to local and indigenous companies. It could also include raising import duties in order to protect local products.

On the other hand, from the perspective of employment and poverty levels, the results showed actual increases in extreme poverty population, suggesting that the real income rises may happen not due to increases of the poor people's incomes, but through further rises in the income of the rich. The history of the initial layoffs (which were later compensated) though, the way the privatization process was handled seems to have exacerbated the adjustment costs of the structural reform. Thus, the implementation of additional policies to redistribute some of the gains of privatization from winners to losers may both mitigate the negative effects on living standards and the economy.

Lastly, the findings in chapter 4 have an important implication for environmental and industrial policies. The levels of general sickness seem to go down with increases in copper production, suggesting the fact that the income effect is stronger here. Higher levels of the income allow people to have better access to health protection. Privatization, leading to the introduction of better technology and investments into new facilities by the new owners generally benefited the health conditions. This also adds to the justification of privatization. The health problems in urban constituencies seem to rather suggest that policy-makers should draw their attention to the traditional urban air and water pollution. This, however, requires further research.

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Appendices

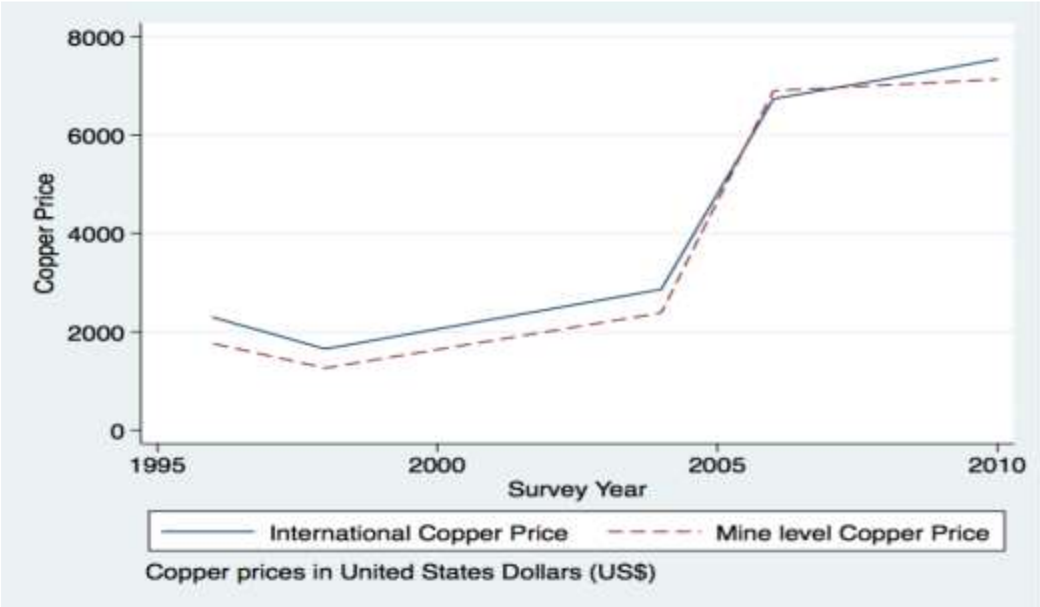

Figure A1: Figure showing the movement of the international and mine level copper prices

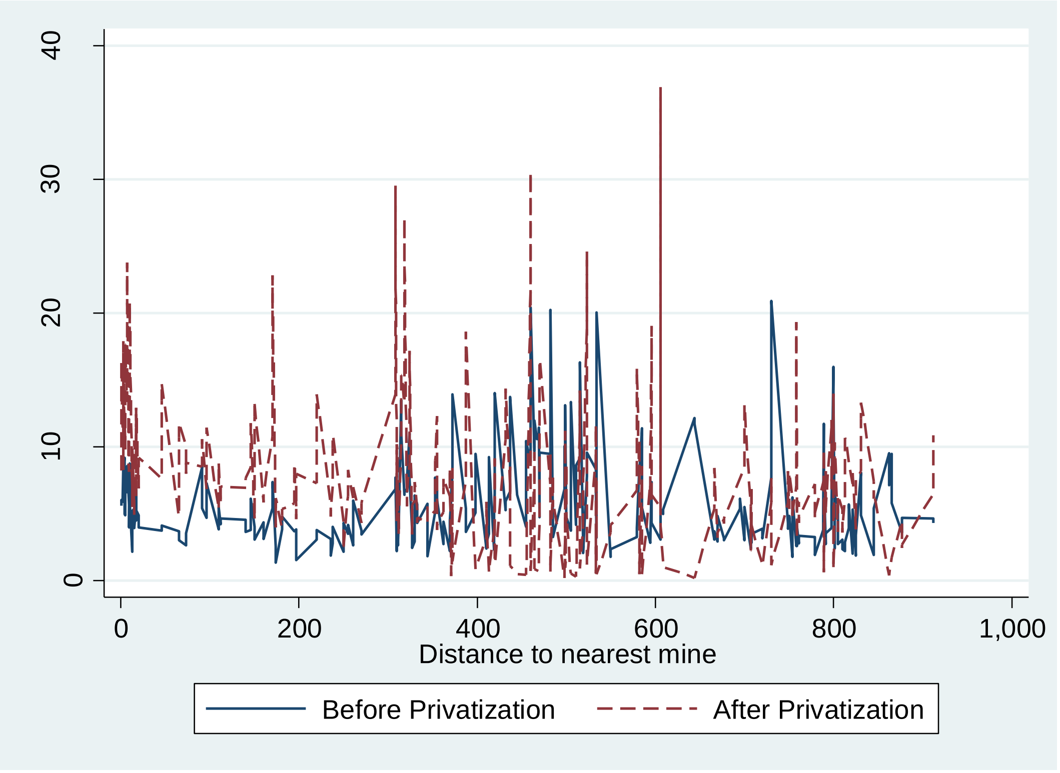

Figure A2: Figure showing the conditional mean on real incomes by distance

<u>Table A1</u>: Summary statistics for all Variables

Variable		Mean	Std. Dev.	Min	Max	Observations
Per capita mine level Copper Output	overall	3881.328	7314.503	0.000007	72046.24	N = 750
	between		4217.147	416.976	27774.29	n = 150
	within		5984.364	-23893	48153.28	T = 5
Average Household size	overall	5.5192	0.799569	3.5	10	N = 750
	between		0.4609	4.56	6.86	n = 150
	within		0.654229	3.4992	8.7992	T = 5
Average age of household heads	overall	42.118	3.147251	25	60	N = 750
	between		2.047821	36.4	48.4	n = 150
	within		2.39458	24.918	55.918	T = 5
Percentage of the Educated	overall	81.22667	10.91449	6	99	N = 750
	between		10.49235	42.4	98.6	n = 150
	within		3.102348	14.4267	99.42667	T = 5
International Copper Price	overall	4216.058	2428.808	1653.71	7538.37	N = 750
	between		0	4216.06	4216.058	n = 150
	within		2428.808	1653.71	7538.37	T = 5
Percentage of Ultra Poverty in the population	overall	43.30693	20.90831	1	93	N = 750
	between		14.64383	6.4	78.4	n = 150
	within		14.96198	-1.0931	87.50693	T = 5
Percentage of Moderate Poverty in the population	overall	17.5348	8.365731	1	70	N = 750
	between		4.448822	7.8	36.6	n = 150
	within		7.092188	-2.2652	57.7348	T = 5
Percentage of Total Poverty in the population	overall	60.84173	20.08347	5	100	N = 750
	between		15.08666	18.4	86.2	n = 150
	within		13.30241	20.6417	103.2417	T = 5
Percentage of Non-poor in the population	overall	39.0316	19.77129	0	95	N = 750

	between		14.95769	13.8	81.6	n =	150
	within		12.97559	0.6316	74.8316	T =	5
Total Copper output	overall	493266.8	144384.6	110	756000	N =	750
	between		6530.176	413822	493800	n =	150
	within		144237.6	79554.8	835444.8	T =	5
Distance to the nearest mine	overall	414.1773	273.3563	1	912	N =	750
	between		274.0882	1	912	n =	150
	within		0.718997	409.777	431.7773	T =	5
Mine level copper output	overall	14498.24	42817.93	0	280000	N =	750
	between		38955.65	0.008	196458	n =	150
	within		17998.25	-57162	173961.6	T =	5
Mine level copper price	overall	699.7896	1910.297	0	10827.26	N =	750
	between		1515.656	0.008	4187	n =	150
	within		1168.029	-2835.5	7991.766	T =	5
Employment	overall	6.896973	20.21385	0.01	90	N =	750
	between		19.75734	0.01	83.8	n =	150
	within		4.509098	-15.903	50.09697	T =	5
Population	overall	74442.41	60757.56	17923	1204763	N =	750
	between		45098.27	19797.6	340907.2	n =	150
	within		40847.13	-161357	938298.2	T =	5
Percentage of females in the population	overall	20.1296	9.167127	6	43	N =	750
	between		8.343716	8	33.2	n =	150
	within		3.845829	7.9296	36.9296	T =	5
Access to electricity	overall	31.8848	22.14232	2.3	96.7	N =	750
	between		21.66984	4.78	94.02	n =	150
	within		4.817467	15.8448	64.9448	T =	5
Access to clean water	overall	76.82947	13.4786	1.1	99	N =	750

	between		10.76455	61.1	96.16	n = 150
	within		8.149604	8.44947	101.3495	T = 5
Total Income	overall	636377.7	723480.5	24792.8	6398164	N = 703
	between		384994	140006	2602895	n = 149
	within		613960.9	-2E+06	4431647	T-bar = 4.71812
Poverty line	overall	80685.16	41064.34	28979	146009	N = 749
	between		1331.639	64463.1	80772.26	n = 150
	within		41047.11	28891.9	145921.9	T = 4.99333
Real Incomes	overall	7.278747	5.512812	0.1698	43.82034	N = 703
	between		3.540572	2.69628	24.60459	n = 149
	within		4.186005	-10.811	33.21592	T-bar = 4.71812
Anaemia	overall	4.322827	2.093303	0.1	9.3	N = 750
	between		1.466888	0.64	7.84	n = 150
	within		1.497214	-0.1172	8.742827	T = 5
Chest infections	overall	0.175348	0.083657	0.01	0.7	N = 750
	between		0.044488	0.078	0.366	n = 150
	within		0.070922	-0.0227	0.577348	T = 5
Diarrhoea	overall	0.390316	0.197713	0	0.95	N = 750
	between		0.149577	0.138	0.816	n = 150
	within		0.129756	0.00632	0.748316	T = 5
General sickness	overall	0.6084173	0.200835	0.05	1	N = 750
	between		0.150867	0.184	0.862	n = 150
	within		0.133024	0.20642	1.032417	T = 5
Percentage of males in the population	overall	0.798704	0.091671	0.57	0.94	N = 750
	between		0.083437	0.668	0.92	n = 150
	within		0.038458	0.6307	0.920704	T = 5
Population density	overall	230.0932	806.4204	1.96504	7092.704	N = 750
	between		787.9067	2.20125	5131.724	n = 150

	within		181.1968	-1092.3	2855.443	T =	5
Female-headed households	overall	111.7836	55.26185	25.2	344.4	N =	750
	between		48.87698	38.56	204.44	n =	150
	within		26.03212	20.5036	252.2036	T =	5
International Copper Price *Privatization	overall	6.385863	3.552817	0	8.927761	N =	750
	between		0.545405	5.14042	6.687974	n =	150
	within		3.510931	-0.3021	10.17321	T =	5

<u>Table A2</u>: Summary statistics for all Variables for 1996

Variable		Mean	Standard Deviation	Min	Max	Observations
Average household size	overall	6.228667	0.90282	4.2	10	N = 150
	between		0.90282	4.2	10	n = 150
	within		0	6.228667	6.22867	T = 1
Average age of household heads	overall	42.14133	4.26234	25	60	N = 150
	between		4.26234	25	60	n = 150
	within		0	42.14133	42.1413	T = 1
Percentage of the Educated	overall	79.46667	12.3395	6	98	N = 150
	between		12.3395	6	98	n = 150
	within		0	79.46667	79.4667	T = 1
International Copper Price	overall	2293.39	0	2293.39	2293.39	N = 150
	between		0	2293.39	2293.39	n = 150
	within		0	2293.39	2293.39	T = 1
Percentage of Ultra Poverty in the Population	overall	49.10667	19.9718	4	90	N = 150
	between		19.9718	4	90	n = 150
	within		0	49.10667	49.1067	T = 1
Percentage of Moderate Poverty in the Population	overall	15.99333	6.26217	1	33	N = 150
	between		6.26217	1	33	n = 150
	within		0	15.99333	15.9933	T = 1
Percentage of Total Poverty in the Population	overall	65.1	18.4725	14	97	N = 150
	between		18.4725	14	97	n = 150
	within		0	65.1	65.1	T = 1
Percentage of Non-poor in the Population	overall	34.96667	18.4301	3	86	N = 150
	between		18.4301	3	86	n = 150
	within		0	34.96667	34.9667	T = 1

Total Copper Output	overall	397334.1	32650.9	110	400000	N =	150
	between		32650.9	110	400000	n =	150
	within		0	397334.1	397334	T =	1
Distance to the nearest mine	overall	414.2947	274.107	1	912	N =	150
	between		274.107	1	912	n =	150
	within		0	414.2947	414.295	T =	1
Mine level copper output	overall	12234.68	43950.2	0.01	280000	N =	150
	between		43950.2	0.01	280000	n =	150
	within		0	12234.68	12234.7	T =	1
Mine level Copper Price	overall	317.0419	788.45	0.01	2285	N =	150
	between		788.45	0.01	2285	n =	150
	within		0	317.0419	317.042	T =	1
Employment	overall	6.805	21.3366	0.01	90	N =	150
	between		21.3366	0.01	90	n =	150
	within		0	6.805	6.805	T =	1
Population	overall	62206.39	32193.1	17923	206477	N =	150
	between		32193.1	17923	206477	n =	150
	within		0	62206.39	62206.4	T =	1
Percentage of females in the population	overall	19.80333	10.3695	7	43	N =	150
	between		10.3695	7	43	n =	150
	within		0	19.80333	19.8033	T =	1
Access to electricity	overall	27.24333	21.6052	2.3	90.5	N =	150
	between		21.6052	2.3	90.5	n =	150
	within		0	27.24333	27.2433	T =	1
Access to clean water	overall	75.50933	11.5221	60	99	N =	150
	between		11.5221	60	99	n =	150
	within		0	75.50933	75.5093	T =	1
Total Income	overall	146223	83232.8	38175.44	462760	N =	149

	between		83232.8	38175.44	462760	n =	149
	within		0	146223	146223	T =	1
Real income	overall	5.045825	2.87218	1.317348	15.9688	N =	149
	between		2.87218	1.317348	15.9688	n =	149
	within		0	5.045825	5.04583	T =	1
Government funding	overall	2200	0	2200	2200	N =	150
	between		0	2200	2200	n =	150
	within		0	2200	2200	T =	1
Anaemia	overall	4.868	2.02529	0.1	9	N =	150
	between		2.02529	0.1	9	n =	150
	within		0	4.868	4.868	T =	1
Chest Infections	overall	0.1599333	0.06262	0.01	0.33	N =	150
	between		0.06262	0.01	0.33	n =	150
	within		0	0.1599333	0.15993	T =	1
Diarrhoea	overall	0.3496667	0.1843	0.03	0.86	N =	150
	between		0.1843	0.03	0.86	n =	150
	within		0	0.3496667	0.34967	T =	1
General sickness	overall	0.651	0.18472	0.14	0.97	N =	150
	between		0.18472	0.14	0.97	n =	150
	within		0	0.651	0.651	T =	1
Population density	overall	188.2988	625.329	1.97E+00	4017.06	N =	150
	between		625.329	1.97E+00	4017.06	n =	150
	within		0	188.2988	188.299	T =	1
Per capita mine level Copper Output	overall	1332.68	2052.97	1.10E-07	11143.7	N =	150
	between		2052.97	1.10E-07	11143.7	n =	150
	within		0	1332.68	1332.68	T =	1

Table A3: Summary statistics for all Variables for 1998

Variable		Mean	Standard Deviation	Min	Max	Observations	
Average household size	overall	5.47267	0.9111	3.5	9.8	N =	150
	between		0.9111	3.5	9.8	n =	150
	within		0	5.47267	5.4727	T =	1
Average age of household heads	overall	42.4087	3.7643	30	56	N =	150
	between		3.7643	30	56	n =	150
	within		0	42.4087	42.409	T =	1
Percentage of the Educated	overall	80.4533	10.681	42	98	N =	150
	between		10.681	42	98	n =	150
	within		0	80.4533	80.453	T =	1
International Copper Price	overall	1653.71	0	1653.71	1653.7	N =	150
	between		0	1653.71	1653.7	n =	150
	within		0	1653.71	1653.7	T =	1
Percentage of Ultra Poverty in the Population	overall	52.42	17.933	2	93	N =	150
	between		17.933	2	93	n =	150
	within		0	52.42	52.42	T =	1
Percentage of Moderate Poverty in the Population	overall	14.2933	5.3137	3	33	N =	150
	between		5.3137	3	33	n =	150
	within		0	14.2933	14.293	T =	1
Percentage of Total Poverty in the	overall	66.7133	16.081	15	100	N =	150
Population	between		16.081	15	100	n =	150
	within		0	66.7133	66.713	T =	1
Percentage of Non-poor in the Population	overall	33.3	16.055	0	85	N =	150
	between		16.055	0	85	n =	150
	within		0	33.3	33.3	T =	1
Total Copper Output	overall	347000	0	347000	347000	N =	150
	between		0	347000	347000	n =	150

	within		0	347000	347000	T =	1
Distance to the nearest mine	overall	414.148	274.08	1	912	N =	150
	between		274.08	1	912	n =	150
	within		0	414.148	414.15	T =	1
Mine level copper output	overall	9772.92	32619	0	196000	N =	150
	between		32619	0	196000	n =	150
	within		0	9772.92	9772.9	T =	1
Mine level Copper Price	overall	227.875	566.71	0	1650	N =	150
	between		566.71	0	1650	n =	150
	within		0	227.875	227.88	T =	1
Employment	overall	6.56827	20.382	0.01	85	N =	150
	between		20.382	0.01	85	n =	150
	within		0	6.56827	6.5683	T =	1
Population	overall	63939.4	33067	18428	212299	N =	150
	between		33067	18428	212299	n =	150
	within		0	63939.4	63939	T =	1
Percentage of females in the population	overall	18.9633	8.7826	6	35	N =	150
	between		8.7826	6	35	n =	150
	within		0	18.9633	18.963	T =	1
Access to electricity	overall	28.6073	21.435	3.5	93.5	N =	150
	between		21.435	3.5	93.5	n =	150
	within		0	28.6073	28.607	T =	1
Access to clean water	overall	74.71	10.402	58.3	96.3	N =	150
	between		10.402	58.3	96.3	n =	150
	within		0	74.71	74.71	T =	1
Total Income	overall	289045	180142	63273.9	987029	N =	149
	between		180142	63273.9	987029	n =	149
	within		0	289045	289045	T =	1

Real income	overall	6.12553	3.8176	1.34092	20.917	N =	149
	between		3.8176	1.34092	20.917	n =	149
	within		0	6.12553	6.1255	T =	1
Government funding	overall	4350	0	4350	4350	N =	150
	between		0	4350	4350	n =	150
	within		0	4350	4350	T =	1
Anaemia	overall	5.242	1.7933	0.2	9.3	N =	150
	between		1.7933	0.2	9.3	n =	150
	within		0	5.242	5.242	T =	1
Chest Infections	overall	0.14293	0.0531	0.03	0.33	N =	150
	between		0.0531	0.03	0.33	n =	150
	within		0	0.14293	0.1429	T =	1
Diarrhoea	overall	0.333	0.1606	0.00E+00	0.85	N =	150
	between		0.1606	0.00E+00	0.85	n =	150
	within		0	0.333	0.333	T =	1
General sickness	overall	0.66713	0.1608	0.15	1	N =	150
	between		0.1608	0.15	1	n =	150
	within		0	0.66713	0.6671	T =	1
Population density	overall	193.543	642.87	2.06181	4130.3	N =	150
	between		642.87	2.06181	4130.3	n =	150
	within		0	193.543	193.54	T =	1
Per capita mine level Copper Output	overall	790.719	1160.6	1.07E-07	6704.4	N =	150
	between		1160.6	1.07E-07	6704.4	n =	150
	within		0	790.719	790.72	T =	1

Table A4: Summary statistics for all Variables for 2004

Variable		Mean	Standard Deviation	Min	Max	Observations	
Average household size	overall	5.344667	0.59127	3.7	7.8	N =	150
	between		0.59127	3.7	7.8	n =	150
	within		0	5.344667	5.34467	T =	1
Average age of household heads	overall	42.16667	2.51232	35	49	N =	150
	between		2.51232	35	49	n =	150
	within		0	42.16667	42.1667	T =	1
Percentage of the Educated	overall	81.16	10.5226	42	99	N =	150
	between		10.5226	42	99	n =	150
	within		0	81.16	81.16	T =	1
International Copper Price	overall	2863.47	0	2863.47	2863.47	N =	150
	between		0	2863.47	2863.47	n =	150
	within		0	2863.47	2863.47	T =	1
Percentage of Ultra Poverty in the Population	overall	48.77333	20.697	3	93	N =	150
	between		20.697	3	93	n =	150
	within		0	48.77333	48.7733	T =	1
Percentage of Moderate Poverty in the Population	overall	17.64	11.6482	1	70	N =	150
	between		11.6482	1	70	n =	150
	within		0	17.64	17.64	T =	1
Percentage of Total Poverty in the	overall	66.41333	18.5412	14	100	N =	150
Population	between		18.5412	14	100	n =	150
	within		0	66.41333	66.4133	T =	1
Percentage of Non-poor in the Population	overall	33.72667	18.419	0	86	N =	150
	between		18.419	0	86	n =	150
	within		0	33.72667	33.7267	T =	1
Total Copper Output	overall	443000	0	443000	443000	N =	150
	between		0	443000	443000	n =	150

	within		0	443000	443000	T =	1
Distance to the nearest mine	overall	414.148	274.085	1	912	N =	150
	between		274.085	1	912	n =	150
	within		0	414.148	414.148	T =	1
Mine level copper output	overall	16758.26	46530.1	0.01	191685	N =	150
	between		46530.1	0.01	191685	n =	150
	within		0	16758.26	16758.3	T =	1
Mine level Copper Price	overall	429.6461	1013.1	0.01	2850	N =	150
	between		1013.1	0.01	2850	n =	150
	within		0	429.6461	429.646	T =	1
Employment	overall	5.9884	18.8102	0.01	86	N =	150
	between		18.8102	0.01	86	n =	150
	within		0	5.9884	5.9884	T =	1
Population	overall	78423.5	99980.5	20031	1204763	N =	150
	between		99980.5	20031	1204763	n =	150
	within		0	78423.5	78423.5	T =	1
Percentage of females in the population	overall	20.56533	9.19684	8	43	N =	150
	between		9.19684	8	43	n =	150
	within		0	20.56533	20.5653	T =	1
Access to electricity	overall	31.92867	21.663	4.9	94.9	N =	150
	between		21.663	4.9	94.9	n =	150
	within		0	31.92867	31.9287	T =	1
Access to clean water	overall	77.852	11.1421	59.5	97.2	N =	150
	between		11.1421	59.5	97.2	n =	150
	within		0	77.852	77.852	T =	1
Total Income	overall	602949.8	299452	244102.7	2109472	N =	130
	between		299452	244102.7	2109472	n =	130
	within		0	602949.8	602950	T =	1

Real income	overall	7.38237	3.66642	2.988734	25.8279	N =	130
	between		3.66642	2.988734	25.8279	n =	130
	within		0	7.38237	7.38237	T =	1
Government funding	overall	6500	0	6500	6500	N =	150
	between		0	6500	6500	n =	150
	within		0	6500	6500	T =	1
Anaemia	overall	4.877333	2.0697	0.3	9.3	N =	150
	between		2.0697	0.3	9.3	n =	150
	within		0	4.877333	4.87733	T =	1
Chest Infections	overall	0.1764	0.11648	0.01	0.7	N =	150
	between		0.11648	0.01	0.7	n =	150
	within		0	0.1764	0.1764	T =	1
Diarrhoea	overall	0.3372667	0.18419	0.00E+00	0.86	N =	150
	between		0.18419	0.00E+00	0.86	n =	150
	within		0	0.3372667	0.33727	T =	1
General sickness	overall	0.6641333	0.18541	0.14	1	N =	150
	between		0.18541	0.14	1	n =	150
	within		0	0.6641333	0.66413	T =	1
Population density	overall	223.4854	754.372	2.196203	4905.39	N =	150
	between		754.372	2.196203	4905.39	n =	150
	within		0	223.4854	223.485	T =	1
Per capita mine level Copper Output	overall	2657.215	3446	9.01E-08	22613.9	N =	150
	between		3446	9.01E-08	22613.9	n =	150
	within		0	2657.215	2657.22	T =	1

Table A5: Summary statistics for all Variables for 2006

Variable		Mean	Standard Deviation	Min	Max	Observations	
Average household size	overall	5.292	0.5562	3.7	7.3	N =	150
	between		0.5562	3.7	7.3	n =	150
	within		0	5.292	5.292	T =	1
Average age of household heads	overall	42.0333	2.6271	37	52	N =	150
	between		2.6271	37	52	n =	150
	within		0	42.0333	42.033	T =	1
Percentage of the Educated	overall	82.0267	10.441	43	99	N =	150
	between		10.441	43	99	n =	150
	within		0	82.0267	82.027	T =	1
International Copper Price	overall	6731.35	0	6731.35	6731.4	N =	150
	between		0	6731.35	6731.4	n =	150
	within		0	6731.35	6731.4	T =	1
Percentage of Ultra Poverty in the Population	overall	33.968	19.772	1	78	N =	150
	between		19.772	1	78	n =	150
	within		0	33.968	33.968	T =	1
Percentage of Moderate Poverty in the Population	overall	20.564	8.1813	1	47	N =	150
	between		8.1813	1	47	n =	150
	within		0	20.564	20.564	T =	1
Percentage of Total Poverty in the	overall	54.532	22.303	5	96	N =	150
Population	between		22.303	5	96	n =	150
	within		0	54.532	54.532	T =	1
Percentage of Non-poor in the Population	overall	45.0147	21.831	4	95	N =	150
	between		21.831	4	95	n =	150
	within		0	45.0147	45.015	T =	1
Total Copper Output	overall	523000	0	523000	523000	N =	150

	between		0	523000	523000	n =	150
	within		0	523000	523000	T =	1
Distance to the nearest mine	overall	414.148	274.08	1	912	N =	150
	between		274.08	1	912	n =	150
	within		0	414.148	414.15	T =	1
Mine level copper output	overall	17378.7	42537	0.01	141777	N =	150
	between		42537	0.01	141777	n =	150
	within		0	17378.7	17379	T =	1
Mine level Copper Price	overall	1241.39	2775.8	0.01	10827	N =	150
	between		2775.8	0.01	10827	n =	150
	within		0	1241.39	1241.4	T =	1
Employment	overall	6.98167	19.575	0.01	84	N =	150
	between		19.575	0.01	84	n =	150
	within		0	6.98167	6.9817	T =	1
Population	overall	79030.7	55206	20606	514147	N =	150
	between		55206	20606	514147	n =	150
	within		0	79030.7	79031	T =	1
Percentage of females in the population	overall	20.818	8.838	8	43	N =	150
	between		8.838	8	43	n =	150
	within		0	20.818	20.818	T =	1
Access to electricity	overall	34.158	21.779	5.2	95.4	N =	150
	between		21.779	5.2	95.4	n =	150
	within		0	34.158	34.158	T =	1
Access to clean water	overall	74.8127	19.643	1.1	96	N =	150
	between		19.643	1.1	96	n =	150
	within		0	74.8127	74.813	T =	1
Total Income	overall	1000593	690834	222782	4E+06	N =	130
	between		690834	222782	4E+06	n =	130
	within		0	1000593	1E+06	T =	1

Real income	overall	10.0047	6.9075	2.22755	39.884	N =	130
	between		6.9075	2.22755	39.884	n =	130
	within		0	10.0047	10.005	T =	1
Anaemia	overall	3.3968	1.9772	0.1	7.8	N =	150
	between		1.9772	0.1	7.8	n =	150
	within		0	3.3968	3.3968	T =	1
Chest Infections	overall	0.20564	0.0818	0.01	0.47	N =	150
	between		0.0818	0.01	0.47	n =	150
	within		0	0.20564	0.2056	T =	1
Diarrhoea	overall	0.45015	0.2183	0.04	0.95	N =	150
	between		0.2183	0.04	0.95	n =	150
	within		0	0.45015	0.4501	T =	1
General sickness	overall	0.54532	0.223	0.05	0.96	N =	150
	between		0.223	0.05	0.96	n =	150
	within		0	0.54532	0.5453	T =	1
Population density	overall	244.062	841.15	2.32175	5625.5	N =	150
	between		841.15	2.32175	5625.5	n =	150
	within		0	244.062	244.06	T =	1
Per capita mine level Copper Output	overall	7557.83	9040.8	7.03E-08	66825	N =	150
	between		9040.8	7.03E-08	66825	n =	150
	within		0	7557.83	7557.8	T =	1

Table A6: Summary statistics for all Variables for 2010

Variable		Mean	Standard Deviation	Min	Max	Observations
Average household size	overall	5.258	0.4994319	4	6.5	N = 150
	between		0.4994319	4	6.5	n = 150
	within		0	5.258	5.258	T = 1
Average age of household heads	overall	41.84	2.016975	38	48	N = 150
	between		2.016975	38	48	n = 150
	within		0	41.84	41.84	T = 1
Percentage of the Educated	overall	83.02667	10.25183	45	99	N = 150
	between		10.25183	45	99	n = 150
	within		0	83.02667	83.027	T = 1
International Copper Price	overall	7538.37	0	7538.37	7538.4	N = 150
	between		0	7538.37	7538.4	n = 150
	within		0	7538.37	7538.4	T = 1
Percentage of Ultra Poverty in the Population	overall	32.26667	17.31185	2	73	N = 150
	between		17.31185	2	73	n = 150
	within		0	32.26667	32.267	T = 1
Percentage of Moderate Poverty in the Population	overall	19.18333	7.535691	2	50	N = 150
	between		7.535691	2	50	n = 150
	within		0	19.18333	19.183	T = 1
Percentage of Total Poverty in the Population	overall	51.45	19.32378	7	85	N = 150
	between		19.32378	7	85	n = 150
	within		0	51.45	51.45	T = 1
Percentage of Non-poor in the Population	overall	48.15	18.81308	15	93	N = 150
	between		18.81308	15	93	n = 150
	within		0	48.15	48.15	T = 1
Total Copper Output	overall	756000	0	756000	756000	N = 150
	between		0	756000	756000	n = 150
	within		0	756000	756000	T = 1

Distance to the nearest mine	overall	414.148	274.0847	1	912	N =	150
	between		274.0847	1	912	n =	150
	within		0	414.148	414.15	T =	1
Mine level copper output	overall	16346.61	46920.2	0.01	231124	N =	150
	between		46920.2	0.01	231124	n =	150
	within		0	16346.61	16347	T =	1
Mine level Copper Price	overall	1282.994	2754.471	0.01	7538.4	N =	150
	between		2754.471	0.01	7538.4	n =	150
	within		0	1282.994	1283	T =	1
Employment	overall	8.141533	21.06515	0.01	86	N =	150
	between		21.06515	0.01	86	n =	150
	within		0	8.141533	8.1415	T =	1
Population	overall	88612.01	53682.23	21972	364565	N =	150
	between		53682.23	21972	364565	n =	150
	within		0	88612.01	88612	T =	1
Percentage of females in the population	overall	20.498	8.532484	7	36	N =	150
	between		8.532484	7	36	n =	150
	within		0	20.498	20.498	T =	1
Access to electricity	overall	37.48667	22.92249	2.3	96.7	N =	150
	between		22.92249	2.3	96.7	n =	150
	within		0	37.48667	37.487	T =	1
Access to clean water	overall	81.26333	11.44805	63.7	94	N =	150
	between		11.44805	63.7	94	n =	150
	within		0	81.26333	81.263	T =	1
Total Income	overall	1200400	1090336	24792.82	6E+06	N =	145
	between		1090336	24792.82	6E+06	n =	145
	within		0	1200400	1E+06	T =	1
Real income	overall	8.221412	7.467597	0.1698034	43.82	N =	145

	between		7.467597	0.1698034	43.82	n =	145
	within		0	8.221412	8.2214	T =	1
Anaemia	overall	3.23	1.729637	0.2	7.3	N =	150
	between		1.729637	0.2	7.3	n =	150
	within		0	3.23	3.23	T =	1
Chest Infections	overall	0.1918333	0.0753569	0.02	0.5	N =	150
	between		0.0753569	0.02	0.5	n =	150
	within		0	0.1918333	0.1918	T =	1
Diarrhoea	overall	0.4815	0.1881308	0.15	0.93	N =	150
	between		0.1881308	0.15	0.93	n =	150
	within		0	0.4815	0.4815	T =	1
General sickness	overall	0.5145	0.1932378	0.07	0.85	N =	150
	between		0.1932378	0.07	0.85	n =	150
	within		0	0.5145	0.5145	T =	1
Population density	overall	301.076	1086.135	2.387276	7092.7	N =	150
	between		1086.135	2.387276	7092.7	n =	150
	within		0	301.076	301.08	T =	1
Per capita mine level Copper Output	overall	7068.195	11325.99	140.7157	72046	N =	150
	between		11325.99	140.7157	72046	n =	150
	within		0	7068.195	7068.2	T =	1

Table A7: Definitions of Variables

Variables	Description	Source
Per capita mine level copper output	This is measures as mine level copper output divided by the constituency population	Author's Interpretation
Income	Defined as household expenditure divided by the poverty line	Central Statistical Office (CSO)
Household size	The average household size in each constituency	Author's Interpretation
Age	This the average age of the household heads in each constituency	Author's Interpretation
Population density	Population in each constituency divided by the area of each constituency	Author's Interpretation
Female headed-households	Percentage of households in each constituency that are headed by females	Author's Interpretation
Access to clean water	Percentage of households with access to clean water within 5km to their homes	Author's Interpretation
Government funding	Constituency development funds allocated to each constituency by the government	Ministry of Finance and National Planning
Extreme Poverty	Percentage of the population not being able to meet to the minimum cost of basic needs which corresponds to the cost of the food basket	Central Statistical Office (CSO)
Moderate Poverty	Percentage of the population being able to meet the minimum cost of basic needs which corresponds to the cost of the food basket but fall below the per adult equivalent expenditure (Poverty line)	Central Statistical Office (CSO)
Non Poor	Percentage of the population that are above the food poverty line in each constituency	Central Statistical Office (CSO)
Employment	Percentage of the population that are employed by the mines in each constituency	Author's Interpretation
International Copper Price	The average annual price of copper on the global market	Westmetall
Female headed-households	Percentage of households in each constituency that are headed by females in urban areas	Author's Interpretation
Facilities		Author's Interpretation

	Percentage of households with access to clean water and good sanitation in each constituency	
Privatization	A dummy variable representing the post-privatization period of the mines equal to one and zero otherwise	Author's Interpretation
Anaemia	Percentage of the population with reported cases of anaemia in each constituency	Author's Interpretation
Chest Infections	Percentage of the population with reported cases of chest infections in each constituency	Author's Interpretation
Diarrhoea	Percentage of the population with reported cases of Diarrhoea in each constituency	Author's Interpretation
General sickness	Percentage of the population with reported cases of general sicknesses in each constituency	Author's Interpretation
Distance	Defined as the distance of each constituency to the nearest mine	Author's Interpretation

Notes: The table reports the exact definitions of the variables used in the models