From enclave to inclusive, the impact of socially responsible mining on local communities in the Limpopo province of South Africa

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From Enclave to Inclusive: The Impact of Socially Responsible Mining on Local Communities in the Limpopo Province of South Africa

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Abstract

This study sets out to evaluate the impact of natural resources on local economies, within the context of a developing country with a strict procurement policy on its extractive industry. Using ward level data combined with firm data, the study essentially uses a difference-in-differences estimation procedure, by exploiting local input demand shock from large industrial mines, as well as distance from a mine, as sources of variation. The main finding of this paper is that industrial mining, when governed by procurement policy that favours the hosting communities, can improve the local living standards. This finding remains robust to different indicators of mine expansion, and checks for alternative explanations such as selective migration. It uses the Limpopo province of South Africa as a fitting case study. (JEL L72, O13, O18, Q32, Q33, R11)

Keywords: Natural resources, extractive industries, poverty, corporate social responsibility

1. Natural Resources and Poverty

Most of the evidence of the impact of natural resources on living standards comes from aggregate data at country level and offers limited insight about the local economic effects of resource abundance (Aragón and Rud, 2013). There is generally very little empirical evidence on the impact of natural resource extraction on local communities. This presents an important empirical challenge towards understanding the impact of natural resources and the mechanisms thereof, in local communities in developing countries.

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Aragón and Rud (2013) examine the local economic impact of a large golden mine in Northern Peru using annual household data over a period of ten years. They find evidence of a positive effect of the mine's demand for local inputs on real income; diminishing with distance. This finding is confirmed by a similar study by the World Bank which uses a new district-level database on Peru, and finds evidence that producing districts have better average living standards than otherwise similar districts: larger household consumption, lower poverty rate, and higher literacy; diminishing with distance. However, this study finds that district level consumption inequality increases in all districts belonging to a producing province; a result which may explain the social discontent with mining activities in the country (Loayza et al., 2013).

Overall, a fuller view on the literature covering the impact of extractive industries on poverty is provided by a study by Gamu et al. (2015) who survey fifty-two empirical studies they distinguish by mode of resource extraction. They find that industrial mining is frequently associated with poverty exacerbation, while artisanal mining is associated with poverty reduction. The former is concluded from studies that use aggregate level data, while the latter uses sub-national census-based data. This confirms the motivation for more granular data level studies to understand the impact of industrial mining at the local level, which will be the focus of this paper.

Moving beyond the focus on poverty, the literature has largely associated natural resource abundance with bad institutions (Sachs and Warner, 1999, 2001), conflict (Berman et al. 2014), and the undermining of democracy (Tsui, 2011). These outcomes are structural and systematic, rooted in the enclave features of the industry. Together, these accompanying associations of extractive industries have led to enquiries around mitigating these effects through corporate social responsibility (CSR).

This study sets out to evaluate the impact of natural resources on local economies, within the context of a developing country with a strict procurement policy. It uses the Limpopo province of South Africa as a fitting case study. The study follows Aragón and Rud (2013).

The main challenge of this study will be to isolate the causal impact of mine expansion on local income poverty outcomes, during the period of study. To achieve this, the study sets out to exploit three sources of variation: the significant increase in local demand for inputs, driven by stronger local procurement and by an increase in production; the ward's distance to a nearest mine which is a source of heterogeneous exposure to the increase in mining activity; and the opening and closure of mines.

The main finding of this paper is that industrial mining, when governed by procurement policy that favours the local communities, can improve the local living standards. This finding remained robust to different indicators of mine expansion, and checks for alternative explanations such as selective migration. Because of a lack of data, this study was unable to perform a richer study on other measures of community wellbeing, such as health outcomes. To the contrary, the dependent variable throughout this study is a measure of income poverty; with one measure defining the extreme poor, and the other measure defining those who can afford sufficient nutrition and non-food items.

As an extension, this paper includes an initial attempt to understand the impact of firm behavior within the extractive industry, by constructing an index of CSR dimensions collected for each of the firms in the sample of this study. The index is only preliminary, and its construction is not yet based on scientific evidence. The results from the empirical test revealed only a mild suggestion that firm responsibility may have an additional value to improving local economic wellbeing, particularly for the poorest communities closest to a mine.

The rest of the paper proceeds as follows: Section 1.1 presents the case study. Section 1.2 outlines some of the limits of the study. Section 1.3 presents information about the data and variables. Section 1.4 presents and discusses the empirical strategy, followed by a discussion on threats to identification in section 1.5. Section 1.6 then presents the main results, followed by robustness checks in section 1.7. Section 1.8 proposes future improvements. Section 2 then briefly investigates the role of CSR. Section 3 concludes.

1.1. The case of the Limpopo Province

In 2010 Citigroup reported that South Africa is the world's richest country in terms of the value of its mineral reserves, estimated at US$2.5 trillion[1]. Most of the mineral resources are concentrated in the center-east of the country, which consists of the Northern Cape, North-West, Free State, Gauteng and the Limpopo provinces (Department of Mineral Resources, 2009).

[1] The report estimated that Russia comes second and Australia third (Citigroup, 2010)

The Limpopo province is the northernmost province of South Africa. It borders Botswana to the west, Zimbabwe to the north and Mozambique to the east. The capital of the city is Polokwane, which lies at the center of the province, while Johannesburg lies 300 kilometers south.

Isolating the Limpopo province as a case study on the impact of natural resources is ideal because of the following reasons. First, the province is the poorest in South Africa, with an official headcount of 74.4 percent in 2006, 78.9 percent in 2009, and 63.8 percent in 2011; against a national average of 57.2 percent, 56.8 percent, and 45.5 percent respectively (Lehohla, 2014). The large poverty headcount provides a strong context for a study on poverty, and the gradual decline in poverty provides an opportunity to understand part of the cause of this gain.

The second reason is that the province is predominantly rural (89 percent). Nothing much happens there except agriculture, tourism, and mining. This allows the study to isolate the mining industry and evaluate its impact.

Figure 1: Land used for agriculture in Limpopo. (Source: Author. GIS data from Department of Environmental Affairs)

Thirdly, the province is endowed with an abundance of mineral resources, which contribute on average 22 percent of the province's Gross Domestic Product. Total mineral sales of Limpopo constituted 15 percent on average of South Africa's total mineral sales between 2001 and 2011. The deposits in the province include platinum, copper, coal, iron ore, and diamond (Department of Mineral Resources, 2014). Therefore this sector is large enough to explain part of the socio-economic wellbeing of the province.

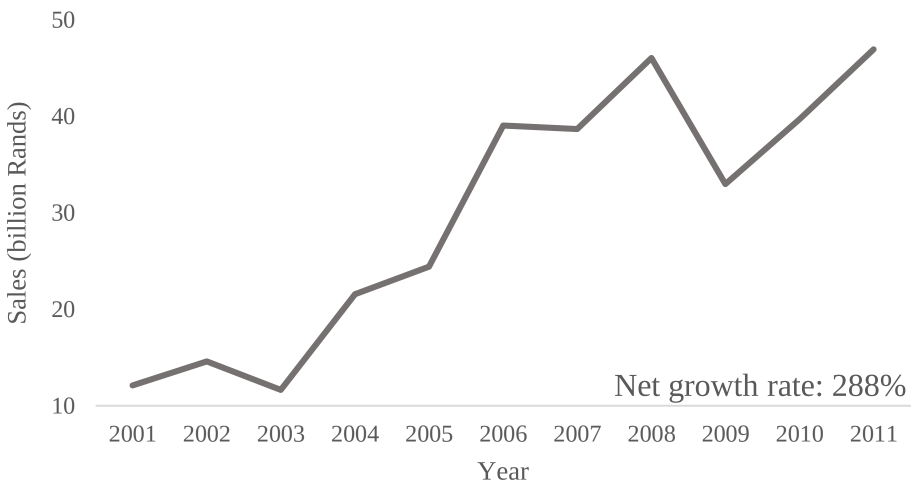

Figure 2: Limpopo Province Estimated Primary Mineral Total Sales. (Source: Author. Data from the Department of Mineral Resources). *Note that it is not clear whether the prices are nominal or real.*

Finally, the province has experienced a significant increase in both the intensity of mining (the number of mines) and the size of mining (see Figure 2). This feature is critical for the success of the empirical strategy of this paper, which uses this increase in mine activity as a treatment, and therefore allows comparison with communities that are not exposed to the demand shock.

1.2. Limits of the Study

This section outlines some of the critical limits of the study, both on what the paper is able to do and what it is unable to do. Four limits worth noting are outlined below.
Firstly, the main limit to this study is the lack of availability of data that could provide a richer set of variables, such as information on prices of local goods, health outcomes, environmental outcomes, and a richer vector of control variables at the ward level. It is likely that income poverty, as a measure of wellbeing, is insufficient to account for other important dimensions of overall community welfare. Furthermore, this study can only provide short-term results on the impact of mining on poverty, while long-term effects such as environmental wellbeing may significantly matter for the net effect of industrial mining.

Secondly, the study does not have an instrument to completely rule out possible endogeneity stemming from non-random choice of mine location or level of production. This issue is further discussed in section 1.5 of the paper and section 1.8 accounts for this issue as an additional scope for future improvement of this study.

Thirdly, because of the limits in the available data, this study cannot observe ward-level poverty rates before the opening of mines, particularly for those wards that already had mines on the first wave of this study. With this issue in mind, the study carefully specifies a model that seeks to consistently isolate the true counterfactual.

Finally, fixed effects may not be enough to account for important, uncontrolled for factors that explain the socio-economic wellbeing of communities. Nonetheless, through both ward and time fixed effects, the study can minimise the effects of these uncontrolled for characteristics. Appendix A provides a full table of available controls in this study.

1.3. Data and Main Variables

The empirical analysis uses three waves of data consisting of a stratified municipal ward sample, combined with firm data, for the years 2001, 2007, and 2011. The ward data is available through the South African Local Government Association (SALGA)'s *municipal barometer*, and is sourced from Statistics South Africa's *population census* waves 2001 and 2011, together with its *community survey* 2007. The analysis focuses on the Limpopo Province, which consists of 453 wards per wave for the period under study. The variable of interest is the share of individuals living in poverty per ward per year. The poverty lines used are the food poverty line below which one lives in extreme poverty and cannot afford sufficient nutrition, and the upper-bound poverty line describes those who are able to afford sufficient nutrition and non-food items[2].

The firm data is collected from firms' annual reports, and consists of a total of 23 large mines employing above 1000 workers on average per annum[3]; each owned by publicly listed entities. There are two main reasons for restricting analysis to these. The first reason is that a mine has to be large enough to observe a communitywide impact. The second reason is that in general, only publicly listed companies publish annual reports, which are audited by accredited external parties[4]. To measure activity of a mine, the study collects data on mine production volumes per commodity, wage bill, purchases, revenue, and number of workers employed per year. This study adjusts the purchases variable to restrict it to preferential procurement by firm per year,

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[2] The poverty lines are sourced from Statistics South Africa and are inflation-adjusted. See Lehohla, P. (2014).
[3] The exception is diamond mines in this study, which hire below 300 employees on average per annum.
[4] There are 27 listed mines shown on the DMR mine register. The majority of mines listed in the register are farmland registered under individuals and small companies, with no evidence of mining activity. Generally, companies that are not publicly listed are small and do not publish operations data publicly.

which increases confidence that this fraction represents local purchases. The wage bill ordinarily includes bonuses and profits distributed to employees. The sum of the wage bill and local purchases is used as a main measure of a mine's demand for local inputs. Table 1 below presents the summary statistics for the three waves.

To measure the impact of mine activity on local communities, the study constructs a measure of distance between a ward and its nearest mine during a given wave. This variable varies per year with the development of new mines or closure of old mines; whereby the opening of a new, closer mine changes the distance variable for the affected wards. Specifically, distance is the shortest route from a ward's central voting station to the nearest mine using existing road network. This method takes into account that voting stations are chosen based on communitywide accessibility. The study uses the Independent Electoral Commission of South Africa (IEC)'s *Voting Station finder* to locate the precise gps coordinates, and then uses the AfriGIS Map data via the Google Maps tool, to obtain distance approximations. The distance variable varies from 1 to 248 kilometers, with an average of 89.9 kilometers.

Table 1 – Summary Statistics

Variables	Mean *N* = 1606	Standard Error
Percent upper-bound poverty	93.96	0.002
Percent food poverty	89.69	0.003
Percent employed	52.13	0.005
Percent dependency ratio	77.47	0.005
Percent sanitation	29.26	0.007
Percent electricity	34.90	0.006
Percent sewerage system	15.64	0.007
Percent migration	9.65	0.004
Total Population	9,735.21	113.12
Distance to mine	89.92	1.25
Firm data *N* = 3		
Wage bill (Rm)	406.45	177.97
BEE purchases (Rm)	2,803.81	1862.98
Percent BEE Procurement	30.66	18.26
PGM (ounces)	311,529.9	43,830.99
Nickel (tons)	3,509.61	2,301.23
Copper (tons)	32,097.33	2,986.32
Diamond (carats)	5,713,208	2,647,367
Iron Ore (tons)	2,033,333	986,576.6

1.4. Empirical Strategy

The empirical challenge is isolating the causal impact of mining activity on the poverty rate of local communities. The three waves in this study provide the following quasi-experimental set up. In 2001 data is collected, providing information on ward poverty rates, characteristics, and mining activity. During 2001 and 2007, there is an expansion of mining by intensity (more mines) and increased local demand. The survey in 2007 collects the short-term data, and the process is the same for the last wave. Therefore it is possible to compare those wards that are treated and those that are not. For the pre-existing mines, treatment is strictly the expansion of mines. For wards wherein new mines open, the additional treatment is the opening of these mines, where the first year of production is considered the start of the treatment. Therefore, the true counterfactual of this study is wards both with no mines and outside of the 90 kilometer mining exposure threshold – for the period of the study.

The study therefore exploits three sources of variation. First, the study uses the significant increase in local demand for inputs, driven by stronger local procurement and by an increase in production which started from 2003 (see Figure 2). The increase in production was driven by the opening of new mines and favourable primary mineral prices.

The second source of variation is the ward's distance to a nearest mine which is a source of heterogeneous exposure to the increase in mining activity. The study uses 90 kilometers as a threshold to divide wards into two groups – close to mine and far from mine. This threshold is the average distance to a mine. The third source of variation is the opening and closure of mines.

A priori, this study does not know the correct distance threshold. The choice of distance is important to correctly estimate the effects (Tolonen, 2014). To choose the distance, the study ran multiple regressions to determine at which threshold the expansion of mining becomes statistically insignificant[5]. Ensuring the correctness of this threshold is also important for this study to maintain the true counterfactual. Moreover, this threshold is in line with the range of distance (20 kilometers to 100 kilometers) from previous studies that examine local impacts. These studies include (as cited in Tolonen, 2014): Aragón and Rud (2013), Aragón and Rud (2012) where they use 20 kilometers in a study on agricultural productivity in Ghana close to gold mines, and 20 kilometers for labor market effects across Africa (Kotsadam and Tolonen, 2013; in Tolonen 2014).

[5] This exercise is not included in this study.

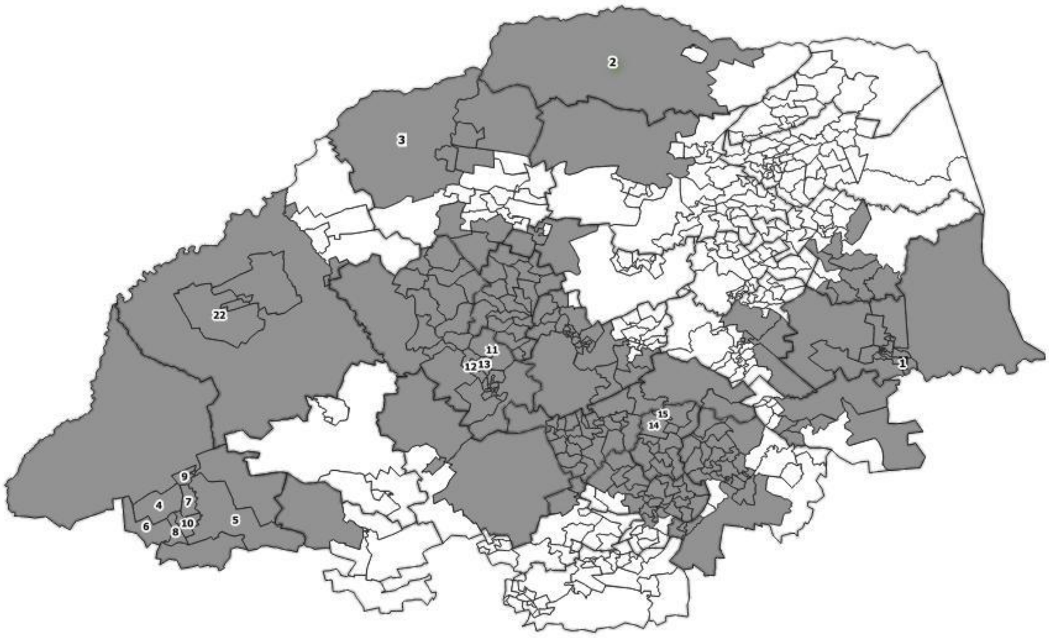

Figure 3: Sample mine locations in 2001 in Limpopo. *Wards within 90 kilometers shaded. Mines shown by number*. (Source: Author. GIS data from the South African Municipal Demarcation Board)

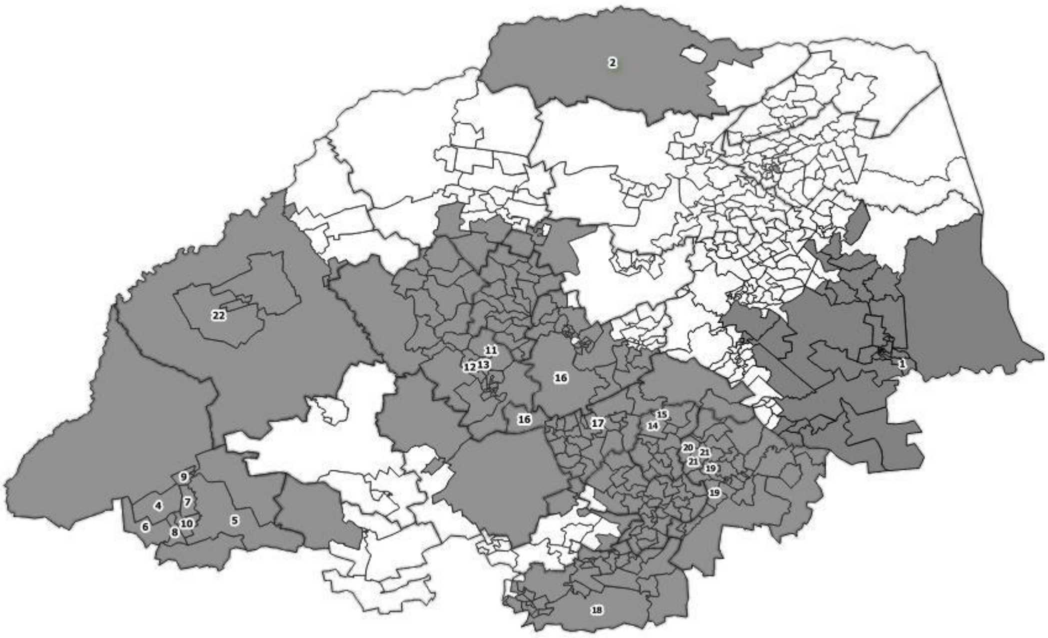

Figure 4: Sample mine locations in 2011 in Limpopo. *Wards within 90 kilometers shaded. Mines shown by number*. (Source: Author. GIS data from the South African Municipal Demarcation Board)

The study is essentially a difference-in-differences procedure that uses the expansion of mining activity as the treatment, and compares wards with mines or located close to mines, to those that have no mines or are far from mines. In order for the study to be valid, the parallel trend assumption must hold. That is, the study assumes that the impact of mining activity declines with distance, and that wards close and far from mines would have performed similarly in the absence of an increase in mining activity.

A major drawback is the lack of data before 2001, in order to gain better insight on the poverty trend between wards close to mines and far from mines. Figure 5 below isolates wards that have no mine in 2001 and farther than 90 kilometers from a mine (the control group), and evaluates the change in mean poverty on those wards that have a mine open locally. It shows similar starting trends between the control group and those wards that eventually get treated. Throughout the study period, 840 observations remain in the control group. In 2001, there are 242 wards within 90 kilometers of a mine (including those that have a mine), 265 such wards in 2007, and 281 in 2011. Therefore, only 39 wards enter the 90 kilometer threshold during the study. This makes the data on mine expansion (proxied by local demand for inputs, for example) an important source of variation in this study because it also treats wards with pre-existing exposure (the total treated group which consists of 788 observations).

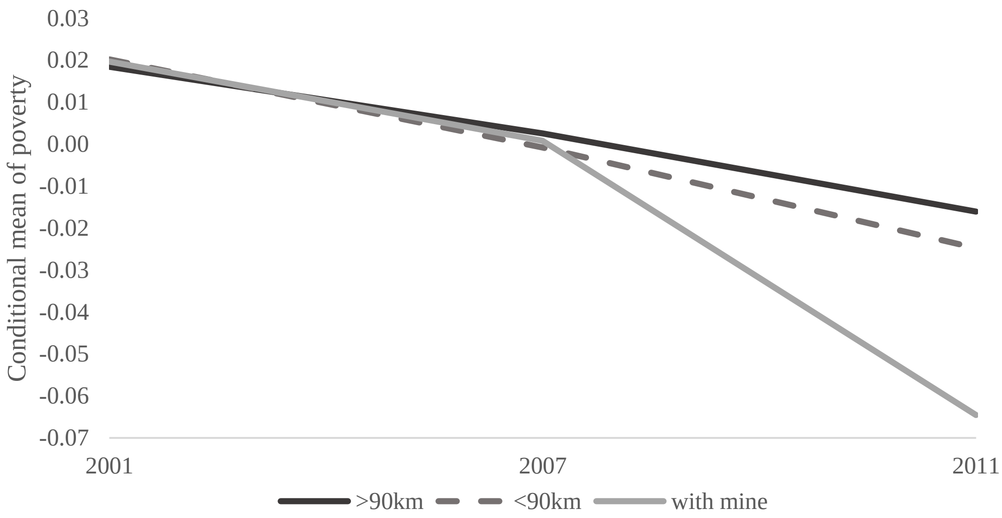

Figure 5: The conditional mean of poverty

1.4.1. Baseline Specification

To evaluate the impact of mining activity on ward-level poverty rate, the following regression is estimated:

$$
\begin{aligned}
y_{w,t} = \beta_0 + \beta_1 mine_{w,t} + \beta_2 distance_{w,t} + \beta_3(\ln M_{w,t} \times mine_{w,t}) \\
+ \beta_4(\ln M_{w,t} \times distance_{w,t}) + \beta_5 \boldsymbol{X}_{w,t} + \beta_6 \alpha_w + \beta_7 \delta_t + \varepsilon_{w,t}
\end{aligned}
$$

where $y_{w,t}$ is the outcome variable measuring share of population living in poverty in ward w in year t. $M_{w,t}$ is the measure of activity of a (nearest) mine in ward w at time t. The main measure of mine activity is the sum of a mine's preferential procurement[6] and its wage costs. However, other measures of activity are used, including sales revenue, and number of mine workers employed. $mine_{w,t}$ is a dummy variable equal one if a ward has a mine, and equal to zero otherwise. $distance_{w,t}$ is a dummy variable, which is equal to one if a ward is located within 90 kilometers to a mine. Both variables vary with time due to opening and closure of mines. The study also uses alternative specifications of distance, such as continuous distance. The specification also includes a vector of ward-level controls $X_{w,t}$[7], ward-level fixed effects α_w and time fixed effects δ_t.

The main parameters of interest are β_3 and β_4, which capture the size of impact on poverty due to an increase in demand for local inputs by mines; varying by distance (exposure to impact) and whether a ward has a mine or not.

1.5. Threats to Identification

This study seeks to convincingly isolate the causal impact of industrial mining on local economic wellbeing, as measured by income poverty. The validity of the empirical strategy, however, relies on assumptions that may be violated. The main assumption is that the timing, the choice of location of mine, and the level of production, is exogenous to local population characteristics and local labour market participation (Tolonen, 2014). However, mine location and production may depend on local characteristics. The necessary condition for establishing a mine is the existence of a deposit. Access to and costs of inputs could also have an influence, as well as institutions – which determine the rules of ownership, revenue sharing, and environmental demands (Tolonen, 2014). For this study, variation in these institutions is not expected at the ward level. Therefore, differences in mine location and production levels are not expected to be driven by ward level characteristics.

Another concern is the choice of mine opening or location based on infrastructure, including road and rail network, and access to water and electricity. Tolonen (2014) notes that if mining operations create new infrastructure, then the treatment will simply include infrastructure. This

[6] Preferential procurement refers to the percentage of a mine's total expenditure devoted to companies that comply with Black Economic Empowerment policies.
[7] See Appendix A for a full list of controls.

will not harm the identification strategy, because interest is on the total effect of industrial mining. The threat is only when mines open or expand as a result of infrastructure. This affects the interpretation of the estimates, as they no longer provide the general equilibrium effects of a large-scale mining shock (Tolonen, 2014). Indeed, the type of minerals in this study, such as coal, iron ore, and platinum group metals, heavily rely on good infrastructure. Industrial mines partly create the needed infrastructure (included in companies' capital expenditure budget), but government remains the main provider of major infrastructure investment. In this study, the development of news mines is concentrated around pre-existing mines – which necessarily have better infrastructure for mining in particular – but this location decision is strongly influenced by the location of mineral deposits concentrated regionally. At this point, this study does not find a solution to rule out this concern.

Selective migration could also threaten the identification strategy, if it alters the population characteristics in a way that influences the outcome variable of interest. For instance, if more productive people move closer to communities anticipated to open mines, this increase in average productivity may significantly exert downward pressure on poverty. Therefore, although the study is interested in the general equilibrium effects of mining on the local economy – how it affects economic opportunities of new and old community members – it is crucial to isolate the treatment effect from the selection effect (Tolonen, 2014). Section 1.7 deals with this concern as a robustness check.

In addition, Aragón and Rud (2013) flag tax revenue windfall as a possible threat to identification. Because mines are taxed at the federal level, it is possible that the estimates of impact are simply capturing this channel. If this is the case, it means it is public expenditure that matters for poverty reduction, rather than backward linkages from mining activity. This possibility is considered unlikely in this study; and the concern is further addressed as a robustness check under section 1.7.

Finally, to mitigate the concern of endogeneity relating to mine opening and location, the empirical strategy includes ward fixed effects as well as year fixed effects.

1.6. Main Results

This section reports the empirical results of the model specification. The main outcome variable is the upper-bound poverty rate, which is the share of people who are able to afford sufficiently nutritious food and basic non-food items. The results will also use the food poverty definition, which describes the share of people who can barely afford sufficient food. The main measure of mine activity, or expansion, is the local demand for inputs by mines, measured by the sum of preferential procurement and wages expense. The development of new mines and mine expansion is expected to increase nominal income of workers in affected sectors, as well as increase the price of goods traded locally (Aragón and Rud, 2013). This latter outcome cannot be examined in this study due to unavailability of data.

Table 2 – Results on Impact of Mines on Poverty

	Upper Poverty	Food Poverty	Upper Poverty	Upper Poverty	Upper Poverty	Upper Poverty
	(1)	(2)	(3)	(4)	(5)	(6)
Mine	0.0528	0.1084*	0.1974*	0.0542	0.0858	
	(0.0497)	(.0599)	(0.1073)	(0.1187)	(0.066)	
Mine activity x Mine	-0.0113**	-0.0228***	-0.0315**	-0.0133	-0.0225*	
	(0.0051)	(0.0061)	(0.0156)	(0.0170)	(0.0125)	
Distance <90km	-0.0174	-0.0256	0.0002	0.0202	-0.0203	
	(0.0206)	(0.0248)	(0.0337)	(0.0338)	(0.0268)	
Mine activity x distance <90 km	-0.0037**	-0.0036*	-0.0066	-0.0108**	-0.0051	
	(0.0018)	(0.0022)	(0.0045)	(0.0049)	(0.0042)	
Mine activity x continuous distance						0.0027**
						(0.0011)
Measure of activity[#]	Purchases	Purchases	Sales	Workers	Capital Expenditure	Purchases
Observations	1601	1601	1600	1601	1549	1601
Number of groups	543	543	543	543	543	543
R^2	0.2864	0.5264	0.2916	0.2905	0.3138	0.3091

Note: All regressions include year and ward fixed effects. See Appendix for the set of control variables. Purchases is the sum of a mine's wage bill and local purchases. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Measure of activity is in logarithm.

Table 2 presents the estimates of the impact of mining against the control group. All columns except column 2 use the log of upper-bound poverty as the dependent variable. Column 2 uses the food poverty definition. The preferred measure of mine activity is the demand for local inputs, which better reflects the market interaction between the mine and the local economy (Aragón and Rud, 2013).

The results suggest that mine expansion reduces income poverty for communities within the economic area of mining, as defined by the 90 kilometer distance threshold. More specifically, once distance to mine and presence of mine are controlled for, it is the increase in demand for local inputs that matters for poverty reduction. This implies that communities with mines that do not procure locally are no better off than those communities that are farther away from mines. To the contrary, the above evidence shows that communities with mines may start off poorer[8], meaning that the presence of mines only matters when it creates jobs and business for the local community.

The increase in demand for local inputs is statistically significant and remains important across alternative indicators of mine activity. The poverty-reducing impact is strongest to communities closest to mines, and diminishes with distance. In the baseline specification (column 1), a 10 percent increase in local input demand by mines in the Limpopo province can be expected to decreases income poverty by 0.04 percent in communities within 90 kilometers of exposure, and up to 0.1 percent for communities with mines, *ceteris paribus*. To shed perspective, these results suggest that a 10 percent local demand shock from mines could assist up to 915 people in the population to move out of upper bound income poverty; while the impact is double for those defined as food-poverty poor (column 2)[9]. Referring to figure 1, it shows that during the period under study, recorded sales from mining in the province grew by a net growth of 288 percent. However, the results above suggest that sales as a measure of impact may not fully capture the gains of mine activity, further justifying the use of local procurement figures because they account for revenue sharing with the local community, as well as localised business stimulation.

The impact of capital expenditure is only localised to communities immediately around a mine because capital expenditure accounts for investment used to open and sustain a mine. To that end, the infrastructure is localised around a mine, and any community-benefitting infrastructure such as building of roads, taxi ranks, and housing, in localised around a mine for the use of the mine (such as bring labour closer), but also to make the efforts of the mine visible to the hosting community.

The identification of the impact of mine expansion relies on the impact diminishing with distance. In addition to a carefully selected distance threshold that ensures the integrity of the control group, column 6 shows the results of using continuous distance instead of the 90

[8] Notice the positive coefficients of the *mine* covariate

[9] Referring to Table 1, the mean upper bound poverty rate is 93.96%, and the mean population by ward is 97356.21. Multiplying these figures with 0.1 decrease in poverty translates to 915 people.

kilometer threshold. The positive and significant coefficient suggests that farther communities from the mine demand shock fare poorer.

Overall, these results suggest that the practice of inclusive mining – that is, policies geared towards local procurement – is what matters for local communities. Stated differently, the impact of natural resources on local communities is welfare improving only within an institutional framework that strongly favours the local economy. This result is further explored in section 2.

At this stage the study cannot make strong conclusions about the overall benefit to the communities deriving from mining activity, without more information such as local price changes for both tradable and non-tradable goods, sectoral changes, health outcomes, and other indicators that impact on overall wellbeing.

1.6.1. Impact of Mining by Commodity Type

This section briefly investigates the preceding findings by type of commodity[10]. We may expect that the different production requirements of each mineral impact communities differently, either in the size of impact or in the direction of impact. For instance, diamond mining may employ relatively few people because the deposits may be available at relatively shallow and concentrated levels, compared with other commodities such as coal and platinum. By nature, the infrastructure requirements, type and size of inputs into production differ for the mining of each commodity. Policy could also differ for each sub-sector. For instance, some minerals may be declared nationally strategic, and the implications to the mining of these commodities may influence the welfare of hosting communities.

[10] Mine production was not included as an indicator of mine expansion because the commodities in this study are measured differently and cannot be directly added. The production process and infrastructure requirements are different for different minerals, and therefore may have different implications for local communities.

Table 3 – Results on Impact of Mines by Commodity Type

	Upper Poverty	Food Poverty	Upper Poverty	Upper Poverty
	(1)	(2)	(3)	(4)
Mine	0.0422	0.0338	0.0274	
	(0.0500)	(.0582)	(0.0489)	
Mine activity x Mine	-0.0102**	-0.0147***	-0.0091*	
	(0.0051)	(0.0060)	(0.0050)	
Distance <90km	-0.0239	-0.0211		-0.0179
	(0.0213)	(0.0248)		(0.0210)
Mine activity x distance <90 km	-0.0012	-0.0005*		-0.0030
	(0.0053)	(0.0062)		(0.0052)
Coal x Mine activity x distance<90 km	-0.0382***	-0.0723***	-0.0401***	-0.0379***
	(0.0094)	(0.0112)	(0.0081)	(0.0093)
Copper x Mine activity x distance<90 km	-0.0017	-0.0067	-0.0034	-0.0000
	(0.0090)	(0.0110)	(0.0076)	(0.0090)
Iron ore x Mine activity x distance<90 km	-0.0376	-0.1030**	-0.0403	-0.0377
	(0.0262)	(0.0454)	(0.0258)	(0.0262)
PGM x Mine activity x distance<90 km	-0.0017	-0.0037	-0.0040***	-0.0008
	(0.0048)	(0.0056)	(0.0014)	(0.0047)
Measure of activity#	Purchases	Purchases	Purchases	Purchases
Observations	1601	1533	1601	1601
Number of groups	543	542	543	543
R^2	0.1681	0.2950	0.1683	0.1640

Note: All regressions include year and ward fixed effects. See Appendix for the set of control variables. Purchases is the sum of a mine's wage bill and local purchases. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Measure of activity is in logarithm.

Table 3 presents the results. The estimates of the impact of mining (for communities with mines) remains stable and significant for poverty reduction. In the above table, the omitted commodity dummy is diamond mining.

By commodity, this study suggests that the poverty-reducing impact of mine expansion is driven primarily by coal mining. That is, communities in the coal mining region may be benefiting more than others from mining activity, particularly in comparison to communities with diamond mines. This result is robust to alternative baseline commodity dummies. It is unlikely that this result is driven by the overrepresentation of coal mines in the sample, as there are only three coal mines in the sample; whereas platinum mines consists the majority of the sample – 13 mines. In the context of the insignificance of other commodities, this result is surprising. Table 4 below provides the total employment statistics of the mines by commodity in this study's sample. Platinum mines are the largest employer because they require vast amounts of inputs into production, especially labour.

Table 4 – Total Employment Statistics of Mines by Commodity

Year	Platinum	Coal	Iron ore	Copper
2001	28863	2969	1000	2245
2007	54225	3253	1009	2110
2011	49194	2750	1704	2321

There are three immediate reasons that may explain the significance of coal. The first reason is location and timing. The communities are located in the Waterberg coalfield, which is rich in coal, and has a number of small to medium sized mines that are not included in the sample. Moreover, this coalfield is located close to the North West province, which is also rich in mining activity. The second reason is that unlike minerals like platinum, most of the coal output is consumed locally, particularly for electricity generation, and therefore is likely to have strong backward linkages. Finally, coal is of strategic importance to the government, and therefore coal mining is likely to enjoy infrastructure investments from government compared to other mining sectors; which would ultimately improve local living standards for hosting communities.

Should these results truly reflect reality, they may explain part of the reason of the repeated and violent platinum mining strikes particularly between 2012 and 2014, where mine workers and communities flagged problems relating to poor working conditions, low wages, and low positive community impact. An obvious channel requiring further investigation is the nature and extent of backward and forward linkages from this sector, particularly in comparison to the coal sector.

1.7. Alternative Explanations

It may be possible that the preceding section's finding only capture factors other than mine expansion, that explain the fall in the share of poverty. The following explores the possibility of increased tax revenue and selective migration as alternative explanations.

1.7.1. Tax Revenue

Generally, local governments receive tax revenue from local operating mines; in which case the impact of mining may run through this channel. For example, there could be an expansion of public employment, which could lead to increased local wages; or a demand shock from increased public works (Aragón and Rud, 2013)[11]. The following two reasons make it unlikely that the preceding results capture this channel. Firstly, the analysis of this study is at the ward level. Given that tax is collected at the municipal level, which has a strict government agenda to allocate tax revenue equitably, prioritising the poorer areas, we should not have found economic benefit from mining activity that is isolated only within the 90 kilometer distance of exposure. This is because municipalities consist of wards spreading beyond the 90 kilometer threshold, and therefore given the policy mandate, there is no reason that tax revenue expenditure would be localised to wards with mining. On the contrary, the poorer areas are likely to benefit more from this tax. Secondly, the tax revenue on mining companies is exceptionally low relative to local procurement by mines[12]. This casts doubt that tax revenue may be driving the results, and supposes a strong assumption that tax revenue has a strong social return.

To formally evaluate this possibility, annual tax paid per mine is added as a covariate to the baseline specification, along with its interaction with mining exposure (proxied by distance of 90 kilometer), to test whether tax revenue captures explanatory power away from the impact of mines.

[11] Mining revenue collection in South Africa is by deferral government (see PriceWaterhouseCoopers, 2012), although federal government in South Africa is not fiscally autonomous (see Calitz and Essop, 2013).

Table 5 – Results Controlling for Tax

	Upper Poverty	Food Poverty
	(1)	(2)
Mine	0.1516***	0.1948***
	(0.0592)	(0.0671)
Mine activity x Mine	-0.0198***	-0.0287***
	(0.0058)	(0.0066)
Distance <90km	0.0310	0.0627
	(0.0403)	(0.0456)
Mine activity x distance <90 km	-0.0035*	-0.0040*
	(.0008236)	(0.0023)
Ln (Tax)	0.0058	0.0083
	(0.0056)	(0.0064)
Ln (Tax) x distance <90km	-0.0094	-0.0146*
	(0.0071)	(0.0081)
Observations	1532	1532
Number of groups	542	542
R^2	0.2874	0.5435

Note: All regressions include year and ward fixed effects. See Appendix for the set of control variables. Purchases is the sum of a mine's wage bill and local purchases. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Measure of activity is in logarithm.

The results in Table 5 show that the demand for inputs by mines remains statistically poverty reducing for mining communities (both column 1 and 2), while additional tax revenue may be poverty reducing in the poorest areas of communities exposed to mining (column 2). The positive coefficient of tax on poverty is surprising, but consistent with the finding of Aragón and Rud (2013). It suggests that additional tax outside mining communities is not poverty reducing, at least in the short run. Apart from a possibility that tax revenue has low social returns, this could be because public projects take longer to mature. Alternatively, tax revenue may be funding provision of public goods, without direct income poverty gains (Aragón and Rud, 2013).

1.7.2. Selective Migration

Before a mine is established, there are necessary processes concerning approvals from government and community stakeholders that are undertaken, generally taking well above a year to complete. The anticipation of a mine opening could alter the composition of the local population through selection. *A priori*, it is not known whether the opening of a mine leads to positive or negative migration. Nonetheless, compositional changes of the population, if significant, affect poverty income. It could be possible that in anticipation of the opening of a mine, the poorer move closer to the mining area while the wealthier move farther away in anticipation of the negative health and migration impacts. This changes community characteristics and biases the true size of the impact of a mining demand shock. Alternatively, the opening of a mine or mine expansion could attract productive labor, which would exert downward pressure on income poverty.

To test the impact of selective migration, it is necessary to identify the nature of migration and test whether this subpopulation drives the results (Aragón and Rud, 2013). As an initial attempt to test this impact, pending better complementary data on migration, the study interacts the share of the population born outside the province with the share of the educated population. The results in Table 6, which should be taken with caution, suggest that an increase in migrants with secondary education reduces income poverty, contrary to the tertiary educated counterparts (which are significantly few as a share of population). Interpreted together with the significant positive relationship between poverty and the share of the rest of population with secondary education (column 2), it may contrast migrants who migrate to work as unskilled workers in mines, to the rest of the local population who on average have secondary education but remain unemployed. Important for this study is that the impact of mining remains robust.

Table 6 – Results Controlling For Selective Migration

	Upper Poverty	Food Poverty
	(1)	(2)
Mine	0.0437	0.0397
	(0.0517)	(0.0581)
Mine activity x Mine	-0.0108**	-0.0152***
	(0.0054)	(0.0061)
Distance <90km	-0.0126	-0.0020
	(0.0216)	(0.0242)
Mine activity x distance <90 km	-0.0041**	-0.0051**
	(.0019)	(0.0022)
Migration	-0.0308	-0.0397
	(0.0339)	(0.0380)
Migration x Secondary education	-0.1506*	-0.4534***
	(0.0900)	(0.1011)
Migration x Tertiary education	-0.0994	0.4467
	(0.4743)	(0.5325)
Secondary education	0.0089	0.0428**
	(0.0189)	(0.0212)
Tertiary education	0.0776	0.0055
	(0.1334)	(0.1498)
Observations	1533	1533
Number of groups	542	542
R^2	0.2333	0.4809

Note: All regressions include year and ward fixed effects. See Appendix for the set of control variables. Purchases is the sum of a mine's wage bill and local purchases. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Measure of activity is in logarithm.

1.8. Improvements to the Study

Data

The main limit to this study is the availability of data that could provide a richer set of variables, such as information on prices of local goods, health outcomes, environmental outcomes, and a richer vector of control variables at the ward level. For instance, the Limpopo province has a large agricultural sector, and a better understanding of the impact of mining on communities will be achieved by gaining insight on how mining impacts this sector. Does mining draw labour away from agriculture, and does that hurt the agricultural sector? Better data would contribute to understanding these relationships.

To that end, the next step of this study will be to use the National Income Dynamics (NIDS) survey data, which is a national panel study of households in South Africa. The survey is specifically designed to track and understand the shifting face of poverty in South Africa. The NIDS started in 2008, therefore it can complement or replace the ward level data used in this paper[13].

Spatial Randomisation Placebo Test

Tolonen (2014) performs a randomization inference test to further rule out any possibility that her results are driven by model misspecification. Her study offsets mine location by 0 to 50 kilometers in any direction, to test if the results attenuate toward zero.

Test for Pollution using Rainfall Data

Pollution is one of the main hazardous effects caused by industrial mining. This variable may be valuable as a control to the model specification. Tolonen (2014) uses rainfall indicator interacted with a dummy for active mine. This method as a measure of pollution effects is justified because the geographic spread of pollutants from mines can increase with rainfall.

Instrumenting for Mine Location/Production

In order to rule out possible endogeneity associated with mine location or mine production, a further improvement would be to identify an appropriate instrument. This instrument should explain the location of mines without having direct impact on local poverty.

2. Bringing in the Community: The Role of CSR in Mining

The role of Corporate Social Responsibility (CSR), particularly in the extractive industry, is receiving increasing research attention, especially because of its potential hazardous impact on environmental and economic outcomes. Hence, responsible mining is increasingly becoming a pillar of mining firms (Hilson, 2012); certainly on paper, although unclear in practice (Campbell, 2012). Apart from the negative aspects, this study has contributed to the literature that finds positive impacts of industrial mining at the local community level. This finding provides an opportunity to further explore policy options to increase the welfare-improving aspects of industrial mining, while restraining its hazardous impacts.

[13] At present, this study could not use this data because of classified aspects of the data which require the Author to collect the data under the supervised facilities of *DataFirst*, University of Cape Town.

Studies in the area of CSR in the extractive industry have already advanced conceptual frameworks within which the role of CSR can be understood, while the gap of empirical evidence remains. Conceptually, CSR in mining is understood to establish a channel of stakeholder engagement (Mutti, et al., 2012 and McDonald and Young, 2012), solidify legitimacy (Campbell, 2012), mitigate risk (Ibid.), and bridge a shift from enclave to inclusive development and sustainability (Ackah-Baidoo, 2012). The study of Gamu et al. (2015) from a review of thirteen specific linkages between extractive industries and poverty, find the importance albeit limited effects of CSR activities.

The policy-driven evolution from enclave-type mining to inclusive mining presents an important empirical challenge to understand whether and to what extent this change in firm behavior impacts local economic outcomes. Therefore this section briefly explores the policy context of the findings in section 1.6. The results showed that there are backward linkages emanating from a demand shock from mines to local economies through the practice of local procurement. This is a major advancement for the extractive industry, given that most of its output, except for coal, is exported – generally with minimal or no beneficiation, which could further increase gains locally.

The Mineral and Petroleum Resources Development Act

The South African government introduced a policy that was meant to govern the country's mineral and petroleum resources in a way that benefits local citizens. The policy is the Mineral and Petroleum Resources Development Act 28 of 2002 ('MPRDA'), which introduced a new regime that placed government as the custodian of mineral and petroleum resources; replacing the previous system of common law mineral rights, prospecting rights, mining rights, and statutory rights (Badenhorst, 2011). To re-secure mining rights, companies had to comply with minimum 'firm responsibility' standards in line with development goals of government. To maintain these rights, companies have to continue to comply annually towards desired targets. There are two immediate outcomes that flow from the MPRDA. First, by putting an emphasis on local procurement, it possibly created backward linkages into local service industries. Second, it introduced CSR beyond the historic norm of Corporate Social Investment (CSI), which had no policy guideline nor included other important dimensions of firm responsibility.

Furthermore, this legislated corporate social responsibility has provided two critical benefits: a channel for the mining sector to engage as a stakeholder in local development, which is a crucial institutional arrangement for the stability of the sector in the context of South Africa; and a measurable contribution of each mine using the annual independently evaluated scorecards that measure and rank each mine's compliance with responsibility.

This paper seeks to perform an initial assessment of the impact of firm behavior on local community economic outcomes, using income poverty as a dependent variable.

2.1. Empirical Specification and Results

The first major empirical challenge is measuring responsible behaviour of mines. Not only does the concept of firm responsibility involve multiple, unclearly defined dimensions, but there is generally lack of organised data on these dimensions. The second critical challenge, particularly for this study, is mapping the causal impact of firm behaviour to the broader local economic outcomes.

Therefore this section is a very initial attempt that at best suggests critical CSR dimensions that should be taken into account; and suggests an empirical estimation of the impact of mine behaviour on local income poverty.

The study collects additional data on the sample of firms covered in the preceding section. This data includes variables such a percentage procured locally, percentage of management that is defined as historically disadvantaged, firm investment in training and education, as well as compliance with safety and environmental regulation[14]. An index of responsibility is then constructed, following the priorities of the MPRDA. However, because of a lack of clearly defined weights on the CSR dimensions, the study imposes weights based on the inferred importance of each dimension. Essentially, the index attempts to measure the maximum benefit on poverty given a firm that has at least 50 percent black ownership, 50 percentage black management, and other relevant dimensions. The following briefly outlines the construction of the index.

Index Construction:

1. Does the mine have Black Economic Empowerment (BEE) Partner ownership: score out of 50% ownership, weight is 30%
2. What is the percentage of BEE Procurement? Score out of 50%, weight is 25%

[14] The database may be available by request from the Author.

3. What is the share of Historically Disadvantaged South Africans (HDSA includes non-whites and women). Score out of 50, weight is 20%
4. Skills training as share of wage bill, compared to average per year; weight 10%
5. Lost time injury frequency rates (LTIFR), compared to sample industry average per year; weight 10%
6. Occupational Health and Safety Management Systems—Requirements (officially BS OHSAS 18001) certificate (granted if company complies with environmental management practices); weight 2.5%
7. ISO 14000 certificate (granted if company complies with safety management practices); weight 2.5%

The study estimates the following specification (extended from the baseline specification):

$$\begin{aligned} y_{w,t} = \beta_0 + \beta_1 mine_{w,t} + \beta_2 distance_{w,t} + \beta_3(\ln M_{w,t} \times mine_{w,t}) \\ + \beta_4(\ln M_{w,t} \times distance_{w,t}) + \beta_5(\ln M_{w,t} \times mine_{w,t} \times CSR) \\ + \beta_6(\ln M_{w,t} \times distance_{w,t} \times CSR) + \beta_7 \boldsymbol{X}_{w,t} + \beta_8 \alpha_w + \beta_9 \delta_t + \varepsilon_{w,t} \end{aligned}$$

Table 7 – Results on the Impact of Firm Responsibility on Poverty

	Upper Poverty	Food Poverty
	(1)	(2)
Mine	0.0843	0.0667
	(0.0548)	(0.0658)
Mine activity x Mine	-0.0163***	-0.0131*
	(0.0066)	(0.0079)
Distance <90km	-0.0305	-0.0368
	(0.0226)	(0.0272)
Mine activity x distance <90 km	-0.0015	-0.0018
	(.0024)	(0.0029)
Mine activity x CSR x Mine	0.0027	-0.0073**
	(0.0026)	(0.0032)
Mine activity x CSR x distance <90 km	-0.0016	-0.0012
	(0.0009)	(0.0010)
Observations	1601	1601
Number of groups	543	543
R^2	0.2901	0.5326

Note: All regressions include year and ward fixed effects. See Appendix for the set of control variables. Purchases is the sum of a mine's wage bill and local purchases. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Measure of activity is in logarithm.

Column 1 above, which uses the upper bound poverty line, does not provide much information about the benefits of firm responsibility. Once the expansion of the mine has been taken into account, there does not appear to be any additional benefit to other dimensions of CSR. Column 2, with food poverty line as the dependent variable, suggests however that there may be some additional value to firm responsibility for the poorest communities closest to a mine. These results are only initial and suggestive, until a credible method of measuring and accounting for CSR is developed. It is likely that above other weaknesses of the index herein constructed, it captures what is already captured by the mine expansion treatment.

Overall, this section deserves further development in order to better complement the findings of the impact of extractive industries on local communities.

3. Conclusion

This study set out to evaluate the impact of natural resources on local economies, within the context of a developing country with a strict procurement policy. It used the Limpopo province of South Africa as a fitting case study. The study follows Aragón and Rud (2013), on their study that uses annual household data to evaluate the economic impact of a large gold mine in Peru. The main challenge of this study was to isolate the causal impact of mine presence and expansion on local income poverty outcomes, during the period of study. To achieve this, the study set out to exploit three sources of variation. Firstly, the study used the significant increase in local demand for inputs, driven by stronger local procurement and by an increase in production.

The second source of variation used is the ward's distance to a nearest mine which is a source of heterogeneous exposure to the increase in mining activity. The study used 90 kilometers as a threshold to divide wards into two groups – close to mine and far from mine. This threshold is the average distance to a mine. The third source of variation that was used is the opening and closure of mines. The counterfactual throughout the study was wards with no mines and no exposure to mining activity. This definition heavily relied on the choice of the distance threshold.

The main finding of this paper is that industrial mining, when governed by procurement policy that favours the local communities, can improve the local living standards. This finding remained robust to different indicators of mine expansion, and checks for alternative explanations such as selective migration. Because of a lack of data, this study was unable to perform a richer study on other measures of community wellbeing, such as health outcomes. To the contrary, the dependent variable throughout this study is a measure of income poverty; one defining the extreme poor, the other defining those who can afford sufficient nutrition and non-food items.

As an extension, this paper carried out an initial attempt to understand the impact of firm behaviour within the extractive industry, by constructing an index of CSR dimensions collected for each of the firms in the sample of the study. The study cautioned that the index is preliminary, and is not yet based on scientific evidence. The results from the empirical test revealed only a mild suggestion that firm responsibility may have an additional value to improving local economic wellbeing, particularly for the poorest communities closest to a mine.

Together with the section covering limitations of this study and further improvements required, this study is proposed only as an initial empirical undertaking on isolating the impact of the mining industry in the Limpopo province. At this stage, the study is suggestive rather than prescriptive.

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[15] Data sources follow at the end of the list

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Data Sources:

1. Municipal ward data:
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   Municipal Demarcation Board of South Africa
   http://www.demarcation.org.za/
2. Firm level data
   Available from company annual reports
3. Distances calculation at ward level
   Available at http://maps.elections.org.za/vsfinder/

Appendix A

Table 8 – Results on Impact of Mines on Poverty Showing the Full List of Controls.

	Upper Poverty	Food Poverty
	(1)	(2)
Mine	0.0486	0.0513
	(0.0518)	(0.0589)
Mine activity x Mine	-0.0113**	-0.0166***
	(0.0054)	(0.0062)
Distance <90km	-0.0155	-0.0087
	(0.0216)	(0.0246)
Mine activity x distance <90 km	-0.0039**	-0.0048**
	(.0019)	(0.0022)
Ln (Employment)	-0.0162*	-0.0110
	(0.0097)	(0.0111)
Ln (Population)	0.0077	0.0013
	(0.0079)	(0.0089)
Race – coloured	-1.1259**	-1.6430***
	(0.5272)	(0.5996)
Race – Indian	0.5588*	0.7344**
	(0.2919)	(0.3320)
Race – white	-0.1311*	-0.2109***
	(0.0755)	(0.0859)
Dependency ratio	0.0602**	0.0957***
	(0.0269)	(0.0306)
Sanitation	0.0663***	0.0741***
	(0.0211)	(0.0240)
Sewerage system	-0.0831*	-0.2376***
	(0.0434)	(0.0494)
Refuse removal	-0.0379	0.0122
	(0.0301)	(0.0343)
Electricity	0.1057***	0.0837***
	(0.0234)	(0.0267)
Migration	-0.0675**	-0.1279***
	(0.0310)	(0.0353)
Secondary education	0.0007	-0.0029
	(0.0026)	(0.0029)
Tertiary education	-0.0061	-0.0046
	(0.0119)	(0.0135)
Year 2007	-0.0376***	-0.0614***
	(0.0068)	(0.0077)
Year 2011	-0.0779***	-0.1098***
	(0.0084)	(0.0096)
Observations	1533	1533
Number of groups	542	542
R^2	0.2945	0.5584