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Spill-Overs of a Resource Boom: Evidence from Zambian Copper Mines

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Spill-Overs of a Resource Boom: Evidence from Zambian Copper Mines*

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Abstract

Do local populations benefit from resource booms? How strong are market linkages between the mining sector and the regional economy? This paper exploits exogenous variation in mine-level production volumes generated by the recent copper boom in Zambia to shed light on these questions. Using a novel dataset, I find robust evidence that an increase in local copper production improves living standards in the surroundings of the mines even for households not directly employed in the mining sector: a 10% increase in constituency-level copper output is associated with a 2% increase in real household expenditure; positive effects on housing conditions, consumer durable ownership and child health are of similar magnitude. The positive spill-overs extend to the rural hinterland of mining cities, neighboring constituencies, and constituencies on the copper transportation route. Additionally, I identify boom-induced changes in the demand for services and agricultural products as key channels through which the urban and rural populations benefit from the mine expansions. Since the boom failed to generate fiscal revenues, these effects can be interpreted as the result of the mines' backward linkages. Taken together, these findings highlight the welfare potential of local procurement policies in resource rich developing countries.

Keywords: Commodity Shocks, Local Development, Mining, Natural Resources.
JEL classification: I31, O12, O13, Q32, Q33

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1 Introduction

Many developing countries are rich in natural resources and face the question how to best manage their resource wealth in order to generate economic prosperity for their citizens. While the macroeconomic management of resource abundance has been at the center of much scholarly debate (Collier et al., 2009; Van der Ploeg and Venables, 2011), little is known about the local impact of resource extraction. Do local populations benefit from natural resource booms? How strong are market linkages between the mining sector and the regional economy? What is the catchment area of a typical mine? These questions are highly relevant to policy makers in resource rich countries yet the empirical evidence is scarce and inconclusive.

The estimates in this paper help to shed light on these questions. I exploit a natural experiment that creates exogenous variation in mine-level copper production in Zambia to examine local spill-overs from mine activity. Investigating market linkages between the mining industry and the regional economy within a treatment-effects framework allows me to advance Hirschman's (1958) analysis of backward linkages[1] and estimate spill-over effects with great local precision.

The welfare implications of the Zambian copper boom, however, are not clear a priori since copper mining is generally considered an enclave activity (Hirschman, 1958) with limited linkages to the regional economy. Further, Dal Bó and Dal Bó (2011) show theoretically that positive shocks to capital intensive industries like copper mining increase the risk of conflict - a prediction empirically confirmed by Dube and Vargas (2013) in their case study of oil windfalls in Columbia. Related studies use within-country variation to document the adverse effect of oil windfalls on corruption in Brazil (Caselli and Michaels, 2013) or the adverse environmental impact of Gold mining in Ghana (Aragon and Rud, 2013a).

In contrast to these findings, I show for the Zambian case that an expansion of the mining sector can improve living standards locally if the sector is sufficiently integrated into the regional economy. Although the absolute benefits appear modest in relation to the size of the boom[2], the spill-overs from mine activity are substantial. A 10% increase in constituency-level copper output, for example, raises real household expenditure by 2%. To the best of my knowledge, this is the first study to examine the market linkages of the mining sector in an African context.

The recent copper boom in Zambia constitutes a natural experiment to estimate the local economic effects of changes in mine-level production. Copper mining is the backbone of the Zambian economy but the country is only a small player in the international copper market[3]. Consequently, the demand-driven increase in the world price of copper starting in 2003 was an exogenous shock to Zambia. In response to the price boom, annual copper production more than tripled and total export revenues increased almost

[1] In the context of this paper, the term *'backward linkages'* refers to the interaction between the mining companies and their local suppliers, i.e. the local input demand effect of increased copper production. Conversely, the term *'forward linkages'* refers to the local processing of copper.

[2] A back-of-the-envelope calculation suggests that considerably less than 1% of the notional *value* of copper stays in the area where it was mined.

[3] In recent years, the value of gross copper exports exceeded 30% of GDP but Zambia's share of world copper production has consistently been below 4%.

tenfold between 2003 and 2010. A counterfactual exercise suggests that the discounted windfall revenues over the relevant period amount to approximately 100% of 2002 GDP. The intensity of the boom, however, varied substantially across mining areas. Two new mines commenced production during the sample period in response to higher copper prices while two others actually lowered production due to depleting reserves, creating exogenous spatial and temporal variation in mine-level copper production. Despite the substantial size of the boom, the mining sector has made virtually no contribution to public finances over the relevant period. The Zambian mines were state-owned for most part of the post-independence period and only privatized in the late 1990s in response to staggering losses and increased pressure from the international donor community. In a weak bargaining position, the government made very generous tax concessions and effectively gave away the country's natural resources. Crucially, this means government redistribution is not confounding the analysis as any fiscal channel can credibly be excluded. The Zambian case, therefore, is an ideal laboratory to examine the strengths of market linkages between the mining sector and the regional economy: any identified effect from mine-level copper production on local living standards captures the true local spill-overs and does not pick up regional or national confounding effects. The absence of fiscal linkages means in conjunction with the exogenous variation in mine-level copper production that the Zambian copper boom provides an excellent framework to study spill-over effects from resource extraction.

With that goal in mind, I interpret the analytical frameworks developed in Corden and Neary (1982) and Moretti (2010) in the Zambian context to derive a set of testable predictions. In the presence of strong market linkages, an increase in local copper production should improve socioeconomic outcomes in the surroundings of the mines. The high pre-boom unemployment in mining regions suggests that adjustments should occur primarily at the extensive margin and mitigate the predicted increase in relative prices. Due to well-developed trade and transportation links in the mining regions, positive spill-overs would likely extend to the rural hinterland of mining cities and neighboring districts. Negative externalities of increased mine production through environmental degradation and general equilibrium effects on local prices, however, may offset positive spill-overs and possibly even lower living standards in mining regions if linkages are weak. Hence, whether the boom improves measures of welfare in mining areas is a priori unclear and, ultimately, an empirical issue.

In order to test the competing hypotheses empirically and identify channels of transmission from mine production to living standard measurements, I use five rounds of newly available household survey data. The data covers a wide range of key indicators of living standards between 1996 and 2010 and has, to the best of my knowledge, not been analyzed in the context of the copper boom. Additionally, I combine four different data sources to construct a new data set of annual mine-level copper production since 1994. This enables me to create a panel data set at the constituency level, the lowest level at which the location of the mines can be identified. The identification strategy exploits the exogenous variation in constituency-level copper production to investigate the impact of increased mine activity on socioeconomic outcomes using a fixed effects model. The advantage of this strategy is that it allows me to estimate the spill-over effects from copper mining with great local precision and to compute the catchment area of a typical mine. The validity of this approach rests on the identifying assumption that - conditional on pre-boom characteristics like copper production, infrastructure, and human capital - mining and non-mining constituencies would have behaved similarly in absence of the copper boom. Similar pre-boom evolution of key outcome variables provides confidence in this regard.

Several key findings emerge. First, the copper boom appears to improve living standards in the surroundings of the mines. I find that an increase in local copper production has positive and significant effects on household expenditure, housing conditions, consumer durable ownership, and child health in mining constituencies and substantially reduces local unemployment. For example, a 10% increase in constituency-level copper output is associated with a 2% increase in real per capita expenditure. Boom-induced direct and indirect employment effects constitute important transmission mechanisms: the unemployment rate falls by 3% following an increase in local copper production by 10,000 metric tons and the fraction of people employed in the services sector simultaneously rises by at least 5%. Additionally, the copper boom appears to reduce overall poverty in mining areas suggesting that the spill-overs from increased mine production trickle-down to the poorest households. Yet, the absolute benefits appear modest in relation to the size of the boom. Relating changes in expenditure to the estimated value of locally extracted copper indicates that considerably less than 1% of the notional value of copper remains in the constituency in which it was mined. Second, the positive spill-over effects of increased mine production extend to the rural hinterland of mining cities, neighboring constituencies, and constituencies located on the copper transportation route. Consistent with increasing transportation costs and imperfect labor mobility, the magnitude of spill-overs to surrounding areas decreases monotonically with distance and becomes statistically insignificant after c. 75km. This implies the total catchment area of all twelve mines comprises more than two million people. Third, consistent with the theoretical literature on the Dutch Disease (Cordon and Neary, 1982), relative prices increase slightly in response to the boom but there is little evidence of higher overall inflation in mining regions, arguably due to the locally elastic supply of labor (Moretti, 2010). Since the boom failed to generate fiscal revenues or dividend income for the Zambian population, I interpret the estimated effects of mine expansion on living standards as a result of the mines' market linkages rather than fiscal linkages or rents from resource extraction.

The findings are robust to different lag structures of local copper production, alternative clustering choices for standard errors, and the exclusion of any particular set of mines from the sample. Estimating the baseline specification for the non-migrant sample shows that the positive spill-over effects from increased mine activity are not driven by selective migration and can indeed be attributed to strong backward linkages of the mines.

Arguably, government spending is the main confounding variable in this analysis. The baseline results would be biased if fiscal and campaign spending increased disproportionately in mining-areas relative to the rest of the country. Unfortunately, an official decomposition of fiscal spending by region or district is not available. I address this issue in two steps. First, I give an overview of Zambia's recent political history. Critically, the rise of the Patriotic Front (PF) between 2001 and 2011 started in the Copperbelt and coincided with the copper boom. The ruling party (MMD) subsequently reduced its efforts in the mining regions (Cheesman and Hinfelaar, 2009; Fraser and Larmer, 2007) suggesting that government spending may have actually decreased in those regions. Second, I turn to insights from the literature on Zambian politics to motivate the use of constituency-level election data as a proxy for changes in the spatial distribution of political spending over time. The resulting evidence is consistent with Cheesman and Hinfelaar's (2009) account that the MMD gradually shifted its political focus away from the mining areas of the Copperbelt towards relatively poorer rural regions in response to the rise of the PF. As a consequence, the positive effects of mine-level production on local living standards appear even more pronounced when controlling for government spending.

I identify increased labor demand for auxiliary services as a key channel through which the urban population benefits from the mine expansions. Higher demand for locally produced goods and services reduces unemployment and increases the share of workers employed in the services sector, thereby raising average incomes in mining cities. This effect is transmitted to the rural hinterland via increased demand for agricultural products and trade links between urban and rural areas.

The findings in this paper document a powerful local multiplier effect for the Zambian mining sector and indicate the welfare potential of local procurement policies in resource rich developing countries. Although the extractive industry is relatively capital-intensive, local populations can benefit from mine activity if the sector is sufficiently integrated into the regional economy. It is within the means of policy makers to strengthen backward and forward linkages by establishing and enforcing subsidy, tariff and purchasing policies that benefit local companies and favor domestic value addition over the export of primary commodities.

Contribution to the Literature By establishing these results, this work contributes to the literature exploring effects of resource wealth on socioeconomic outcomes. My findings add to the extensive literature on the resource curse following on from Sachs and Warner's (1995, 2001) seminal cross-country analysis. Their finding that resource abundance is negatively associated with long-term economic growth has been scrutinized in great detail and linked to the quality of institutions (Mehlum et al., 2006) and conflict (Brunnschweiler and Bulte, 2009; Brückner and Ciccone, 2010; Collier and Hoeffler, 2004, 2005)[4]. Due to endogeneity and omitted variable issues associated with cross-section evidence (Caselli and Micheals, 2013), the literature has recently turned to within-country regional variation to examine spill-over effects of resource booms.

This paper contributes to this emerging strand of the literature by exploiting a natural experiment to credibly identify causal links and transmission channels from increased mine production to higher living standards in the surroundings of the mines. Within this literature, the paper most closely related to my work is Aragon and Rud (2013b). They examine the local economic impact of a Peruvian gold mine and

[4]See Frankel (2010) or van der Ploeg (2011) for an overview.

show that the mine's expansion raised household income through increased demand for locally procured inputs. To the best of my knowledge, it is the only other study that explicitly examines market linkages between the mining sector and the regional economy. Other evidence is less benign. The same authors find that gold mines in Ghana have reduced agricultural productivity and increased poverty locally through environmental pollution (Aragon and Rud, 2013a). Similarly, Caselli and Micheals (2013) show that oil windfalls to Brazilian municipalities failed to raise household incomes locally, arguably due to increased corruption[5].

In all three studies, however, the boom generates windfall revenues to the state. My results directly complements those studies by showing that local populations can benefit from resource booms even in the complete absence of fiscal linkages if the mining sector is sufficiently integrated into the local economy. On the Zambian copper boom, the closest contribution is Wilson's (2012) analysis of boom-induced changes in sexual risk-taking behavior. He finds that increased copper production substantially reduced rates of transactional sex and multiple partnerships in mining cities.

This paper methodologically advances the literature on backward and forward linkages. Following Hirschman's (1958) pioneering work, the branch of the literature has largely focused on national account data although the use of (local) input-output tables is unlikely to yield reliable estimates of local multipliers (Moretti, 2010). Using within-country variation allows me to estimate the strength of the linkages with great local precision, identify transmission mechanisms and be more specific about welfare implications. My findings on relative price and labor market adjustments in response to a commodity boom contribute to the large literature on the Dutch Disease which is summarized in Van der Ploeg (2011). By establishing that average child health improves in response to the boom I also contribute to the literature examining the effect of economic shocks on child outcomes (Cogneau and Jedwab, 2012). Finally, the findings documenting changes in the spatial distribution of government spending add to the understanding of recent political developments in Zambia (Cheesman and Hinfelaar, 2009; Fraser and Larmer, 2007).

The remainder of this paper is organized as follows. The next section gives an overview of the copper boom and provides the historical background information relevant to the identification strategy. Section 3 discusses the analytical framework and derives three testable predictions. Section 4 describes the data while Section 5 outlines the empirical strategy and discusses possible threats to identification. Section 6 presents the main results and Section 7 provides robustness checks. Section 8 examines possible channels of transmission empirically. Section 9 concludes and draws out a policy message.

[5] Related work examines the (adverse) effects of resource booms on conflict (Angrist and Kugler, 2008; Dube and Vargas, 2013) and corruption (Monteiro and Ferraz, 2009; Vicente, 2010).

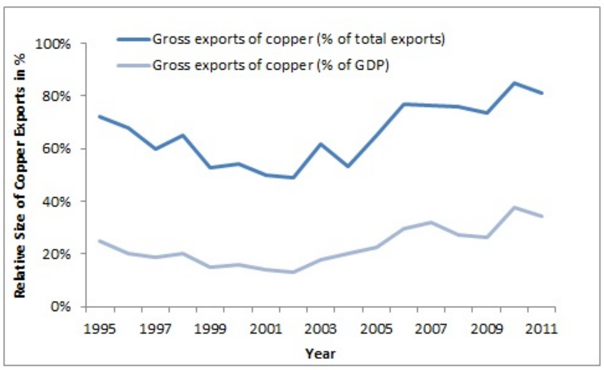
2 Copper Mining in Zambia and the Copper Boom

This section discusses the role of mining in the Zambian economy[6] and provides information relevant to the identification strategy. A counterfactual exercise suggests that the discounted windfall revenues between 2003 and 2010 are comparable in size to Zambia's GDP in 2002.

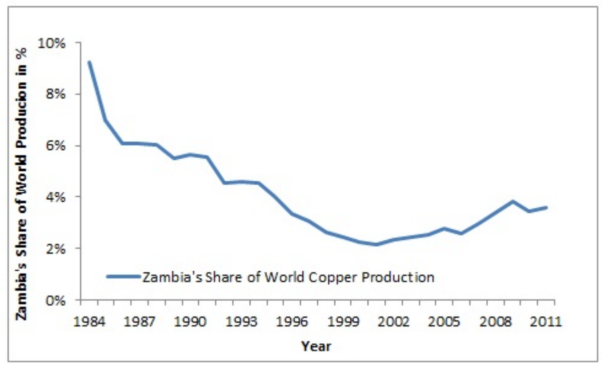
2.1 Copper Mining in Zambia

Figure 1: Copper Mining in Zambia

(a) Relative Size of Copper Exports



(b) Zambia's Share of World Production



Source: Bank of Zambia, Raw Materials Group, World Bank, Author's calculations.

Copper Mining and the Zambian Economy Copper mining is the backbone of the Zambian economy and the country's political and economic history has been closely linked to developments in the mining sector ever since copper was first commercially mined in the late 1920s. In recent years, copper and cobalt generated more than three-quarters of Zambia's export earnings and the value of gross copper exports exceeded 30% of GDP (Figure 1a).

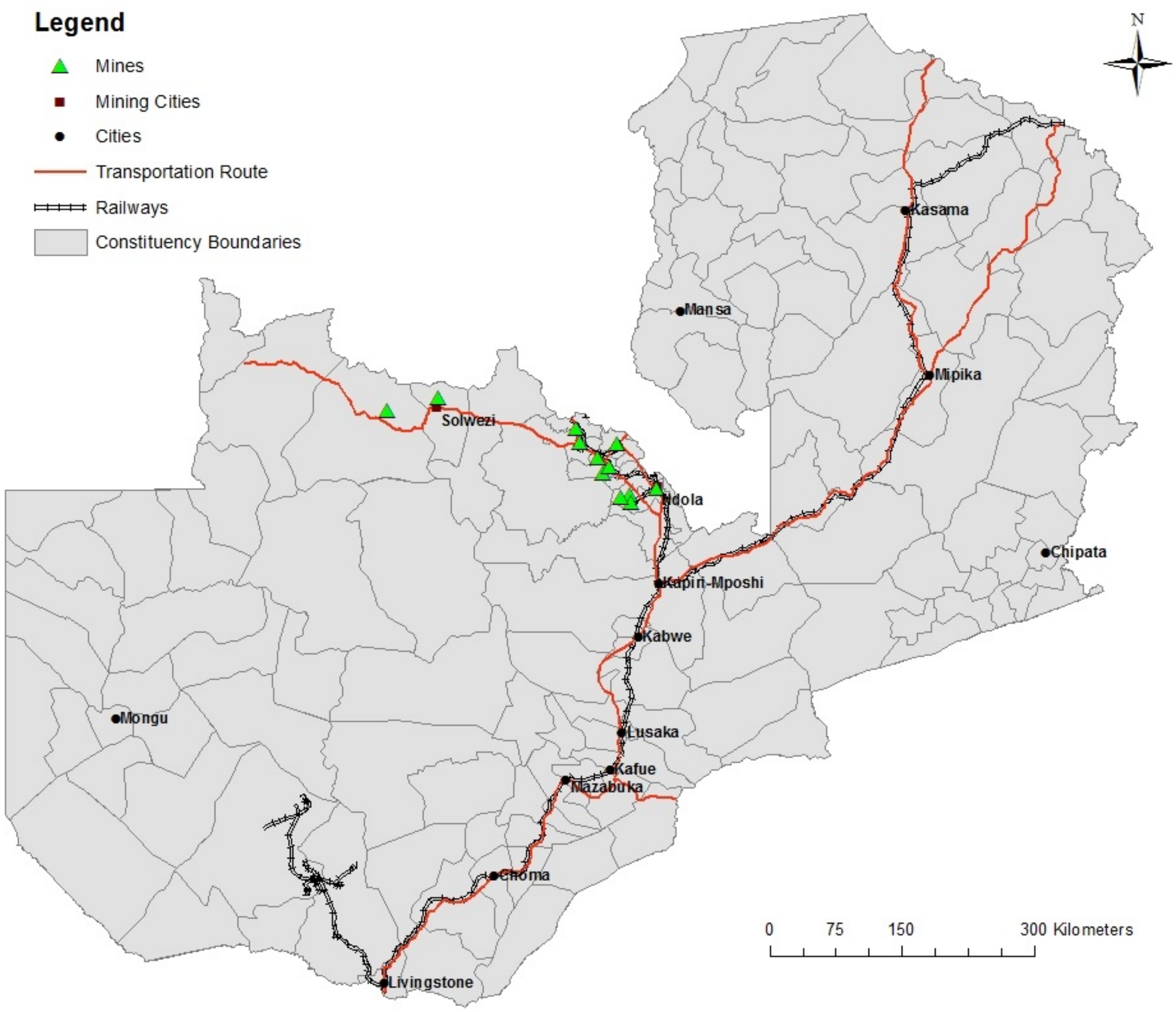
Zambia, however, is only a small player in the international copper market. Even though the country was the seventh-largest copper producer in the world in 2010 the country's share of world copper production was consistently below 4% over the past 15 years (Figure 1b). The only country with substantial market power is Chile, accounting for c. 35% of world mine production (ICSG, 2012). Copper is an excellent electrical conductor and used for electrical wiring and in related applications including industrial machinery, electronic products, and building construction.

The majority of Zambia's copper deposits is located in the Copperbelt, a mineral-rich region in the north of Zambia that extends into the Katanga region of the Democratic Republic of Congo and contains about a tenth of the world's copper and nearly half of the world's cobalt reserves[7] (USGS, 2013). The

[6]This section draws on the works of Adam and Simpasa (2009) and Fraser and Lungu (2007).
[7]Cobalt is only produced as a by-product of copper mining in Zambia (Adam and Simpasa, 2009).

Zambian side of the belt is the largest industrial zone in sub-Saharan Africa outside South Africa and includes the mining cities of Ndola and Solwezi (Figure 2).

Figure 2: Zambia



For geographic and geological reasons mining is very capital- and cost-intensive in Zambia. Labor productivity compares unfavorably with other mining countries[8], the nearest major seaport is c. 1,800km away (Dar es Salaam, Tanzania), and fixed-cost of production have increased substantially over time as mines moved deeper underground. The mines in the Copperbelt are among the wettest and deepest in the world and require very import- and capital-intensive technology to operate (Adam and Simpasa, 2009). Consequently, most Zambian mines are placed in the top quartile of the international cost curve (WMC, 2013) and the average unit cost of production is around twice the global average (Adam and Simpasa, 2009). The unfavorable geology of the Copperbelt in conjunction with the high sunk costs in the mining industry implies that foreign mining companies have strong incentives to react to changes in the price of

[8]In Chile, copper output per worker is nearly seven times higher than in Zambia (UKAID, 2011).

copper and adjust production accordingly.

Transportation Most of the copper ore mined on both the Zambian and the Congolese side of the Copperbelt is concentrated and smelted locally, transited through Zambia, and shipped predominantly as copper cathode from the seaports of Durban and Dar es Salaam (Fraser and Lungu, 2007). The copper is transported by truck or rail along the North-South Corridor: about two-thirds of copper exports leave Zambia via the southern route through Lusaka and Zimbabwe or Botswana to Durban (c. 2,600km) while the remaining share is transported to the northeast via Mpika to Dar es Salaam (c. 1,800km). The southern route is mainly serviced by trucks whereas between a third and a half of the copper exports to Tanzania are carried by rail (Engman, 2009). Both transportation routes are shown in Figure 2. Revenues for logistics companies are substantial. A copper export volume of 820,000 metric tons in 2010 implies that even under conservative assumptions more than 680,000 tons of copper were transported by truck during that year. Given a transport price of c. $110 per ton and an average truck capacity of 30 tons a back-of-the-envelope calculation suggest copper exports involved c. 22,700 return trips to the coast and led to revenues for trucking companies of around $75m (Engman, 2009).

History of Copper Mining in Zambia The mining sector in Zambia has undergone two major transitions in the last century: the mines were nationalized shortly after independence and re-privatized in the late 1990s in response to operational inefficiencies and increased pressure from the international donor community.

Copper was first commercially mined in Zambia in the late 1920s and two foreign mining companies - Anglo American Corporation (South Africa) and Roan Selection Trust (US) - dominated the sector in subsequent decades. Copper mining quickly became an integral part of Zambia's (then Northern Rhodesia) economy and the country's share of world copper production consistently exceeded 10% in the 1950s. A prolonged period of high and stable copper prices and the rapidly growing copper industry fostered economic growth and, at independence in 1964, Zambia had the highest per capita GDP in all of sub-Saharan Africa (Adam and Simpasa, 2009). Coinciding with the peak in production, the government announced the nationalization of the mining sector in 1969. The state acquired majority holdings in the Zambian operations of Anglo American and the Roan Selection Trust and created two new corporations that were merged in 1982 to form Zambia Consolidated Copper Mines (ZCCM). Anglo-American remained a minority shareholder in newly formed entity but mining licenses and exclusive prospecting rights reverted back to the government (Craig, 2001).

Zambia experienced a record-breaking decline in economic performance in the last quarter of the 20th century. The oil crises of the 1970s brought about a collapse of the copper price and pushed the country into a severe debt crisis. With falling prices, chronic underinvestment in the mining sector and increasing production cost annual copper output declined steadily from over 700,000 metric tons in the early 1970s to below 230,000 metric tons in 2000 and the sector's contribution to GDP fell by more than 50% to 7.9% in 2002. As a result, Zambia's per capita GDP collapsed by an unprecedented 50% in the two decades leading up to 1994 (Fraser and Lungu, 2007).

Crumbling under an overwhelming debt burden and dependent on aid flows the government was forced to engage with donors and adopt economic liberalization policies. Privatization of ZCCM became inevitable when losses amounted to almost $1m per day in the mid-1990s and placed significant strains on the fiscal budget (Craig, 2001). Between 1997 and 2000 the government entered under great pressure from the donor community into an opaque process of bilateral negotiations. The assets of ZCCM were eventually sold to seven different corporations while the state assumed its financial liabilities and environmental legacies but remained an indirect minority shareholder in most operations (see Craig, 2001, for more details). The terms of each deal were results of bilateral bargaining and defined in secret, legally-binding *Development Agreements*.

Tax Agreements The government was under enormous pressure to privatize[9] and mounting losses of ZCCM and ever falling copper prices further reduced its already diminished bargaining power. In this buyer's market, foreign investors negotiated extremely favorable terms and tax concessions. The sales proceeds did not cover the liabilities ZCCM had accumulated leaving the government to pay the difference (Craig, 2001) and examples of favorable tax treatment are plentiful (cf. Adam and Simpasa, 2009). Mining companies enjoy a lower corporate income tax (25% vs. 35% for non-mining companies), can carry-forward losses for up to 20 years, are not required to pay import duties on capital inputs, and capital expenditure can be deducted in full in the year it occurs. The effective royalty rate of 0.6% of gross revenues is at least an order of magnitude smaller than the international average and stability periods of 15 to 20 years guarantee those terms. Taken together, these concessions imply that mining companies enjoyed a marginal effective tax rate of around 0% in the last decade (Dymond, 2007). As a consequence, the mining sector's contribution to public finances has been negligibly small during the course of the boom (see below).

2.2 The Copper Boom

Driven by a surge in demand, loose monetary policy, and a weak dollar the world price of copper rapidly increased between 2003 and 2006 after a decade of reduced volatility (Figure 3), increasing by more than 700% from its trough in October 2001 to a monthly average price of almost $10,000 per metric ton a decade later. Cobalt prices increased to a similar extent. The price shock was exogenous to Zambia and largely unexpected: limited market share (see above) implies Zambia is a price taker in the international copper market and the exit of Anglo American in 2002[10] documents that leading players in the industry did not expect the copper price to rise substantially in the medium-term.

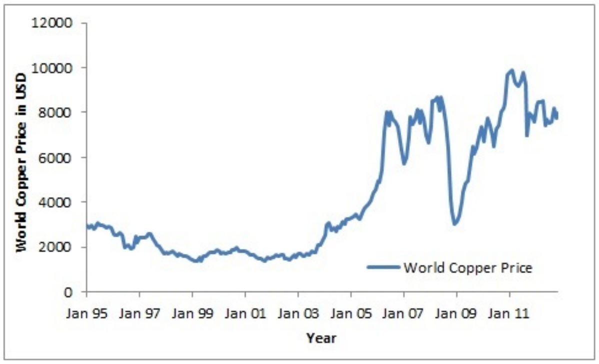
In response to the shock, annual copper production in Zambia more than tripled to around 820,000

[9] Privatization of ZCCM was part of the conditionality set by the IMF and the World Bank for Zambia to qualify for debt relief. Similarly, several loans were granted only in exchange for the promise to privatize and the donor community withheld more than $500m in aid payments in 1999 when Zambia refused to comply (Dymond, 2007).

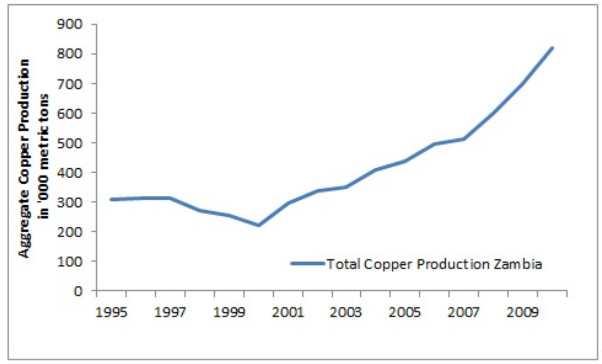
[10] Anglo American completely withdrew from the Zambian mining sector in 2002 due to the perceived unprofitability of its operations. The company did not expect prices to recover and passed its mining license and equity holdings in Konkola Copper Mines (KCM) free of charge to the Copperbelt Development Foundation. The subsequent surge in the world price of copper, therefore, really was a shock to the Zambian mining industry.

Figure 3: The Copper Boom

(a) World Price of Copper



(b) Aggregate Copper Production (Zambia)



Source: Bank of Zambia, Datastream.

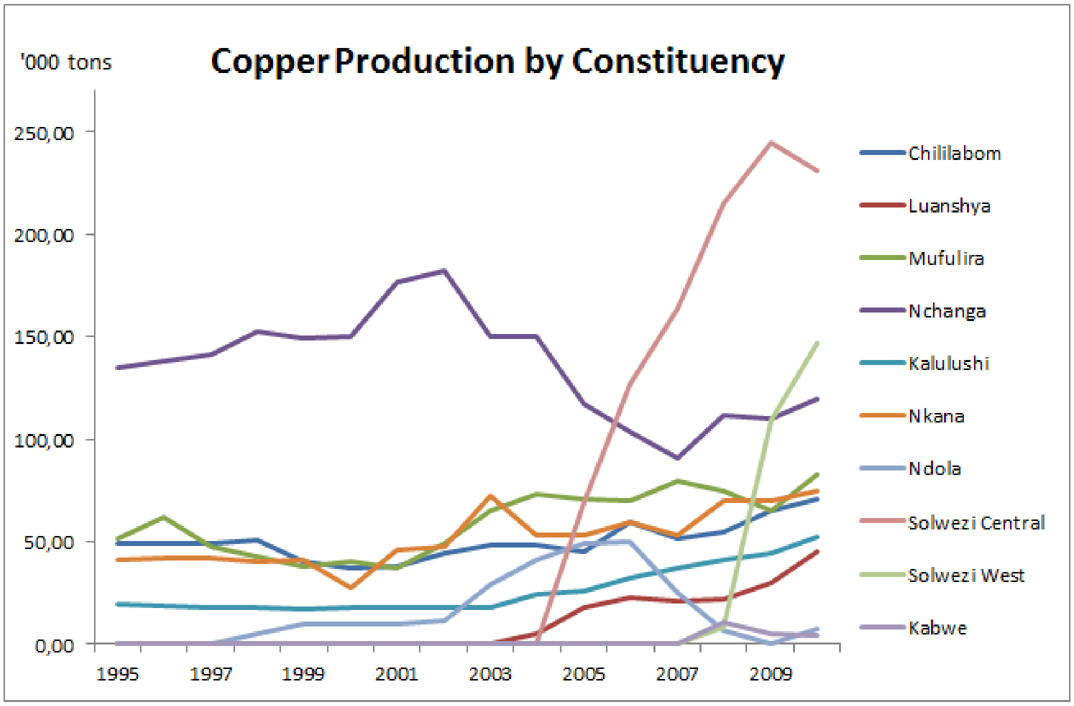
metric tons in 2010 (Figure 3). With rapidly increasing prices and production volumes, gross earnings of copper and cobalt exports exploded between 2003 and 2010 (rising almost tenfold from \$669m to \$6,072m), reflecting increased investment in technology, exploration and production capacity. Other copper exporters reacted in a similar fashion to the boom; Chile, for example, saw copper production increase by almost one million metric tons over the relevant period. The collapse of the copper price during the financial crisis did not affect production volumes in Zambia due to sluggish short-run responsiveness in production volumes and a quick recovery of the commodity markets (pre-crisis levels were reached by the end of 2009).

The change in output is indeed a response to the price shock rather than merely a privatization effect. As Fraser and Lungu (2007) point out, investment spending by ZCCM between 1990 and 1996 amounted to c. \$125m annually which is of similar magnitude as investment undertaken by the foreign mining companies from 1997 to 2003 following privatization (c. \$135m per year). Hence, the surge in investment observed from 2004 onwards can confidently be attributed to higher commodity prices.

The boom also had significant effects on employment in the mining sector. In an attempt to improve efficiency ZCCM had reduced the workforce by more than 60% leading up to the privatization and employment only picked up in the mid-2000s, nearly tripling to almost 60,000 mine-workers in 2008 (Wilson, 2012).

The intensity of the boom, however, varied substantially across mining areas. Figure 4 documents the significant heterogeneity in production across mining constituencies in response to the price shock. While some mines saw only modest increases in output, two new mines resumed or commenced production (Kansanshi Mine in Solwezi Central and Lumwana Mine in Solwezi West, respectively) after the onset of the shock. Due to its relatively high production cost Kansanshi was unprofitable at the prevailing prices in the 1990s and production was suspended - the mine was deemed to be ZCCM's least valuable asset and eventually sold for \$3m in cash plus optional payments up to \$25m (Craig, 2001). Kansanshi resumed

Figure 4: Annual Copper Production by Constituency



Source: Companies' Annual Reports, Raw Materials Group, ZCCM Annual Reports, Author's calculations.

production in 2005 and is today the largest copper mine in Africa with an annual production in excess of 200,000 metric tons (First Quantum Annual Report, 2012). Similarly, rising commodity prices provided Equinox with incentives to intensify exploratory activities in the area covered by their mining license[11], invest in new technology, and to ultimately commence production at Lumwana in 2008 (Equinox Annual Report, 2009). In contrast, production declined during the boom at the mines in Ndola (Bwana Makuba) and Nchanga (Nchanga Open Pits) as both are running out of copper (Wilson, 2012).

The Scale of the Boom In order to quantify the size of the windfall I perform a counterfactual exercise in the spirit of Aron (1999) and Adam and Simpasa (2009). The copper and cobalt price boom started in 2003 (cf. Figure 3) so that 2002 prices serve as counterfactuals. Since the boom is ongoing, I restrict my analysis to the years of my sample period and calculate the windfalls between 2003 and 2010. Following Adam and Simpasa (2009), windfalls are defined as the additional exports revenues due to price changes, treating production levels and, thus, export volumes as predetermined. Appendix Table A1 shows the calculations. The exercise is performed separately for copper and cobalt but estimates are combined to compute the overall size of the minerals boom. I adjust annual windfalls figures for changes in the cost of imports using the Manufactures Unit Value Index (MUV, column 5) and deflate nominal quantities into

[11]Resulting in, amongst others, the discovery of new copper reserves at Chimiwungo North.

2002 Dollars using the World Bank GDP deflator for Zambia (column 9). Table 1 presents the results for various discount rates. The mineral boom 2003-2010 is large in absolute terms with windfall estimates ranging between 86% and 110% of 2002 GDP.

Table 1: Scale of the Boom

Discount Factor	Size of Windfalls as % of 2002 GDP
5%	110.0 %
8%	94.6 %
10%	85.9 %

Source: See Appendix Table A1

The Effect on Public Finances Despite its magnitude, the copper boom has not translated into substantial fiscal revenues due to the generous tax concessions set out in the Development Agreements. Appendix Table A2 provides a break-down of central government revenues by type and sector. Total tax revenue as share of GDP did not increase over the course of the boom and the mining sector's contribution to public finances was negligible small in most years. Extensive loss carry-forward provisions and the ability to fully deduct capital expenditure from taxable income meant that the entire mining industry has paid virtually no corporate income tax in the period between privatization and the end of 2007[12]. The royalty rate of 0.6% is already low by international standards but there is evidence suggesting that some companies may not have even paid these low rates (Dymond, 2007). In addition, the Zambian state has not benefited financially from its equity participations in the mining companies: any dividend payments made to the state-owned holding company ZCCM-IH were used to cover operating costs and ZCCM-IH itself never made dividend payments to its shareholders (Adam and Simpasa, 2009). By the end of 2007, the Zambian government had received virtually no tax revenues from the copper boom and decided to impose a windfall tax as well as higher tax and royalty rates on the mining sector despite the legally binding stability periods. In response to opposition from the mining companies and the collapse in copper prices (cf. Figure 3), the government removed the windfall tax and reversed other elements of the new tax code in late 2008. With the recovery of copper prices and the revised tax regime, 2010 was the first year since privatization in which the mining industry contributed more than 10% to fiscal revenue. In relation to the size of the boom, however, the mining sector's contribution to public finances has been negligibly small over the sample period.

3 Analytical Framework

The scale of the Zambian copper boom is substantial but profits accrue exclusively to foreign companies and the contribution of the mining sector to public finances has been negligibly small. Despite concerns

[12] *"In 2006 First Quantum Minerals, which is still well within the period of the tax holiday provided by its development agreement, decided that the situation was embarrassing and decided to start paying tax, contributing $19m to the Zambia Revenue Authority"* (Fraser and Lungu, 2007, p. 57).

among the Zambian population that the copper leaves the country without leaving much of a trace in the Zambian economy (Lungu, 2008), it is not unreasonable to expect that the expansion of the mines has spurred economic activity locally via the mines' market linkages. However, it has often been argued (Adam and Simpasa, 2009; Fraser and Lungu, 2007) that linkages to the rest of the economy are weak.

This section offers a simple theoretical framework to motivate three testable hypotheses about the local multiplier effect of the resource boom and presents the competing hypothesis.

Zambia fits the small open economy framework due to the country's substantial international trade activity but negligible market power in the commodity markets. An exogenous shock to the copper price induces a mining boom, raising profit margins and marginal factor productivity in the industry (booming sector). Mining companies react by investing in production capacity, technology, and prospecting activities, thereby increasing production volumes where possible. Economic theory predicts that factor inputs are allocated efficiently such that depleting mines receive (at best) a small share of the investment levels. A share of the additional inputs (labor, smaller capital inputs) is sourced locally suggesting that a fraction of the windfall revenues trickles down to mine workers, local sub-contractors, and providers of auxiliary services.

The boom, therefore, has two important implications (Cordon and Neary, 1982). First, production factors in the mining sector become more productive in the margin relative to the rest of the economy, leading - in theory - to a reallocation of mobile production factors between sectors (resource movement effect). Second, higher economic activity raises the demand for non-traded goods (local spending effect). However, the capital- and import-intensive nature of mining in Zambia implies that a large share of the additionally required resources cannot be drawn from other parts of the country, mitigating the resource movement effect. Hence, the local spending effect is likely to dominate (Calí and te Velde, 2007; Corden and Neary, 1982).

The standard model assumes full employment, mobility of the labor force and fixed labor supply in the short run such that higher demand for non-traded goods should result in a reallocation of production factors: the non-traded goods sector expands at the expense of the non-booming traded sector causing the equilibrium wage to increase in the services sector without affecting overall employment. Zambia deviates in two important respects from the standard model. First, non-traditional exports have only accounted for a small fraction of total exports even in pre-boom years (cf. Figure 1). Second, mining areas in particular suffered under severe pre-boom unemployment (cf. Section 4). This suggests that adjustment occurs predominantly at the extensive margin.

The immediate effect of the boom - accruing to mining employees directly due to increased labor demand - may be limited due to the capital-intensity of the actual operations. The mining sector, however, purchases non-critical services locally (UKAID, 2011) and demand for transportation, construction, and cleaning services is thought to be strongly correlated with local mine production. The locally elastic labor supply curve implies a large local multiplier (Moretti, 2010) with spill-overs to the wider services sector including restaurants, hotels and guest houses, morticians, and laundry services. Since those professions do not tend to require large shares of skilled labor (Goderis and Malone, 2011), excess demand for labor can be met by drawing on the local pool of unemployed such that adjustments should occur primarily at the extensive margin and mitigate the predicted increase in relative prices. Hence, the boom-induced local spending effect should increase welfare measures and reduce unemployment around the respective mines via their links to the regional economy.

Hypothesis 1: An increase in mine-level copper production improves living standards and reduces unemployment in areas around the mines relative to the rest of the country.

Alternatively, the resource boom may entail substantial local Dutch Disease symptoms and adverse environmental effects that actually reduce relative living standards in mining areas. Material living standards would decrease in response to a surge in local copper production if the mines' market linkages are indeed weak (as suggested by Fraser and Lungu, 2007) and the boom induces higher inflation in mining regions because increased demand of the mining sector raises prices of non-traded goods relative to those of traded goods (Frankel, 2010). Additionally, high flows of migration into mining cities may drive up unemployment locally and exacerbate this effect. Finally, the environmental impact of Zambia's mining sector is the topic of much debate (cf. Fraser and Lungu, 2007) and may adversely affect agricultural productivity and living standards in mining regions (see Aragon and Rud, 2013a, for a discussion of the environmental effects of mining in Ghana). Hence, whether or not the mineral boom raises welfare measures depends on the extent of the mine's backward linkages and the corresponding local multiplier effect and is, ultimately, an empirical issue.

Competing hypothesis: An increase in mine-level copper production fails to improve living standards in mining areas and increases unemployment and relative prices in the Copperbelt (again, relative to other regions).

If hypothesis 1 turns out to be supported by the data and there is evidence of positive spill-over effects from increased mine production, then we would expect those effects to extend - to some degree - to areas that are either spatially connected or otherwise exposed to the boom. Intuitively, higher purchasing power of the urban population raises the demand for food (locally produced) and results in higher agricultural income and improved living standards for the rural population. Further, there is no reason to expect that backward linkages are confined to the most local environs. The high population density and relatively developed transportation infrastructure of the Copperbelt suggest the presence of strong trade links between mining and non-mining areas in the region. Hence, non-mining districts may well benefit from increased mine production due to trade links and the local multiplier effect. Finally, a service sector has developed over time along the copper transportation route, catering for overland buses and truck drivers (Engman, 2009). The volume of copper exports has increased substantially during the boom, reaching over 22,000 return trips in 2010 (cf. Section 2), and is likely to benefit the population living along the transportation route.

Hypothesis 2: The positive spill-overs of increased mine-production extend to the rural hinterland of mining cities, neighboring districts, and the population along the copper transportation route.

However, transportation costs are increasing in distance and likely to place an upper bound on intra-regional trade. Agricultural rents diminish with distance from markets (located without exception in close vicinity of the respective mines) and spill-overs from mine activity are likely to be weaker for households living further away from the mines. Hence, distance from the mines is a source of heterogeneous exposure to the copper boom.

Hypothesis 3: The positive spill-over effects vanish with distance from mines and become insignificant beyond a certain point.

The remainder of this paper tests these predictions empirically. The next sections describe the data and empirical strategy.

4 Data and Descriptive Statistics

Main outcome variables are a set of living standard measurements at the constituency level, Zambia's lowest administrative level[13]: average per capita expenditure, unemployment rate, a measure of housing conditions, an index of consumer durable ownership, and a proxy for child health. I choose constituencies as the unit of observation because this is the lowest geographical level at which the location of the mines can be identified. Zambia consists of 150 constituencies of which 9 contain a mine (mining constituencies) and 46 are located on the copper transportation route (cf. Figure 2). Hence, there are 141 non-mining constituencies. Household and individual level data comes from five waves of the Living Conditions Monitoring Survey (LCMS). The survey is nationwide repeated cross-section carried out by the Zambian Central Statistical Office (CSO) to measure and monitor poverty of time. I construct a panel data set at the constituency level with 150 observations observed at five different points in time.

LCMS collects data on a wide range of key indicators of living standards that are representative at all relevant sub-national and locational (rural and urban) levels. The CSO has been conducting the Living Conditions Monitoring Surveys since 1996 and kindly shared five of the six data sets collected thus far. I have access to the three pre-boom waves LCMS I-III conducted in 1996, 1998, and 2002 as well as two boom waves (LCMS V and VI, conducted in 2006 and 2010)[14].

Each survey round is relatively large in size, covering roughly 1 in every 113 households (LCMS 1998): 61.455 individuals (11.788 households) were surveyed in 1996, 93.471 (16.710) in 1998, 54.100 (9.741) in 2002, 97.738 (18.662) in 2006, and 102.882 (19.398) in 2010. The survey design ensures cross-sectional

[13]Zambia consists of 9 provinces, 72 districts, and 150 constituencies.
[14]Unfortunately, I have not been able to obtain LCMS IV (2004).

comparability of all variables of interest. With the exception of the 2002 round, all surveys in the LCMS series were conducted within a short period of time (usually one or two months). LCMS III adopted a different methodology and surveyed a smaller number of households at several pre-specified points in time during the course of 2002. Those dates were identical across regions such that averages are comparable cross-sectionally. Hence, seasonal variation in the data is no concern in cross-section or panel analysis.

As the main dependent variable and proxy for living standards I use constituency-level averages of adult-equivalent per capita expenditure in constant Kwacha[15] (*Expenditure*). For a comprehensive analysis of spill-overs from mine activity I compute five additional measures of living conditions. Unemployment rate seeks to capture the labor market dynamics of the boom. The fraction of children that fell ill in the two weeks leading up to the interview (*Illness*) is used as a proxy for child health. The LCMS data also provides detailed information on consumer durable ownership (car, mobile phone, TV, DVD player, radio) and housing conditions (access to electricity and tap drinking water). Since the variables in the respective groups are highly correlated and capture essentially the same concept, it makes sense to aggregate them using the first factor of a principal component analysis. Additionally, this allows for a clearer presentation of the results and reduces measurement error of the dependent variable. The resulting indices are denoted (*Housing*) and (*Ownership*), respectively. In order to investigate the boom-induced effects on measures of poverty I make use of the fact that the Central Statisical Office (CSO) of Zambia assigned a poverty status to each household based on household expenditure in relation to a minimum consumption basket. This enables me to compute the fraction of at least moderately poor households in each constituency (*Poverty*).

The measurement of unemployment deserves some further discussion. Obtaining a reliable estimate of a (local) employment or unemployment rate in a developing country is inherently difficult and results should be interpreted with caution. I classify a working age person as unemployed if he or she (a) is not working but wishing to do so/looking for a job or (b) preforming unproductive unpaid family work. Crucially, the estimated effects on unemployment in Section 6 should be interpreted in combination with the evidence on changes in the sectoral composition of employment provided in Section 8.

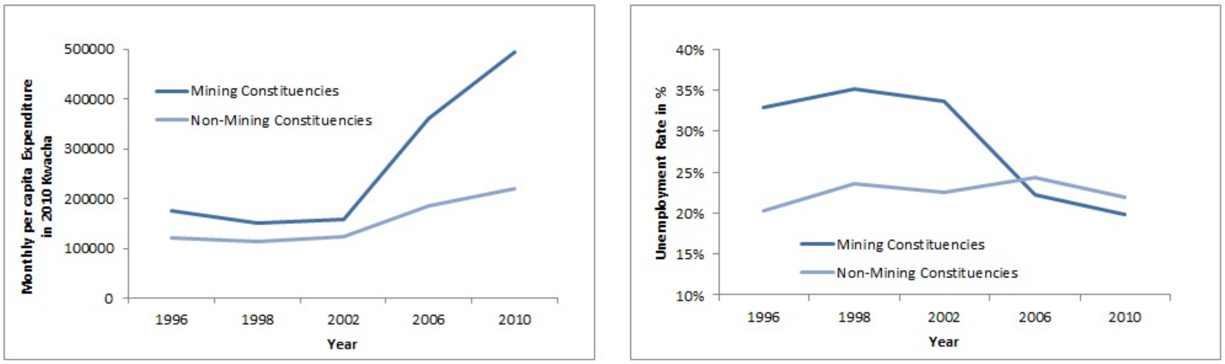
A series of individual and household level controls seeks to capture time-varying differences across constituencies in educational attainment, household size, gender, age, and the composition of employment. *Migrant* and *Mine Worker* control for the shares of migrants and mine worker in the constituency. A list and detailed definition of all variables employed in the analysis can be found in Appendix A3. In addition, ArcGIS software is used to create a map of Zambia with constituency level boundaries (those shown in Fig. 2) and to compute the Euclidean distance between the centroid of each constituency and every large-scale copper mine. This allows me to analyze spill-overs of the mines to non-mining constituencies and how these effects change with distance.

Descriptive Statistics Table 2 presents pre-boom summary statistics for the main variables of interest, broken down by constituency type. Crucially, even before the onset of the boom copper producing con-

[15] 1 US Dollar was worth approximately 5,200 Zambian Kwacha on 10 April, 2013

Figure 5: Evolution of Outcome Variables

(a) Expenditure (b) Unemployment Rate



Source: Central Statistical Office, Author's Calculations.

stituencies differed substantially from non-producing constituencies in virtually all socioeconomic regards (Column 5). Copper producing regions enjoyed significantly higher average living standards, had a more educated population and even demographic characteristics differed significantly. Notably, however, pre-boom unemployment was substantially lower in non-producing regions documenting the extent to which the regional economy of the Copperbelt suffered under low commodity prices despite its superior infrastructure. Pre-boom differences between mining and non-mining areas were mostly in levels with similar evolution of welfare measures between 1996 and 2002 (Figure 3). Trajectories, however, changed dramatically during the boom and mining regions economically outperformed the rest of the country. Unemployment in mining constituencies fell by almost half between 1998 and 2010 with virtually no change in overall employment elsewhere. These observations motivate a panel analysis and document the necessity to control for fixed effects.

Copper production volumes at the national and constituency-level serve as the main explanatory variables. Annual data on aggregate production (Figure 2b) comes from the Bank of Zambia. Mine-specific data on the scale of operations (volume and costs of production, investment spending, wage bills, or tax payments) would be the ideal type of data to estimate the local multiplier for the mining sector as expenditure on locally sourced inputs best captures the interaction between the mining sector and the regional economy. These data, however, are by and large not readily available at the mine-level such that copper output becomes the preferred measure of mine expansion because input demands are likely to be highly correlated with production volumes. I combine four different data sources to construct a time-series of annual copper production since 1994 for each large scale mine. Old ZCCM annual reports and later the regulatory filings of the respective holding companies provide the most accurate information. Availability of reports, however, is limited for the privatization period and the early days under private ownership. Additional data comes from Raw Materials Group (IntierraRMG) and the World Mine Cost Data Exchange.

Table 2: Main Summary Statistics (Pre-Boom).

	(1) Mining Const.	(2) Const. on Copper Transportation Route	(3) Rest of Zambia	(4) Non-Mining Const.	(5) Difference (1) - (4)
Outcome Variables					
Asset Value	2,947,217	2,496,575	2,107,671	2,418,794	528,423 ***
	754,125	1,529,321	412,812	1,381,790	
Expenditure	161,928	153,218	103,421	119,584	42,344***
	(76,537)	(80,958)	(45,867)	(63,882)	
Housing Conditions	0.90	0.66	0.21	0.36	0.54***
	(0.54)	(0.55)	(0.32)	(0.46)	
Illness	21.0%	22.4%	29.7%	27.3%	-0.06***
	(9.5%)	(11.3%)	(14.8%)	(14.1%)	
Living Costs	1,241,096	852,448	47,3767	595,486	645,610***
	766,989	713,863	298,517	503,068	
Monthly Rent	47,244	40,134	21,900	29,021	18,223
	(76,150)	(52,841)	(44,143)	(48,461)	
Ownership	0.38	0.29	0.12	0.18	0.20***
	(0.20)	(0.18)	(0.09)	(0.15)	
Poverty	48.2%	55.5%	69.4%	64.9%	-0.17***
	(17.7%)	(18.9%)	(17.0%)	(18.8%)	
Unemployment Rate	33.9%	30.8%	18.0%	22.1%	0.12***
	(9.3%)	(13.4%)	(12.2%)	(13.9%)	
Services	5.3%	7.0%	1.7%	3.4%	0.02**
	(4.0%)	(6.6%)	(2.7%)	(4.9%)	
Services (incl. Finance)	7.5%	9.6%	2.6%	4.9%	0.03**
	(5.3%)	(8.7%)	(4.0%)	(6.7%)	
Services (incl. Health)	8.1%	9.3%	3.0%	5.0%	0.03***
	(4.9%)	(7.7%)	(3.8%)	(6.1%)	
Control Variables					
Age	20.4	20.3	21.2	20.9	-0.50***
	(0.7)	(1.3)	(1.8)	(1.7)	
Degree	10.6%	6.8%	3.3%	4.5%	0.06***
	(11.6%)	(7.9%)	(5.0%)	(6.2%)	
Fraction Migrants	2.3%	2.9%	2.7%	2.8%	0.00
	(1.5%)	(2.2%)	(3.5%)	(3.2%)	
Fraction Mine-Workers	6.2%	1.0%	0.2%	0.5%	0.06***
	(7.8%)	(3.6%)	(1.3%)	(2.2%)	
Household Size	5.7	5.7	5.3	5.4	0.25**
	(0.6)	(0.8)	(1.1)	(1.0)	
Male	49.2%	49.5%	48.9%	49.1%	0.00
	(2.7%)	(2.4%)	(3.3%)	(3.0%)	
Ruling Party	70.4%	81.2%	76.1%	77.8%	-0.07
	(46.5%)	(39.3%)	(81.4%)	(41.6%)	
Rural	22.7%	45.3%	81.4%	69.7%	-0.47***
	(30.5%)	(40.8%)	(25.5%)	(35.5%)	
School	59.2%	58.8%	53.5%	55.2%	0.04
	(17.4%)	(14.8%)	(13.1%)	(13.8%)	
Winning Party	51.9%	59.4%	64.9%	63.1%	-0.11
	(50.9%)	(14.8%)	(47.8%)	(48.3%)	
Observations	27	138	285	423	

Notes: Standard deviations are given in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

Data from the Zambian Ministry of Mines and Minerals Development complements the data set. Using ArcGIS and coordinates of the mines, I assign each mine to a constituency and aggregate copper production at the constituency level. The resulting time series are plotted in Figure 4. $Transport \times Output$ seeks to capute the spill-overs to areas along the copper transportation route by interacting annual aggregate copper production with a copper transportation route dummy (cf. Figure 3).

One would expect the value of copper production to be less correlated with local input demand and, thus, to be less suited to examine the strength of backward linkages because the eventually realized sales revenues are irrelevant for the operations of the mines beyond the effects on production decisions. Yet, the value of copper production can be used to investigate on the magnitude of the spill-overs and to estimate what share of the revenues accrues to the local population. To this end I define *Localvalue* as mine-level production volume times the average copper price in Kwacha during that particular year.

Presidential election data comes from the Electoral Commission of Zambia. Section 7 motivates the use of election outcomes as a proxy for local government spending.

5 Identification Strategy

The main goal of the empirical exercise is to test the three hypotheses derived in section 3 and identify possible channels of transmission. As discussed in section 2, the individual mines have contributed very little to public finances over the sample period and the profits accrue to foreign companies and leave the country. Further, the literature on Zambian politics suggests that government spending has diverted away from mining regions over time (cf. Section 6). This makes me confident to interpret the estimated effects of mine expansion on measures of living standards as a result of the mines' market linkages rather than fiscal linkages or rents from resource extraction.

To test the hypotheses, I exploit three sources of exogenous variation. First, the large increase in aggregate copper output following the shock to the world price of copper. Second, the substantial variation in mine-level production responses to the price shock. As discussed in Section 2, changes in production volume are either a direct consequence of higher commodity prices (e.g. re-opening of mines) or due to geological reasons (depleting mines) and, thus, exogenous in this framework. Third, distance to the mines provides exogenous variation in the exposure to the copper boom.

The considerable heterogeneity in constituency-level production responses motivates two distinct treatment groups. Mining-constituencies are treated by changes in local production volumes and treatment intensity varies substantially within this group. Constituencies located on the copper transportation route are treated by changes in aggregate production volumes and the remaining areas constitute the control group. Hence, the identification strategy is an extended difference-in-differences estimation. The validity of this approach rests on two identifying assumptions. First, spill-over effects from mine-activity are stronger in mining regions than elsewhere. Second, conditionally on pre-boom characteristics (such as copper production, infrastructure, human capital, etc.), mining and non-mining constituencies would have behaved similarly in absence of the price shock. Effectively, this imposes a restriction on the nature of time-varying unobservables. The similar pre-boom evolution of the unemployment rate and per capita expenditure for both groups (Figure 3) gives confidence that this assumption holds approximately. Since unobserved heterogeneity among constituencies is likely to be correlated with copper production, I test the three hypotheses using different versions of the following fixed effect model. The baseline specification takes the form

$$Y_{c,t} = \beta_1 Localoutput_{c,t-1} + \beta_2 (Transport \times Output_{c,t-1}) + \delta_2 \boldsymbol{\Gamma_{c,t}} + \boldsymbol{\alpha_c} + \boldsymbol{\lambda_t} + \varepsilon_{c,t} \tag{1}$$

where $Y_{c,t}$ is a measure of living standards or price level in constituency c at time t and $Localoutput_{c,t-1}$ denotes the volume of copper production in constituency c, lagged by one year. $Transport \times Output_{c,t-1}$ is the interaction between lagged aggregate (nationwide) copper production and a dummy variable that takes the value one if the respective constituency is located on the copper transportation route. The vector of controls, $\boldsymbol{\Gamma_{c,t}}$, includes socioeconomic constituency characteristics to control for time-varying observables (age, gender ratio, fraction of rural households, educational attainment, fraction of migrants) and the direct effect of mine expansion (fraction of mine workers). All regressions include constituency ($\boldsymbol{\alpha_c}$) and year ($\boldsymbol{\lambda_t}$) fixed effects, and $\varepsilon_{c,t}$ is the error term. β_1 is the main coefficient of interest and measures the average change in living standards in response to a 10,000 metric tons increase in local copper production. β_2 accounts for the fact that higher mining activity may also affect socioeconomic outcomes in other regions with exposure to the boom and measures the average spill-over effect on constituencies located on the transportation route.

Copper production is lagged one year in the baseline specification to allow markets to adjust and the local multiplier to reach its full effect. However, other lag structures can be motivated as well. On the one hand, if spill-over effects take even longer to trickle down, a two-year lag (as employed by Aragon and Rud, 2013b) may be appropriate. On the other hand, it may be reasonable to expect that living standard measurements are relatively more sensitive to investment spending than to actual production. Local sub-contractors are likely to benefit substantially from the expansion of mines and investments in production capacity while spill-overs from production itself may be lower due to scale economies and automated processes. Since capacity utilization has been close to 100% even in pre-boom years (Adam and Simpasa, 2009) production volumes may be a good proxy for prior investment spending. Hence, copper output led by two periods may capture the true spill-over effect from increased mine activity. The robustness section provides evidence that results are not driven by any particular choice of the lag structure.

The baseline specification imposes the somewhat unrealistic restriction that spill-overs are confined to constituencies in which the respective mines are located. However, the transport infrastructure is reasonably developed in the mining areas and the high population density means that constituencies in the Copperbelt are relatively small in size. Moreover, evidence suggests that people commute even long distances in seek of lucrative employment opportunities as long as transportation costs are sufficiently low. Hence, we would expect backward linkages of the mines to extend into neighboring constituencies. To test hypothesis 3 and estimate spill-overs to non-mining areas I relax this restriction and define *Localoutput* as the combined copper output of all mines within certain radii from the centroid of the respective constituency. Extending the radius allows me to identify the average catchment area of the mines.

To ensure fair representation in elections, urban districts like Lusaka or Ndola are divided into multiple constituencies. Hence, serial correlation of outcome variables within districts may become an issue as one would expect constituencies within the same urban area to behave similarly. To address this concern I follow Pepper (2002) and adjust standard errors for nested two-way clustering at the constituency and district level by clustering at the higher level of aggregation (district level). I discuss the sensitivity of the results to different clustering levels (constituency) and multi-way clustering (district-year) in the robustness section. Once distance measures are used to define relationships between variables, spatial correlation may be an additional concern (Conley, 1999). To account for arbitrary spatial dependence that may confound the spill-over analysis I present Conley (1999) standard errors in specifications that include measures of geographic distance.

Time-invariant differences between constituencies and time-varying unobservables common to all regions are picked up by the respective fixed effects but time-varying heterogeneity may pose a challenge to the empirical specification. The coefficient estimates would be biased if time-varying unobservables at the constituency-level were correlated both with copper production and with living standards in the area. The factors most likely to do so are political spending and selective migration. The baseline case controls for the share of migrants in each constituency but a more rigorous treatment of time-varying heterogeneity is postponed until section 7. Endogeneity of production volumes, exploratory activities or prospecting decisions is also unlikely to be a reason for concern. The large-scale copper mines are exclusively owned by multinational mining giants such as Vedanta or Glencore that import large shares of their capital inputs and have access to international factor markets. Hence, one would not expect that those globally operating companies make prospecting decisions based on local labor market dynamics or change production volumes in response to shocks to local factor markets.

6 Findings

This section tests the hypotheses derived in Section 3 and presents the main empirical results. I follow the empirical strategy discussed in the previous section and begin by examining the effect of changes in constituency-level copper output on measures of living standards in the respective constituencies. In a second step, I examine the strength and spatial dimension of the mines' backward linkages by estimating spill-overs to non-mining constituencies and to the rural hinterland of mining cities. Finally, I analyze the effect of the copper boom on local and relative prices. Robustness checks are postponed until section 7.

Changes in mine-level copper production create a local demand shock and entail two primary effects. First, higher mine activity substantially improves a large set of socioeconomic outcomes in the surroundings of the mine, driven by an increase in the demand for locally produced goods and services. Second, prices of non-traded goods increase slightly relative to those of traded goods in response to the boom but there is little evidence of higher overall inflation in mining regions.

6.1 Main Results

The central result of this paper suggests that an increase in local copper output improves measures of living standards in the respective constituencies via the mines' backward linkages. Panel A in Table 3 presents the estimated effect of constituency-level copper production on material living standards, the unemployment rate, and a measure of child health. Results with real per capita expenditure as the dependent variable are reported in column 1: an increase in local copper production by 10,000 metric tons (i.e. 10.8% of the average constituency production volume in 2010) increases average per capita expenditure in mining-constituencies by approximately 6.800 Kwacha, or 4.2%, relative to areas that are not exposed to the boom[16]. Similarly, the constituency unemployment rate falls by 0.7 percentage points, or 3%, in response to an increase in local copper production by 10,000 metric tons (column 2). The analysis of transmission channels in Section 6 provides evidence that the boom substantially increased the size of the services sector as share of total employment. Taken together, this suggests the boom had a considerable impact on total employment and the sectoral composition of employment by creating jobs in the services sector. All estimates are statistically significant at the 1% level even when controlling for the direct effect of the mine expansion (fraction of mine worker in the constituency, itself mostly significant) and selective migraction (fraction of migrants) and imply considerable overall changes in living standards as average mine production has nearly tripled between 1996 and 2010.

These results provide evidence in favor of *Hypothesis 1.* Yet, the concern remains that expenditure is an ill-suited proxy of individual or household welfare because it is subject to changes in local price levels and fails to capture other factors relevant to a person's well-being such as safety, health levels or environmental considerations. To address this shortcoming I present results for additional measures of material well-being and test explicitly for possible adverse consequences of higher mine activity by examining effects on child health[17]. Columns 3 - 5 document the scope of the favorable spill-overs of the boom. Average housing conditions improve significantly in response to an increase in local copper output and people living near the mines are more likely to own consumer durables than their counterparts elsewhere in the country. The effects are statistically significant and reasonably strong in economic terms - both indices rise on average by more than 3% in response to a surge in local mine production by 10,000 metric tons. Individual regressions (not reported) suggest that the fraction of households within a constituency that have access to tap drinking water or electricity increases by 1 and 0.5 percentage points, or 3% and 3.3%, respectively. Similarly, a 10% increase in local production is associated with a 2.7% increase in the fraction of people

[16] Constituency-level production volumes average at c. 47,000 metric tons between 1996 and 2010 such that a 10% increase in local copper output increases expenditure by 3.179 Kwacha or 2%. This is consistent with Aragon and Rud (2013b) who study spill-over effects of a gold mine in Peru and find that a 10% increase in mine activity leads to an increase of 1.7% in real household income.

[17] In addition, I analyze the response of local and relative prices to the copper boom in a later sub-section.

Table 3: Main Results.

Dep. Variable	Expenditure	Unemployment	Ownership	Housing	Illness	Poverty
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
Localoutput	6763.7***	-0.007***	0.011***	0.014***	-0.005***	-0.008***
	(2152.9)	(0.002)	(0.003)	(0.004)	(0.001)	(0.002)
$Transport \times Output$	883.4	-0.003***	0.002***	0.001	0.000	-0.001*
	(558.7)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Mine Worker	376811.2**	-0.261	0.562**	0.863	0.167	-0.732***
	(158772.4)	(0.294)	(0.242)	(0.671)	(0.122)	(0.234)
Migrant	78668.8	0.227	0.191	-0.189	-0.111	-0.473
	(126328.1)	(0.236)	(0.202)	(0.352)	(0.221)	(0.288)
R-Squared	0.56	0.10	0.84	0.47	0.33	0.38
N	745	745	745	745	745	745
Panel B						
Localvalue	393.0**	-0.000**	0.000***	0.000***	-0.000	-0.000***
	(188.4)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Transport \times Value$	1083.**	-0.003***	0.003***	0.001	0.000	-0.001**
	(523.7)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Migrant	81750.9	0.222	0.200	-0.176	-0.117	-0.480*
	(125172.9)	(0.236)	(0.200)	(0.354)	(0.220)	(0.287)
Mine Worker	333076.4**	-0.224	0.518**	0.819	0.174	-0.701***
	(138045.1)	(0.279)	(0.216)	(0.670)	(0.128)	(0.221)
R-Squared	0.58	0.11	0.84	0.47	0.33	0.38
N	745	745	745	745	745	745
District FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
HH Controls	Y	Y	Y	Y	Y	Y

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size. The effects of the fraction of mine workers (*Mine Worker*) and migrants (*Migrant*) in the respective constituency - arguably most important controls - are shown to put the size of the copper effect into context.

that own a mobile phone.

In an attempt to test for health implications of the copper boom I make use of data recorded in the supplementary child health questionnaire. *Illness* denotes the fraction of children below the age of five (arguably the age cohort most sensitive to environmental changes) that fell ill in the two weeks leading up to the interview (self-reported). The results in column 5 indicate a substantial improvement in child health following the expansion of a nearby mine: children in mining constituencies were on average 2% less likely to fall ill when a mine had substantially increased production in the previous year. This result, however, has to be interpreted with caution. Various organizations have repeatedly voiced their concerns about the adverse environmental impact of Zambia's mining sector (cf. Fraser and Lungu, 2007). In particular, the results do not allow statements about long-term effects of the boom nor do they exclude the possibility of negative externalities. A full welfare analysis of the boom would require a thorough examination of all environmental implications. The improvement in health outcomes, however, is consistent with Wilson (2012) - who finds evidence of a boom-induced reduction in risky sexual behavior in mining areas - and may be a result of a change in health seeking behavior, better nutrition or improved sanitary facilities. Although I am unable to disentangle these effects, the changes in child health can be attributed to the boom as all three channels are likely to be a direct consequence of an increase in disposable income.

Distributional Impacts The results so far have focused on average effects and allow no conclusion about the distributional aspects of the boom. It is, however, of particular interest whether spill-overs from local copper production have trickled-down to the poorest households and reduced poverty in mining cities and the surrounding areas. In order to investigate the boom-induced changes in poverty I regress local copper production on the fraction of at least moderately poor households in each constituency (*Poverty*). The estimated effect of local copper production on this poverty measure (column 6 in Table 3) suggests that the boom has reduced overall poverty in mining areas - a 10,000 metric ton increase in local production reduces the fraction of poor households in the respective constituency by 0.8 percentage points or approximately 2%.

Overall, I find strong evidence in favor of *Hypothesis 1.* The regression estimates suggest that the linkages between the mining sector and the regional economy are stronger than previously thought and ensure that the local population benefits from increased mine production. Yet, growing concerns that Zambians may not receive a fair share of copper revenues (cf. Lungu, 2008) motivate the question what share of the copper revenues remains in the constituency. The next sub-section discusses the magnitude of the spill-overs and seeks to relate them to the size of the boom.

Discussion of Magnitudes In order to shed light on the magnitude of the spill-overs and to estimate what share of the revenues accrues to the local population I re-estimate the baseline specification with the value of lagged local copper production (*Localvalue*, defined as local copper production volume times the average copper price in Kwacha during that particular year) as the explanatory variable. *Localvalue* is a rather crude estimate of actual sales revenues and the results - reported in Panel B of Table 3 - should be interpreted accordingly. The estimates are qualitatively similar to those presented in Panel A except that the effect on child health is no longer statistically significant. I, thus, focus on the effects on adult-equivalent per capita expenditure (column 1) in an attempt to compare the monetary benefits accruing to the local population with the gross revenues from the copper sales. The results suggest that an increase in the value of constituency-level copper production by 10 billion Kwacha is on average associated with additional per capita expenditure of approximately 400 Kwacha for people living in vicinity of the mine. According to the Zambian 2000 and 2010 census, total population in mining constituencies averaged at nearly 110,000 people (c. 55,000 adults) per constituency over the relevant period; adult-equivalent population is a convex combination of the two figures.

A back-of-the-envelope calculation suggests that a total expenditure within a typical mining constituency rises on average by between 22 and 44 million Kwacha following a 10 billion Kwacha increase in the value of local copper production. This means incremental copper production increases expenditure in mining areas by approximately 0.4% of its notional value. Those estimates are likely to constitute lower bounds as households may expect the boom to be temporary and save a fraction of additional earnings. The marginal savings propensity, however, is relatively low in developing countries (Dupas and Robinson, 2011) such that net savings are unlikely to be large relative to changes in consumption spending. Loosely speaking, this implies that considerably less than 1% of the value of local copper production remains in the constituency. When interpreting these results one has to bear in mind that the revenue figures are given in gross terms and disregard exploration, operating, and transportation costs. Yet, the size of financial spill-overs appears modest even when taking into account the high cost structure of mining in the Copperbelt.

In summary, backward linkages of the mining sector are considerable. There are strong spill-over effects from mine activity and living standards in mining-constituencies increase substantially with local copper output but the magnitude of spill-overs in monetary terms appears modest in relation to the total value of minerals extracted. The next sub-section tests *Hypotheses 2 and 3* and examines spill-over effects to the rural population and non-mining constituencies.

6.2 Spill-Overs to Non-Mining Constituencies

Constituencies on the Transportation Route The coefficients on the interaction variable $Transport \times Output$ in Table 3 (Panel A) indicate the presence of spill-overs from increased production volumes to constituencies located on the transportation route. The effects are, however, weaker than for mining-constituencies and less likely to be statistically significant. Intuitively, this makes sense. Over time, a services sector has developed along the country's most important roads catering for travelers and truck drivers and a tripling in the number of return trips from the Copperbelt likely improved economic opportunities for people living near those roads (cf. section 2). Consistent with this reasoning, unemployment in constituencies on the transportation route has fallen by about 0.3 percentage points, or 1.1%, following an increase in aggregate production volumes by 10,000 metric tons. There is evidence of a similarly positive effect on consumer durable ownership, in particular mobile phones, but the effect on expenditure levels, housing conditions or child health is not statistically significant. This is little surprising as typically road-side purchases (food, refreshments, phone credit, magazines) are unlikely to generate large revenues to the seller.

Rural Hinterland of Mining Constituencies The analysis so far has made no distinction between different household types and focused on constituency averages. One may be concerned, however, that positive spill-overs are confined to the urban population. In Table 4 I repeat the analysis of Table 3 but exclude urban households from the sample to examine whether positive spill-overs extend to the rural hinterland of mining areas. The results suggest that rural households in the surroundings of the mines are significantly better off following the copper boom compared to the rural population elsewhere in the country. The effects on unemployment and child health in rural areas are qualitatively and quantitatively similar to those for the entire sample and statistically significant at the 1% level. An increase in local production by 10,000 metric tons is associated with additional per capita expenditure of roughly 3,000 Kwacha, approximately 50% of the increase in the baseline specification. Considering that rural expenditure levels are somewhat lower, the proportionate increase of 2.7% is comparable to the findings for the entire sample. The absence of positive effects on housing conditions in rural areas is not surprising. Food expenditure constitutes the bigger part of total spending for low-income households and is very sensitive to changes in income. Better nutrition, in turn, is likely to improve the health of children while attempts to improve housing conditions are considerably more expensive and financially difficult to implement for most households due to the modest absolute increase in disposable income. Rural households, thus, do indeed benefit from the boom but to a smaller extent than their urban counterparts. Channels through which the rural population may benefit are explored in Section 8.

Table 4: Main Results - Rural Sample.

Dep. Variable	Expenditure (1)	Unemployment (2)	Ownership (3)	Housing (4)	Illness (5)	Poverty (6)
Localoutput	2976.1***	-0.005***	0.006*	0.001	-0.007***	-0.007*
	(1123.3)	(0.001)	(0.004)	(0.002)	(0.001)	(0.004)
$Transport \times Output$	36.059	-0.000***	0.001***	0.000*	0.000	-0.000**
	(37.630)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mine Worker	1.7e+05*	-0.096	1.454	1.083	-0.431	-0.687
	(1.0e+05)	(0.300)	(1.286)	(0.821)	(0.462)	(0.475)
Migrant	1.1e+05**	-0.152	-0.031	-0.264*	0.475***	-0.911***
	(4.7e+04)	(0.149)	(0.152)	(0.137)	(0.161)	(0.156)
District FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
HH Controls	Y	Y	Y	Y	Y	Y
R-Squared	0.23	0.10	0.65	0.17	0.27	0.25
N	646	646	646	646	646	646

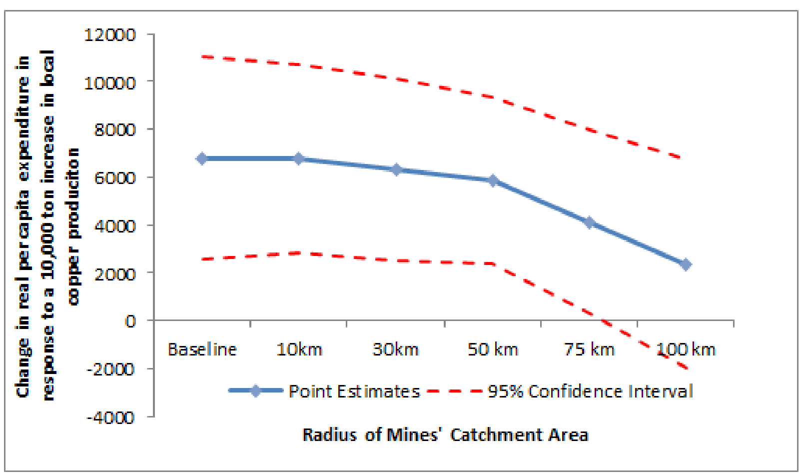
Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size.

Table 5: Spill-Overs to Non-Mining Constituencies.

	Baseline (1)	10km (2)	30km (3)	50km (4)	75km (5)	100km (6)
Localoutput	6763.7***	6781.5***	6309.9***	5882.2***	4132.0**	2373.7
	(2152.9)	(1996.8)	(1921.7)	(1754.6)	(1933.9)	(2198.5)
	[2107.4]	[1968.4]	[1894.7]	[1724.5]	[1901.3]	[2169.0]
$Transport \times Output$	883.4	510.4	506.3	425.7	420.4	947.5*
	(558.7)	(361.1)	(359.2)	(356.7)	(359.8)	(480.0)
	(466.89)	[453.7]	[451.1]	[447.0]	[451.7]	[610.0]
District FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
HH Controls	Y	Y	Y	Y	Y	Y
R-Squared	0.56	0.57	0.57	0.58	0.57	0.43
N	745	745	745	745	745	745

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses. Square brackets give Conley (1999) standard errors allowing for arbitrary spatial correlation. The full set of household controls includes education, age, gender, and household size. *** p<0.01, ** p<0.05, * p<0.10.

Figure 6: Spatial Dimension of the Spill-Overs



Non-Mining Constituencies To examine the extent of positive spill-overs to non-mining areas I relax the restrictive assumption that benefits of increased mine production accrue only to households in the very constituency in which the mines are located and redefine *Localoutput* as the aggregate output of all copper mines within certain radii from the centroid of the respective constituency. Table 5 reports the effects of changes in mine activity on per capita expenditure for different threshold levels and provides evidence that the market linkages of the mines extend beyond the most local environs: constituency-level copper production affects living standards (as proxied by per capita expenditure) even in adjacent non-mining constituencies. Standard errors corrected for spatial dependence (Conley, 1999) - reported in square brackets - are quantitatively similar to the robust standard errors clustered at the district level suggesting that spatial correlation is unlikely to be a reason for concern. Consistent with increasing transportation costs and imperfect labor mobility, the magnitude of positive spill-overs decreases monotonically with distance and becomes statistically insignificant after c. 75km[18]. This pattern is illustrated in figure 6. Nine Zambian constituencies with a total population of c. 980,000 people contain one or more large-scale copper mines. The findings above suggest that the positive effects of the copper boom are even further reaching: the total catchment area of all twelve mines comprises 23 constituencies and more than two million people.

6.3 Local and Relative Price Effects

An analysis of local and relative prices is of interest for at least two reasons. First, the preceding discussion raises the question whether the significant increase in expenditure in mining regions is primarily a price or quantity effect. Expenditure is only a reliable proxy for living standards in this setting if mining areas did not experience significantly higher inflation rates than the rest of the country. Second, the boom has general equilibrium effects on prices of non-traded goods that may partially offset competing effects such as increased demand for locally produced goods or services. The local multiplier of the copper boom, thus, depends crucially on the nature of changes in local prices (Moretti, 2010). In the following I examine boom-induced changes in local and relative prices.

Local Prices In order to compare inflation rates between mining and non-mining areas, I re-estimate the baseline specification with property rental rates, a price index of imported consumer durables and a self-reported measure of living costs[19] as dependent variable. Property rental rates and perceptions of living costs are determined by local market conditions and expected to capture the boom-induced effect on local prices. The asset price index *Asset Value*[20] consists exclusively of imported goods and should not be affected by local copper production. A shortcoming of this analysis is that the data quality does not allow me to control for either property size or the quality of consumer durables[21]. Again, results should be interpreted with care and best in combination with complementary evidence. The point estimates in columns 1-3 of Table 6 indicate that prices in mining regions generally increased in response to the boom but none of the effects is statistically significant at the 10% level. Note that year fixed-effects control for countrywide inflation. Following Moretti (2010) the absence of local inflation in booming regions can be explained by locally elastic supply curves. The high unemployment in mining regions in conjunction with

[18] This result is consistent with Aragon and Rud (2013b) who find that households living within a 100km radius of the Yanacocha mine in Peru benefit from the mine's expansion.

[19] Amount of money necessary for an adequate standard of living

[20] *Asset Value* denotes the price index of four import goods (TV, phone, radio, DVD Player) weighted by the first factor of a principal component analysis. See Appendix Table A3 for details.

[21] In addition, data is not available 1996 and 1998.

competition and scale economies in the agricultural sector may help explain why the increased demand for agricultural products is met by an increase in supply rather than higher prices. Therefore, I find no strong evidence of boom-induced inflation in mining constituencies relative to the rest of the country suggesting that the increase in expenditure is driven by quantity rather than a price effects.

Table 6: Effects on Local and Relative Prices.

Dependent Variable:	Monthly Rent (1)	Asset Value (2)	Living Costs (3)	Relative Prices (4)
Localoutput	4546.0	588.7	18239.4	0.0022*
	(2917.6)	(11614.9)	(14648.8)	(0.0012)
$Transport \times Output$	533.	-8639.8*	-3618.4	0.0002
	(681.3)	(4768.2)	(5168.6)	(0.0003)
R-Squared	0.66	0.16	0.50	0.64
N	544	271	449	252

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size.

Relative Prices Economic theory predicts that boom-induced higher economic activity in mining regions should drive up prices of non-traded goods and services relative to prices of traded goods (Cordon and Neary, 1982; Moretti, 2010). To test for relative price effects and local Dutch Disease symptoms I construct a relative price ratio with rental rates in the numerator and the price index of consumer durables in the denominator. Property rental rates are determined locally and serve as a proxy for the price of non-traded goods. *Asset Value* is used as a proxy for the price of traded goods. Column 4 in Table 6 displays the estimated change in relative prices following a 10,000 metric ton increase in local copper production. The index increases by 0.002 points, or 2.5%, suggesting that prices of non-traded goods increase somewhat faster than those of traded goods in mining constituencies. The effect is weakly significant (p-value of 8.2%) and consistent with the predictions of Moretti's (2010) theoretical framework. Elastic labor and housing supply in conjunction with limited in-migration ensure that the increase in local and relative prices remained modest throughout the boom and only partially offset positive effects of increased mine expansion.

7 Robustness Checks

The preceding analysis provides evidence that changes in local copper production affect living standards in mining areas via the mines' backward linkages. This section examines the robustness of these results and reviews alternative mechanisms that may explain the improvement of socioeconomic outcomes in mining constituencies. In particular, the *"migratory nature"* of Zambia's population (Fraser and Larmer, 2007, p. 615) and changes in the spatial distribution of government spending over time may confound the analysis. Overall, the results of the previous section appear remarkably robust and are not driven by selective migration. The effect of political spending cannot be tested directly due to unavailability of an official decomposition of fiscal spending by region or district. I turn to insights from the literature on Zambian politics to motivate the use of constituency-level election data as a proxy for changes in the spatial distribution of political spending over time. The positive effects of mine-level production on local living standards appear even more pronounced when controlling for government spending.

7.1 Robustness and Specification Checks

Table 7 displays the results of a series of robustness checks. The baseline results are reprinted in Panel A for ease of comparison and Panels B - D explore the sensitivity of the estimates to changes in the lag structure of *Localoutput*. As hinted at previously, slow market adjustment in response to higher mine activity can motivate longer lag structures (Panel B) to allow spill-over effects to trickle down. On the other hand, interpreting production capacity as a proxy for past investment spending may suggest that contemporaneous of future copper production capture the true spill-overs of mine expansion (Panel C and D). The baseline results appear to be remarkably robust to alternative choices of the lag structure. The estimated positive effects of the boom is even more pronounced when allowing for longer lags of local copper production and contemporaneous production levels yield quantitatively similar estimates. Local copper production lead by two years still has highly significant effects on socioeconomic outcomes, albeit somewhat weaker in magnitude.

As a further robustness check I examine the sensitivity of standard errors to alternative clustering choices. In order to control for nested two-way clustering at the constituency and district level, the baseline specification clusters standard errors at the higher level of aggregation (i.e. district level; cf. Pepper, 2002). Panel E presents standard errors clustered at the constituency level, the level at which copper output varies. The standard errors do not change systematically in one direction and all results remain statistically significant at the 1% level suggesting that that clustering levels are only of second-order importance in this setting. To control for serial correlation in outcome variables over time and within districts Panel F presents standard errors that allow for district-year clustering (Cameron et al., 2011). Standard errors with two-way clustering are somewhat larger in all regressions but results remain statistically significant at conventional levels. Panels G and H document that the results are not driven by one particular set of mines. Overall, the estimated effects change remarkably little when excluding the two constituencies with depleting mines (Nchanga and Bwana Makuba) from the sample. The rapid increase in production capacity of the two new mines (cf. figure 4), however, may be a reason for concern. The Kansanshi and Lumwana mines are now two of the largest copper mines in the world and dropping them from the sample unsurprisingly changes some of the point estimates. Nonetheless, the general conclusion that increased mine activity improves socioeconomic outcomes locally continues to be true for the remaining mining constituencies. Similarly, dropping all households residing the capital Lusaka does not qualitatively change the results (Panel I).

Table 7: Robustness Checks.

Dep. Variable	Expenditure (1)	Unemployment (2)	Ownership (3)	Housing (4)	Illness (5)	Poverty (6)
Panel A: Baseline Specification						
Localoutput	6763.7***	-0.007***	0.011***	0.014***	-0.005***	-0.008***
	(2152.9)	(0.002)	(0.003)	(0.004)	(0.001)	(0.002)
R-Squared	0.56	0.10	0.84	0.47	0.33	0.38
Panel B: Contemporary Copper Production						
Localoutput	7655.2***	-0.009***	0.010***	0.012***	-0.004***	-0.006**
	(2288.9)	(0.003)	(0.004)	(0.003)	(0.001)	(0.003)
R-Squared	0.56	0.11	0.84	0.47	0.33	0.38
Panel C: Copper Production Lagged Two Periods						
Localoutput	7307.4**	-0.009***	0.016***	0.015***	-0.003**	-0.012***
	(3022.6)	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)
R-Squared	0.56	0.10	0.84	0.47	0.33	0.38
Panel D: Copper Production Lead Two Periods						
Localoutput	5230.0**	-0.007***	0.008***	0.010***	-0.003***	-0.005***
	(2164.8)	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)
R-Squared	0.56	0.11	0.84	0.47	0.33	0.38
Panel E: Standard Errors Clustered at Constituency Level						
Localoutput	6763.7***	-0.007***	0.011***	0.014***	-0.005***	-0.008**
	(2134.6)	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)
R-Squared	0.56	0.10	0.84	0.47	0.33	0.38
Panel F: Two-Way Clustering of Standard Errors (District-Year)						
Localoutput	6763.7**	-0.007*	0.011**	0.014*	-0.005***	-0.008**
	(2838.9)	(0.004)	(0.005)	(0.008)	(0.002)	(0.003)
R-Squared	0.80	0.37	0.91	0.90	0.51	0.76
Panel G: Dropping Depleting Mines						
Localoutput	8631.7***	-0.009***	0.013***	0.014***	-0.005***	-0.009***
	(2616.0)	(0.003)	(0.004)	(0.004)	(0.001)	(0.002)
R-Squared	0.55	0.10	0.84	0.46	0.34	0.37
Panel H: Dropping New Mines						
Localoutput	37317.9*	-0.038***	0.061***	0.046**	-0.001	-0.033*
	(20115.7)	(0.013)	(0.018)	(0.023)	(0.011)	(0.018)
R-Squared	0.56	0.11	0.84	0.46	0.33	0.37
Panel I: Dropping Lusaka						
Localoutput	6749.3***	-0.007***	0.012***	0.015***	-0.005***	-0.008***
	(2431.1)	(0.002)	(0.003)	(0.004)	(0.001)	(0.002)
R-Squared	0.55	0.09	0.83	0.46	0.32	0.32
Panel J: Non-Migrant Sample						
Localoutput	7481.2***	-0.006***	0.016***	0.019***	-0.003**	-0.013***
	(2268.9)	(0.002)	(0.003)	(0.004)	(0.001)	(0.002)
R-Squared	0.57	0.11	0.83	0.61	0.33	0.43
District FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
HH Controls	Y	Y	Y	Y	Y	Y

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size.

Selective Migration The positive effects of the boom on measures of living standards in mining regions have so far been attributed to the strength of market linkages between the mining sector and the regional economy. However, the results would require a slightly different interpretation if the copper boom had motivated the most productive workers to move to mining areas in search of work. Economic migration is common in Zambia and the boom, therefore, is expected to affect socioeconomic outcomes directly via the mines' backward linkages and indirectly via attracting skilled workers. The baseline specification controls for the fraction of migrants in each constituency but a more rigorous way to disentangle the two effects is to exclude all migrants from the sample. Panel J shows that the estimated effects of the boom on living standards outcomes in mining areas are quantitatively similar for the non-migrant sample. Hence, the spill-over effects from increased mine activity can indeed be attributed to strong backward linkages of the mines.

7.2 Potentially Confounding Factors - The Role of Government Spending

Vote buying and the *"blatant misuse"* of state resources to finance political power struggles or election campaigns has been a common theme in Zambian politics since independence in 1964 (Rakner and Svasand, 2005, p. 68). The results of the previous section would be biased if government spending increased disproportionately in mining-areas relative to the rest of the country.

Political Background For most of the post-independence period, the political landscape in Zambia was dominated by President Kenneth Kaunda and his United National Independence Party (UNIP). Following the landslide victory of Frederick Chiluba in the presidential elections of 1991, the Movement for Multi-Party Democracy (MMD) assumed political control in large parts of the country and remained in power for the entire sample period. MMD leaders continued UNIP's malpractice of using government resources to buy political influence, for example by making donations to influential institutions and selling council houses in strongly contested constituencies (Rakner and Svasand, 2005). Rakner and Svåsand (2005) further document how the degree of political corruption increased during the 2000s with the introduction of the presidential discretionary fund in 1999. Chiluba himself was constitutionally barred from running for a third term as president in 2001 and eventually nominated Vice-President Levy Mwanawasa rather than MMD National Secretary Michael Sata as his successor. Angered by this choice, Sata left the MMD to establish the Patriotic Front (PF) and ran for president himself. Critical for the analysis is the rise of Michael Sata and his Patriotic Front (PF) during the 2000s and how this development affected MMD's political strategy, and the spatial distribution of political spending in recent years. In the decade following the 2001 elections Sata increasingly managed to mobilize both populist and ethnic support (Cheesman and Hinfelaar, 2009) and steadily increased his vote share from 3.4% in 2001 to 42.2% in 2011 when he was eventually elected president (Electoral Commision of Zambia, 2001 and 2011).

Crucially, however, the literature on Zambian politics suggests the changing political landscape and emergence of the PF led to a gradual shift over time in MMD's political focus away from the predominantly urban Bemba-speaking mining-constituencies of the Copperbelt towards poorer rural areas. Cheeseman and Hinfelaar (2009) document that the MMD leaders following Chiluba could no longer rely on support from the politically important urban population in the Copperbelt or other Bemba-speaking regions which had mostly been captured by Sata's PF. Instead, Mwanawasa - and after his death, Rupiah Banda - shifted political attention increasingly towards rural constituencies with the consequence that *"urban Bemba-speaking communities, which had played such a vital role in the MMD's rise to power in 1991, came to feel increasingly marginalized by the government"* (Cheesman and Hinfelaar, 2009, p. 64). Fraser and Larmer (2007) discuss Sata's rise to prominence and argue that part of his success can be attributed to the fact that the PF managed to assume control over MMD's branch structures in the Copperbelt. Importantly, Sata had little financial support and campaigned on populist and ethnic grounds. MMD, on the other hand, consolidated rural votes by increasing state provision of agricultural support in rural areas, including the subsidization of fertilizer production and the purchase of excess food production. Combined, this literature suggests that changes in political spending are unlikely to be responsible for the improvement in living conditions in the Copperbelt. There is no reason to believe that fiscal or campaign spending has increased more over time in the mining-regions of the Copperbelt relative to the rest of Zambia. If anything, the opposite is more likely.

Econometric Analysis Three reasons emerge from the preceding discussion why data on election outcomes may be a good proxy for unavailable constituency-level data on government spending: (i) the same political party (MMD) was in power over the entire sample period; (ii) the party appears to have extensively misused state funds for campaigning purposes, and (iii) there has been a shift in MMD's political focus away from the mining regions in the Copperbelt in response to the rise of Michael Sata. In addition, there seems a reasonably high correlation between political spending and election outcomes. Fraser and Larmer's (2007) observation that increased agricultural support by the government seems *"to have boosted MMD support"* (p. 634) provides some confidence in this regard.

To quantify the effect of politically motivated spending I construct two time-varying dummy variables: *Winning Party* takes the value one if MMD was to become the strongest party in the next presidential election in that respective constituency; *Ruling Party* takes the value one if MMD had been the strongest party in the previous presidential election. Which variable better captures the political spending effect is ultimately an empirical issue. Larmer and Fraser (2007) note that *"[s]enior MMD leaders did promise to "reward" constituencies for voting MMD"* (p. 633) and threatened to neglect constituencies that voted for the opposition. On the other hand, anecdotal evidence suggests that MMD significantly improved efforts in the run-up to the elections[22]. Columns 2 and 3 in Table 8 document the relevance of political spending for household welfare. Both political controls have a large and negative impact on per capita expenditure providing suggestive evidence that changes in the spatial distribution of government spending did indeed affect consumption levels. To analyze how the political spending effect changed over time I interact the political controls with the respective year dummies[23]. Results are shown in columns (4) and

[22] Personal conversation with Miles Larmer, editor of the book *Zambia, Mining, and Neoliberalism: Boom and Bust on the Globalized Copperbelt.*

[23] *Winning Party 2011*, for example, takes the value one in 2010 if MMD won the 2011 election in that particular constituency

Table 8: Effects of Political Spending on Household Expenditure.

Dep. Variable	Expenditure (1)	Expenditure (2)	Expenditure (3)	Expenditure (4)	Expenditure (5)
Localoutput	6763.7***	7928.8***	8787.3***	8151.1***	8384.3***
	(2152.9)	(2195.5)	(1963.6)	(2011.0)	(1910.7)
$Transport \times Output$	883.4	684.1	556.2	564.7	480.3
	(558.7)	(453.6)	(430.7)	(437.3)	(437.0)
Winning Party		-10034.6**			
		(4603.1)			
Ruling Party			-28741.7***		
			(7148.8)		
Winning Party 1996				10305.9	
				(12048.6)	
Winning Party 2001				-4259.2	
				(15984.5)	
Winning Party 2006				14675.0	
				(8943.2)	
Winning Party 2008				-31497.9**	
				(14817.8)	
Winning Party 2011				-35732.9**	
				(13677.1)	
Ruling Party 1996					8435.5
					(13537.4)
Ruling Party 1998					-28358.9
					(28092.3)
Ruling Party 2002					-18428.5*
					(10045.2)
Ruling Party 2006					-34427.4**
					(14853.4)
Ruling Party 2010					-45625.9***
					(15177.7)
Year FE	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y
HH Controls	Y	Y	Y	Y	Y
R-Squared	0.56	0.57	0.58	0.58	0.58
N	745	745	745	745	745

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size.

(5). An interesting pattern emerges: the effect of the political controls is large and positive but statistically insignificant at the beginning of the sample period and becomes more negative and increasingly significant over time. Crucially, the coefficients should not be given causal interpretations - there is no reason to believe that MMD voting directly decreases living standards in a constituency. Rather, the pattern illustrates the changes in Zambia's political landscape over the past 15 years. The evidence is consistent with Cheesman and Hinfelaar's (2009) account that the MMD under Chiluba derived its support from the richer urban areas of the Copperbelt and Lusaka while Mwanawasa and Banda directed the party's focus towards the relatively poorer rural regions.

Notably, the point estimates on localoutput increase substantially with the inclusion of the political variables suggesting that the baseline regression may actually underestimate the true effect of the boom on socioeconomic outcomes due to the presence of omitted variable bias. Election outcomes are very crude way to proxy for political spending by region and I am hesitant to interpret the results as conclusive evidence. Nonetheless, the estimates indicate - in conjunction with the evidence from the literature on Zambian politics - that changes in the spatial distribution of political spending are unlikely to drive the baseline results.

In summary, the conclusion that the local population benefited from the increased mine production due to the presence of backward linkages appears very robust. The next section examines channels of transmission through which this effect may have worked.

8 Channels of Transmission

The previous sections provide robust evidence that changes in local copper production affect measures of living standards in the surroundings of the mines. In this section, I explore possible channels of transmission from mine production to living standards. The findings suggest that the urban and rural population benefited from a boom-induced increase in the demand for services and agricultural products, respectively.

8.1 Why does the urban population benefit from the boom?

The direct effect of the boom - accruing to mining employees in the form of increased labor demand - may be limited due to the capital-intensity of the actual operations even though overall employment in the mining sector nearly tripled over the course of the boom (Wilson, 2012). The absolute increase in wage bills of the mining sector is relatively modest compared to the size of the boom[24] and unable to explain the magnitude and geographical extent of the spill-overs. In the following, I explore the backward linkages of the mines in more detail to shed light on possible transmission mechanisms.

There are two channels through which the boom is expected to raise the demand for services. First,

while *Ruling Party 2010* takes the value one if MMD had won the previous election in that constitueny.

[24]Fraser and Lungu (2007) show that real wages did not increase over the course of the boom and discuss deteriorating working conditions.

directly via increased mine-level demand for local inputs. The mining sector purchases a wide range of services locally and the demand for transportation, construction, and cleaning services is sensitive to changes in the scale of mine operations. Second, indirectly via the local multiplier effect. Higher employment and wage levels in mining areas generate positive spill-overs to the wider services sector including restaurants, hotels and guest houses, morticians, as well as medical and laundry services. Moretti (2010), for example, finds that for each additional job in the traded sector[25], 1.6 jobs are created in the non-tradable sector via the local multiplier. In Cordon and Neary's (1982) analytical framework with full employment, this positive local spending effect is (partially) offset by the resource movement effect (cf. section 3). The presence of large pre-boom unemployment and import-intensive nature of copper mining suggest that the local spending effect dominates. Hence, the excess demand for services is likely met by a rise in the output rather than the price of services and expected to increase employment in the services sector.

Table 9: Channels of Transmission.

	Services (1)	Services (Finance) (2)	Services (Health) (3)
$Localoutput$	0.005***	0.009***	0.005***
	(0.001)	(0.003)	(0.001)
$Transport \times Output$	0.002***	0.001**	0.002***
	(0.001)	(0.001)	(0.001)
R-Squared	0.579	0.522	0.700
N	745	745	745

Notes: Each specification includes constant. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10. The full set of household controls includes education, age, gender, and household size.

To test this prediction I re-run the baseline regression with the fraction of people employed in the services sector as the dependent variable. Table 9 displays the results for various definitions of services sector. In the baseline case (column 1) the services sector comprises construction, transportation, telecommunication and lodging. The definition is extended in columns 2 and 3 to include the finance and real estate sector and the health sector, respectively. The estimated effects indicate that an increase in local copper production by 10,000 metric tons is associated with a 0.5-0.9 percentage point (5-10%) increase in the fraction of people employed in the services sector. The simultaneous decrease in the unemployment rate of similar absolute size (cf. Section 6) suggests that Dutch Disease effects on the sectoral composition of employment are limited in the Zambian case (see, for example, Frankel (2010) for a theoretical discussion).

Hence, the change in the composition of labor demand is an important channel through which the local population benefits from the copper boom.

[25]Moretti examines the local multiplier of the manufacturing sector.

8.2 Why does the rural population benefit from the boom?

Intuitively, higher economic activity in mining areas is expected to raise, amongst other things, the demand for food. Since many agricultural products including vegetables, dairy products and maize are produced and traded locally, farmers in the rural hinterland of mining cities are likely to see some of the benefits of the boom. The *Development Issue* section of the LCMS questionnaire contains questions regarding changes in infrastructure and market conditions that allow for a more thorough analysis of possible transmission channels. In particular, the questionnaire asks whether agricultural inputs or buyers of agricultural products are now more readily available and whether transport or irrigation systems have improved in recent years. To identify why rural households may have benefited from increased copper production, I exclude all urban households from the sample and compute the fraction of rural respondents in each constituency that believe improvements have been made in the four categories. I then re-estimate the baseline specification with these measures on the left-hand side. Results are presented in Table 10.

I am hesitant to attach great importance to the size of the estimated effects as data is only available for 1998 and 2010 but a general message emerges quite clearly: rural households in the surroundings of an expanding mine are more likely to be satisfied with the economic environment in which they operate than their counterparts in non-mining regions.

Table 10: Channels of Transmission - Rural Sample.

	Buyers (1)	Irrigation (2)	Transportation (3)	Inputs (4)
Localoutput	0.007***	0.002***	0.010***	0.011***
	(0.003)	(0.001)	(0.002)	(0.002)
$Transport \times Output$	0.000**	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Mine Worker	1.138	2.131***	0.735	1.139***
	(1.141)	(0.283)	(1.030)	(0.423)
Migrant	-0.135	0.072	0.163	-0.025
	(0.172)	(0.061)	(0.182)	(0.120)
R-Squared	0.43	0.47	0.24	0.28
N	270	270	270	270

Notes: Each specification includes constant. The full set of household controls includes education, age, gender, and household size. Robust standard errors adjusted for clustering at the district level are given in parentheses: *** p<0.01, ** p<0.05, * p<0.10.

Consistent with the intuition that growing urban income should increase the demand for food, rural respondents in the surroundings of an expanding mine report that buyers of agricultural products are now more readily available compared to 1998 and other parts of the country (column 1). Similarly, transport connections to urban areas (column 2) and irrigation systems (column 3) seem to have improved relatively more in constituencies that saw large increases in the production of copper although there is no evidence that state provision of public goods increased disproportionally in mining-constituencies (cf. Section 7). Hence, those (perceived) improvements can at least partially be attributed to market responses. The finding that agricultural inputs are now more readily available in the rural hinterland of mining cities (self-reported, column 4) is consistent with this claim. The prospect of higher revenues incentivizes agricultural producers to increase production capacity and invest in efficiency enhancing technology. The resulting increase in the profit maximizing demand for intermediate inputs, in turn, raises the market supply of fertilizers and machinery.

In summary, the boom-induced labor demand effect, particularly for auxiliary services, raises average income in mining cities. This effect is transmitted to the rural hinterland via increased demand for agricultural products and trade links between urban and rural areas.

9 Conclusion

This paper exploits exogenous variation in mine-level production volumes generated by the recent copper boom in Zambia to examine local spill-overs effects of increased mine activity. Using a novel data set, I find robust evidence that an increase in local copper production improves average living standards in the surroundings of the mines. Although the absolute benefits are modest in relation to the size of the windfalls, the boom entailed substantial direct and indirect employment effects, especially in the services sector, that spurred economic activity locally. The positive spill-overs extend to the rural hinterland of mining cities, neighboring constituencies, and constituencies located on the copper transportation route. Consistent with increasing transportation costs and imperfect labor mobility, the magnitude of spill-overs to surrounding areas decreases monotonically with distance and becomes statistically insignificant after c. 75km. Since the boom failed to generate fiscal revenues or dividend income for the Zambian population, the estimated effects of mine expansion on living standards can be interpreted as a result of market linkages between the mining sector and the regional economy. Finally, I identified increased demand for services and agricultural products as key channels through which the urban and rural populations, respectively, benefit from the mine expansions.

Mining is generally considered an enclave activity with limited linkages to the regional or national economy (Hirschman, 1958). The findings in this paper, however, document a powerful local multiplier effect for the Zambian mining sector and indicate the potential of local procurement policies for resource rich developing countries. Although the extractive industry is relatively capital-intensive, local populations can benefit from mine activity if the sector is sufficiently integrated into the regional economy. It is within the means of policy makers to strengthen backward and forward linkages by establishing and enforcing subsidy, tariff and purchasing policies that benefit local companies and favor domestic value addition over the export of primary commodities. A key contribution of this work is the finding that the strengthening of market linkages between the resource sector and the domestic economy can add to the development of a resource rich country.

The results, however, allow no conclusions about the overall welfare implications of resource booms. In the absence of data on pollution, little can be said about potential negative externalities of increased copper production. A full welfare analysis of the boom would require a thorough examination of all environmental implications. Furthermore, the results reflect short-term effects and it remains to see whether the improvements in material living standards are permanent or transient. Since the Zambian copper boom is still ongoing, the analysis could be extended in several ways as new data becomes available. In particular, the stability periods guaranteed in the *Development Agreements* are about to expire implying that the state can remove some of the tax concessions made during privatization and is increasingly likely to benefit from the boom via tax contributions from the mining sector in the years to come. How such a fiscal windfall should be managed and how it affects living standards and political life in Zambia is subject to further research.

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Appendix

Table A1: Windfall Calculations

Discount Factor: 8%

Year	[1] Value of Exports $m	[2] Quantity Exported 000s ton	[3] Price per ton $	[4] Counterfactual Value of Exports $m	[5] in current $m	[6] MUV	[7] Windfall adj. for import prices $m	[8] GDP current $m	[9] GDP Deflator	[10] GDP in constant $m	[11] in constant $m	[12] Windfall as % GDP	[13] NPV Windfall $m
1. Copper													
2002	554,2	329.964	1.679	554,2	0,0	1,00	0,0	3.711	1,00	3711,0	0,0	0,0%	0
2003	606,9	353.414	1.717	593,5	13,4	1,07	12,5	4.342	1,20	3625,8	10,4	0,3%	10
2004	985,0	393.182	2.505	660,3	324,7	1,15	281,8	5.439	1,44	3785,0	196,1	5,2%	168
2005	1.515,6	428.385	3.538	719,4	796,2	1,19	671,2	7.179	1,68	4269,3	399,2	9,3%	317
2006	3.029,3	476.104	6.363	799,6	2229,7	1,21	1839,9	10.702	1,91	5617,0	965,7	17,2%	710
2007	3.406,5	473.415	7.196	795,1	2611,4	1,29	2027,8	11.541	2,15	5370,1	943,5	17,6%	642
2008	3.684,5	584.288	6.306	981,3	2703,2	1,39	1946,5	14.705	2,43	6063,1	802,6	13,2%	506
2009	3.179,3	675.384	4.707	1134,3	2045,0	1,30	1577,0	12.805	2,68	4784,5	589,2	12,3%	344
2010	5.767,9	822.569	7.012	1381,5	4386,4	1,34	3274,7	15.691	2,95	5313,5	1108,9	20,9%	599
										Total	**5015,7**		**3295**
										% 2002 GDP			**88,8%**
2. Cobalt													
2002	57,8	4.025	14.371	57,8	0,0	1,00	0,0	3.711	1,00	3711,0	0,0	0,0%	0
2003	62,0	3.374	18.378	48,5	13,5	1,07	12,6	4.342	1,20	3625,8	10,6	0,3%	10
2004	118,0	6.102	19.338	87,7	30,3	1,15	26,3	5.439	1,44	3785,0	18,3	0,5%	16
2005	158,2	5.451	29.022	78,3	79,9	1,19	67,3	7.179	1,68	4269,3	40,0	0,9%	32
2006	146,1	4.663	31.332	67,0	79,1	1,21	65,3	10.702	1,91	5617,0	34,3	0,6%	25
2007	261,2	4.614	56.610	66,3	194,9	1,29	151,3	11.541	2,15	5370,1	70,4	1,3%	48
2008	316,5	4.608	68.685	66,2	250,3	1,39	180,2	14.705	2,43	6063,1	74,3	1,2%	47
2009	168,5	5.868	28.715	84,3	84,2	1,30	64,9	12.805	2,68	4784,5	24,3	0,5%	14
2010	303,8	8.703	34.908	125,1	178,7	1,34	133,4	15.691	2,95	5313,5	45,2	0,9%	24
										Total	**317,3**		**216**
										% 2002 GDP			**5,8%**
3. Aggregate Mineral Boom										**Total Windfall**			**3511,1**
										% 2002 GDP			**94,6%**

Table A2: Central Government Revenue, 2001 - 2010 (% of GDP)

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Total Revenue and Grants	24.9%	26.2%	24.9%	23.8%	23.7%	21.6%	22.9%	22.0%	18.9%	19.7%
Tax Revenue	19.1%	17.9%	18.0%	18.3%	17.2%	17.2%	18.4%	18.2%	16.0%	17.7%
Tax on Incomes and Profits	7.2%	7.6%	7.2%	7.8%	7.4%	7.5%	8.1%	7.8%	7.9%	9.4%
Individuals	5.7%	5.9%	5.6%	6.5%	6.0%	5.7%	5.5%	5.4%	5.4%	5.8%
Corporations	1.5%	1.7%	1.6%	1.3%	1.4%	1.8%	2.6%	2.4%	2.1%	3.1%
of which Mining Company Tax	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.23%**	**0.62%**	**1.60%**
Taxes on Goods and Services	4.9%	4.7%	4.3%	4.1%	4.2%	3.6%	2.7%	1.8%	2.1%	2.8%
of which Mining Licence	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.01%**	**0.01%**	**0.00%**	**0.00%**
Mineral Royalty	**0.05%**	**0.02%**	**0.04%**	**0.02%**	**0.12%**	**0.11%**	**0.17%**	**0.39%**	**0.36%**	**0.54%**
Taxes on International Trade	6.5%	5.2%	5.1%	5.6%	5.1%	5.1%	6.7%	7.5%	5.1%	4.7%
Other Revenue	0.5%	0.3%	1.4%	0.8%	0.4%	0.9%	0.7%	0.7%	1.0%	0.9%
Grants	5.7%	8.3%	7.0%	5.5%	6.4%	4.4%	4.5%	3.7%	2.9%	2.0%
Direct Taxes on Mining Companies										
As Share of Total Revenue	0.27	0.10%	0.24%	0.12%	0.71%	0.67%	0.95%	3.41%	6.57%	12.66%
As Share of GDP	**0.05%**	**0.02%**	**0.04%**	**0.02%**	**0.12%**	**0.11%**	**0.18%**	**0.62%**	**0.98%**	**2.14%**

Sources: Adam and Simpasa (2009), Bank of Zambia, Zambia Revenue Authority.

Table A3: Data Appendix

Variable Name	Description	Source
Age	Average age of all respondents in the respective constituency. Question: How old are you now?	LCMS (I-VI)
Age Kids	Average age in months of all children (3-59 months) in the respective constituency. Used in regressions with *Illness* as dependent variable. Question: How old is $\cdots$ now?	
Asset Value	Asset value index constructed using principal component analysis. First, I compute the average value of consumer durables (phones, radios, TVs, VHS/DVD players) per constituency that were bought within the last 12 months. Value refers to the purchase price (N.B: I cannot control for quality of the asset). I then aggregate these values using the first factor of a principal component analysis on the ownership rates of these items. The factor explains 75.33% of the variance. The weights are: 0.8742 for 'phone', 0.9476 for 'DVD', 0.954 for 'TV', and 0.7564 for 'radio'.	
Buyers	Fraction of rural households in constituency that believe buyers of agricultural products are now more readily available than 12 months ago. Questions: Have the following projects or changes occurred in your community in the last 12 months? Buyers of agricultural produce more readily available?	
Degree	Fraction of adults (25 and above) in the constituency that hold a degree. Question: What was the highest grade attained?	
Expenditure	Constituency-level average monthly per capita (adult equivalent) expenditure in 2010 Kwacha. Computed as total monthly household expenditure divided by the number of adult equivalent household members.	
Food Basket	Constituency-level average price of a food basket. Composition of basket: 20 eggs, 10 loafs of bread, 10l milk, 1kg beef, 1 chicken, 1kg tomatoes, one heap of onions and 5kg rice. Unit prices imputed using information on units, quantities and prices. Question: How much was spent on the following food items during the last 2 weeks (unit, quantity, price)?	
HHSize	Mean household size (number of household members) in constituency. Question: How many people reside in this household?	
Housing	Housing conditions index constructed using principal component analysis. First, I compute the fraction of households in each constituency that have access to electricity and tap drinking water. I then aggregate these values using the first factor of a principal component analysis. The factor explains 90.86% of the variance. The weights are: 0.9532 for 'electricity access' and 0.9532 for 'tap drinking water'. Questions: What is the main source of drinking water for this household during the wet and dry seasons? Is your house connected to electricity?	
Illness	Fraction of children (3-59 months) in the constituency that fell ill in the two weeks leading up to the interview. Illness defined as sickness or injury. Question: Has $\cdots$ been sick or injured during the last two weeks?	
Inputs	Fraction of rural households in constituency that believe agricultural inputs are now more readily available than 12 months ago. Questions: Have the following projects or changes occurred in your community in the last 12 months? Agricultural inputs now more readily available?	

Table A3 (cont'd): Data Appendix

Variable Name	Description	Source
Irrigation	Fraction of rural households in constituency that believe the supply of water is now better than 12 months ago. Questions: Have the following projects or changes occurred in your community in the last 12 months? Water supply rehabilited or improved?	LCMS (I-VI)
Living Costs	Constituency-level average of money required on a monthly basis for an adequate standard of living in current Kwacha (self-reported). Question: How much money do you think is needed in a month to have an adequate/minimum standard of living?	
Localoutput	Annual constituency-level copper production in 10.000 metric tons. Sources: Company annual reports (various years), Ministry of Mines and Minerals Development, Raw Materials Group (IntierraRMG), World Mine Cost Data Exchange, ZCCM annual reports (various years).	See description
Localvalue	Imputed value of annual constituency-level copper production in 10 billion Kwacha (2010 prices). Calculated as *Localoutput* times average annual world price of copper in Kwacha.	Datastream
Male	Fraction of male respondents per constituency. Question: Is ⋯ male or female?	
Male Kids	Fraction of boys among all children in the sample (3-60 months). Used in regressions with Illness as the dependent variable. Question: Is ⋯ male or female?	
Migrant	Fraction of households in constituency that migrated within the last 12 months. I use the CSO definition of migration: A person is classified as a migrant if he moved between districts. Question: Where were you residing 12 months ago?	
Mine Worker	Fraction of employed with job in the mining sector (per constituency). Includes mining and quarrying laborers, mining-plant operators, miners and quarry workers, mining and metallurgical technicians, and mining engineers, metallurgists and related professionals. Question: What type of job/business are you doing?	
Monthly Rent	Constituency-level average monthly rental rates in current Kwacha (for renting households). Question: How much rent are you charged per month?	
Output	Annual aggregate volume of copper production in 10,000 metric tons.	Bank of Zambia
Ownership	Consumer durable ownership index constructed using principal component analysis. First, I compute average rates of consumer durable ownership (cars, phones, radios, TVs, VHS/DVD players) per constituency. I then aggregate these values using the first factor of a principal component analysis. The factor explains 71.96% of the variance. The weights are: 0.7843 for 'phone', 0.26253 for 'DVD', 0.26132 for 'TV', 0.22616 for 'car', and 0.20506 for 'radio'. Question: Does this household own a/an ⋯?	

Table A3 (cont'd): Data Appendix

Variable Name	Description	Source
Poverty	Fraction of at least moderately poor households per households (incl. severely poor households). The CSO classifies each household as either severely, moderately or not poor based on household expenditure in relation to a minimum consumption basket. I use this classification to compute the fraction of households per constituency that live below the poverty line.	LCMS (I-VI)
Relative Prices	Relativ price index calculated as *Monthly Rent* over *Asset Value*.	
Rural	Fraction of rural households in each constituency. Question: Rural/Urban?	
Ruling Party	Dummy variable that takes the value one if MMD had been the strongest party in the previous presidential election in the respective constituency	Electoral Commission of Zambia
School	Fraction of respondents (5 and above) in constituency that have ever attended school. Question: Has $\cdots$ ever attended school?	
Services	Size of services sector as share of total employment. Definition of *services sector* includes: construction sector, hotels and restaurants, transportation sector, post, and telecommunication. Question: What sort of business/service is carried out by your employer/establishment/business?	
Services (Finance)	Definition of *services sector* relaxed to include jobs in the financial sector. Additional sectors included: financial intermediation, insurance, real estate, accounting, legal services, advertising, research & development, IT services, auditing. Question: What sort of business/service is carried out by your employer/establishment/business?	
Services (Health)	Definition of *services sector* relaxed to include jobs in the health sector. Additional sectors included: human health activities, veterinary activities, social work activities. Question: What sort of business/service is carried out by your employer/establishment/business?	
Transport	Dummy variable that takes the value one if the constituency is located on the copper transportation route.	ArcGIS
Transportation	Fraction of rural households in constituency that believe transportation facilities are now better than 12 months ago. Questions: Have the following projects or changes occurred in your community in the last 12 months? Transport services provided or improved?	
Unemployment	Constituency-level unemployment rate based on the sample of 16-60 year old. I classify a person as unemployed if he or she (i) is not working but looking for work/means to do business or (ii) is not working and not looking for work/means to do business but available or wishing to do so or (iii) is doing unproductive unpaid family labor. Question: What is your main economic (activity) status?	
Value	Imputed value of gross copper exports in 10 billion Kwacha (2010 prices): official annual copper export volumes times average annual world price of copper in Kwacha.	Datastream, BOZ
Winning Party	Dummy variable that takes the value one if MMD was the strongest party in the subsequent election in the respective constituency	Electoral Commission of Zambia

Note: Unless otherwise indicated, all variables are constructed using LCMS I-VII, CSO (2012)