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Extractive Industries, Production Shocks and Criminality: Evidence from a Middle-Income Country*

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Abstract

The role of extractive industries for development is highly debated. A large literature focusing on countries with weak institutions has shown that such industries can spur conflict and war by providing appropriable resources. This study investigates whether this relationship holds true later in the development process. More specifically, we examine whether the extensive mining industry in South Africa affects local property and violent crime. To estimate the causal effect, our empirical strategy exploits local production changes caused by fluctuations in international mineral prices. In contrast to earlier studies, we find that an increase in mining activity lowers the local crime rate. Several tests suggest that this effect is driven by better income opportunities, affecting the opportunity cost of engaging in criminal activity. In order for this effect to materialize, local institutional quality needs to be sufficiently high. If such conditions are met, the appropriation channel emphasized in the earlier literature is dominated by the change in opportunity costs of crime.

Keywords: Extractive Industries, Mining, Crime, Violence
JEL classification: K42, D74, O13

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1 Introduction

The role of extractive industries for economic development has been widely debated (van der Ploeg, 2011). Extractive industries are major components of many economies and therefore potential engines of development. This is particularly the case for the mining industry, which employs approximately one percent of the global labor force (International Labour Organization, 2015). Mineral resources play a dominant role in 81 countries that collectively account for nearly 70 percent of those in extreme poverty (The World Bank, 2014). Previous research has found that mining spur local structural change and benefit local labor markets (Aragón and Rud, 2013; Kotsadam and Tolonen, 2016). The industry has been crucial for countries such as Botswana and Namibia in the transition from poor to middle income.

At the same time, a growing body of evidence links extractive industries, such as the mining industry, to conflict and civil war in contexts with weak institutions.[1] The main explanation put forward in this literature is that a shock to an extractive industry would increase the rents from appropriating that resource and thereby drive social conflict. However, as highlighted above, extractive industries can also generate job opportunities. According to the seminal work by Becker (1968), this would affect the opportunity costs of engaging in illegal activities and thereby the amount of criminal activity. Taking this into account, the theoretical prediction of the effect of extractive industries on crime is ambiguous. The latter of these two mechanisms—the opportunity cost channel—could potentially play a more dominant role in countries with stronger institutions where social conflict mainly comprises violent and property crime, rather than civil war. A number of countries have both considerable natural resource endowments as well as high crime rates, including South Africa, Botswana, Brazil, and Mexico, which highlights the need to empirically investigate this relationship in such a setting. In this paper we explore the effect of mining activity on crime rates in South Africa.

We argue that the South African setting is of particular importance. Crime, and violent crime in particular, is a serious threat to development in the country. For example, our data shows that 13,123 men, 2,266 women and 827 children were murdered in 2012/13, making it one of the most murder dense regions of the world. Crime is also a major factor behind the emigration of skilled labor, emergence of gated communities, and a flourishing private security sector. At the same time, South Africa has the fifth largest mining industry in the world, contributing to around 8 percent of GDP (Chamber of Mines, 2014). Recently, the link between mining and violence has received both media and government attention, not least since the 2012 Marikana massacre where 44 miners were killed. A *New York Times* report (NYT 2013) suggests that violent crime

[1] Collier and Hoeffler (1998, 2004, 2005) were pioneers of the literature examining links between natural resources and civil war. Recent works include Berman et al. (2015); Buonanno et al. (2015); Maystadt et al. (2014).

has risen as townships have "fallen on hard times as gold mines have closed". In addition, previous studies have claimed that the conditions in the mining industry have spurred criminality in South Africa in a historical context (Kynoch, 1999, 2005). Several factors inherent to the industry have been argued to cause criminal behavior, such as a predominantly male workforce and poor living conditions in the mining areas.

The empirical analysis in this study exploits several different estimation strategies to examine the causal effect of mining activity on crime rates in South African police precincts from 2003 to 2012. Specifically, we explore the effect of mining activity and production shocks on crime rates at different spatial scales, as well as what types of crime are affected, and lastly we try to disentangle the mechanisms behind our findings. Using the panel data for a fixed effects approach, we estimate a negative association between the number of active mines in a police precinct and local crime rates. One potential concern with interpreting this estimate causally is that mine production could be affected by crime levels in the proximity of a mine. To overcome this potential reverse causation, we employ an instrumental variable approach where we instrument the number of actively-producing mines of a specific mineral in a given location by the international price of that mineral. Other papers (cf. Allcott and Keniston, 2015; Berman et al., 2015) have used international prices as exogenous variation to look at the reduced form relationship. Our detailed production data enables us to go further and estimate the first stage and we can therefore also instrument mining activity. The first stage estimate shows that a higher international price of a given mineral increases the number of mines actively producing that mineral. In the second-stage analysis, we investigate how a price induced change in mining activity affects the crime rate at the police precinct level.[2] We find that total crime rates fall by approximately seven percent for each additional active mine. Results suggest that mining activity decreases both violent and property crime.

Subsequently, we make an additional contribution to the literature by investigating the dynamic effects of production shocks by allowing for asymmetric effects of starts and stops in mining production. We find that when a mine stops actively producing, crime rates increase substantially. This finding is in line with the opportunity-cost channel: when a mine closes, direct and indirect income opportunities decrease locally and the incentives to commit crime increase. To check whether income opportunities is a plausible mechanism through which mining activity affect crime we follow the theory outlined by Dal Bó and Dal Bó (2011) and show that our results are driven by relatively more labor intensive mines. Poor availability of mining employment numbers and labor market information at a sufficiently disaggregated geographic level makes it difficult to further assess the viability of the income channel. However, following recent economic literature (Bleakley and Lin, 2012; Henderson et al., 2012; Michalopoulos and Papaioannou, 2013; Pinkovskiy and

[2]Police precincts are South African administrative areas that are smaller than municipalities.

Sala-i Martin, 2016), we proxy economic activity in police precincts using satellite data on lights at night. Doing so, we find that the number of active mines has a positive effect on light density. Similarly, when a mine closes, local economic activity falls. These findings further support the hypothesis that the causal effect of mine closure on crime goes through an income channel.

As discussed above, the dominant explanation as to why natural resources may have detrimental effects to social and economic outcomes is the potential for violent grabbing. Such appropriation is arguably easier to conduct in settings with weaker institutions. To test this hypothesis in our context, we create an indicator for local institutional quality based on municipality audit scores. We show that effects are much smaller, and even positive for violent crime, in areas with poor institutions. This suggests that mining activity can indeed induce a fight over resources, similar to what has been shown in other contexts (c.f. Sanchez de la Sierra, 2015), even in South Africa. The main negative effect, on the other hand, is driven by areas with sound institutional quality. Hence, the grabbing channel seems to be dominated by the income channel for South Africa as a whole – possibly explained by the overall sound South African institutions.

In addition, we consider to what extent labor migration to mining areas can be a mechanism through which crime rates are affected. Domestic and international migrants have long played an important role in the South African mining sector.[3] There are two main reasons why we believe migration to be important. First, the migrant-labor system is associated with serious social concerns, such as informal settlements characterized by lack of social services and unemployment (Aliber, 2003; Hamann and Kapelus, 2004).[4] From a historical perspective, the association between the migrant-labor system and crime has been emphasized (Kynoch, 1999, 2005). Second, the effect of mining activity on migration might be important for local employment and wage outcomes and therefore affect the potential change in opportunity costs. We establish that the number of active mines in a municipality increases the share of migrants in the population by 23 percent for each additional mine. In fact, when a mine starts producing (a positive shock in mining activity), migration increases by 18 percent. Thereafter, we compare the effect of mining activity on crime in municipalities with high and low average migration rates. The results from this analysis are imprecisely estimated but provide suggestive evidence for migration patterns being one determinant of the relationship between mining and crime. We find that production starts in low-migration areas are associated with lower crime rates and that there are typically small and insignificant effects on crime when a mine stops producing. However, in high migration areas, both production starts and stops are associated with higher crime rates. We see two potential explanations for this: first, in-

[3] In 1997, 95 percent of all mine workers were migrants, most from rural South Africa, Lesotho and Mozambique.

[4] The system has even been called a "scar on the face of democratic South Africa" by Deputy President Motlanthe (Financial Times, April 2014). Policies have aimed at improving the social situation and single-sex hostels have become less common. However, often-times the hostels have been replaced by informal settlements where mine workers live.

ward migration increases competition over jobs, and second, production shocks in high migration areas affect individuals with weaker ties to the local labor market. Hence, the income opportunities provided by the mine may be more important for this group.

Previous research on extractive industries finds detrimental effects on social conflict. We find that extractive industries affect overall criminality in a different way. Increases in mining activity lead to lower crime rates, whereas a cessation in production has the opposite effect. This is in contrast to what has been found in countries at risk of conflict, where mining wealth coupled with poor mineral property rights have been shown to increase conflict by providing funding for rebel groups (Bellows and Miguel, 2009). We show that in South Africa, a thriving mining sector can lead to lower local crime rates, presumably by affecting local income opportunities. Hence, this study shows that the relationship between mining and illegal activity is more complex than suggested by earlier studies and is highly context specific, perhaps foremost in terms of institutional quality.

The organization of the paper is as follows. Section 2 looks at previous literature on extractive industries and violence. Thereafter, Section 3 provides a background on the mining industry and crime in South Africa. The following section describes the data and the construction of the samples used in estimation. Section 5 goes through the empirical strategies employed. The results from our main specifications, mechanism checks, and robustness tests are reported in Section 6. Section 7 concludes the paper with a discussion.

2 Previous Literature

In this paper, we use production changes in mineral and coal mines to identify the effects of mining activity on crime. This is, to our knowledge, the first attempt to investigate the effect of extractive industries on various types of crime using official police records. We add to the literature on the ”resource curse”, focusing on the link between natural-resource extraction and social conflict (for an overview of the resource curse, see van der Ploeg 2011).

There is a growing empirical literature on the effects of extractive industries and violence. Recent papers have explored the links between extractive industries and violence at a sub-national level (see, e.g., Caselli et al., 2015; Lei and Michaels, 2014; Maystadt et al., 2014; Rohner, 2006). Couttenier et al. (2014) find that minerals play a role both historically and presently for U.S. homicide rates, and Buonanno et al. (2015) find a relationship between natural resource endowments and the emergence of the Sicilian mafia. Bellows and Miguel (2009) show that diamond mining increased armed clashes during the civil war in Sierra Leone. Aragón and Rud (2013), however, find that household members in mining communities in Peru are no more likely to report having been affected by a criminal act than surveyed households further away.

The paper most similar in spirit to ours is Berman et al. (2015), who investigate the impact of mining on conflict in all African countries from 1997 to 2010. The authors exploit within-mining area panel variation in violence due to changes in the world price of the relevant mineral and find that mining activity increases local area conflict, as measured by the ACLED dataset. Similarly, we explore the effect of changes in mining activity induced by changes in mineral prices, but focus on South African crime rates. We investigate whether the above described patterns of detrimental effects stemming from extractive industries are also true for a middle-income country, using official police records of property and violent crime rather than multi-origin datasets on conflict. Thus, apart from public violence which we have data on, we test the predictions from the relevant literature regarding violent crimes, e.g., murder and assault, and property crimes, e.g., burglary. An additional contribution of this paper is that we can instrument mining production with international prices, in contrast to Berman et al. (2015) who look at the reduced-form relationship between prices and conflict.

A first stepping stone for understanding the aforementioned research question and earlier empirical work is Dal Bó and Dal Bó (2011), who provide a theoretical investigation of how economic shocks and policies affect the intensity of conflict and crime. In particular, the authors show how positive productivity shocks to labor-intensive industries in less-developed countries (e.g., agriculture in Sub-Saharan Africa) diminish conflict, while positive shocks to capital-intensive industries (e.g., the oil industry) do the opposite. The intuition is that a positive shock to a capital intensive industry will cause it to expand and a labor-intensive industry to contract, making labor relatively more abundant and therefore reducing wages. Since wages decrease relative to the value of appropriable resources, appropriation will increase. That is, the incentives for social conflict will increase. This intuition is for example supported by Dube and Vargas (2013), who find that conflict in Colombia increased following a fall in the prices of coffee, a labor-intensive product, and an increase in the prices of oil, a capital-intensive product. Similarly, we test this channel by splitting mining into open-pit (more capital intensive) and underground (more labor intensive).[5]

Another stepping stone in understanding the link between mining and crime is the theory of the economics of crime developed in Becker (1968). The intuition is similar to parts of the reasoning in Dal Bó and Dal Bó (2011). In this model, crime is a type of job chosen in competition with regular wage work. An increase in mining activity will lead to an increase in the opportunity cost of crime if certain requirements are fulfilled.[6] In other words, the closure of a mine or lower production will

[5]The mining industry in South Africa employs around half a million people directly, and many more indirectly (Chamber of Mines, 2014). The relatively high number of direct employment is foremost due to the depths of South African mines that makes mechanization difficult. The South African mining industry is therefore relatively more labor intensive compared to other mining countries, including its African neighbors.

[6]Specifically that mining increases the supply of jobs, and/or the market-clearing wage. If inward migration exceeds the new jobs created, total employment or market wages need not increase. Furthermore, in the case of a mine leading to local "Dutch disease" effects (cf. Allcott and Keniston, 2015) and the crowding out of other industries, such

lead to lower incomes among mine workers and societies that are dependent on the mine, in turn strengthening the driving forces behind crime.

3 Background

3.1 Crime in South Africa

Although South Africa has seen a huge increase in the number of private security guards as well as a tripling of government spending on crime prevention since the mid-1990s, the country is one of the most crime stricken in the world. The Economist (2010) notes that ”a staggering 50 murders, 100 rapes, 330 armed robberies and 550 violent assaults are recorded every day”. The recorded crime levels increased during the last decade of apartheid rule and peaked in the early 1990s. The hope that the levels would decrease after 1994 was not met. Rather, in the period from 1994 to 2000, crime increased. For example, the annual increase in the number of crimes was higher in 1999 than in any previous years after 1994. These changes were mainly driven by huge rises in common robbery (121 percent), residential burglary (25 percent), assault (22 percent), rape (21 percent), and carjackings (20 percent). In addition, violent crime saw a steady increase during the same time period. In 2001, the country was considered to have the highest per capita murder and rape rates and the second highest rate of robbery and violent theft in the world (Schönteich and Louw, 2011). During the sample period of this study, from 2003 to 2012, crime rates have been on the decline again as discussed below. However, from an international perspective the crime rates in South Africa are still exceptionally high. One of the explanations that have been put forward for the high crime rates is widespread unemployment. In 2004, the beginning of our study period, unemployment was 30/41 percent (narrow/broad definition) (Kingdon and Knight, 2004).

3.2 The Mining Industry

Large-scale mining plays an important role in South Africa’s history. It first started in 1867 when alluvial diamonds were found along the Orange River. This was soon followed by the Kimberley diamond discovery and the Witwatersrand Gold Rush in the 1880s. The gold rush led to the onset of the Mineral Revolution, the rapid mineral-driven economic growth that laid the foundations for South Africa’s economic capital Johannesburg.[7] Today the South African mining industry is the fifth largest in the world (Chamber of Mines 2012), and the country has among the largest mineral endowments despites a long history of extraction. South Africa is a producer of many different

as manufacturing, these two relationships need not hold.

[7] See Appendix A for a detailed account of the history of mining in South Africa and its relationship with migration and criminality.

metals and minerals. From a South African perspective, the economically most important mineral groups are platinum (platinum group metals, PGMs), gold, coal and iron ore.[8] Compared to other countries in the world, it is the biggest producer of PGMs, gold, manganese and chromium (Antin, 2013).

More than half a million people were employed in mining in 2012, an increase from 436,000 in 2003 (Chamber of Mines 2013). Only roughly 15 percent of the workforce in 2013 were women (Statistics South Africa, 2013). The employment opportunities are concentrated to certain regions; at the top of the list are the North West (141,000 miners in 2012), Mpumalanga (79,000), Limpopo (73,000), and Gauteng (32,000), but significant mining employment can also be found in Free State, KwaZulu-Natal, and Northern Cape (Statistics South Africa, 2013).

The mining sector's economic importance relative to GDP exceeds its importance in terms of providing employment opportunities. In 2011, the sector employed 0.7 percent of the workforce, but made up 8.8 percent of national GDP. If upstream and downstream industries are included it constitutes as much as 18 percent of all economic activity (Statistics South Africa, 2013).

Despite the small share of employment to value created, labor constitutes a significant share of the production costs, roughly 40 percent. There is significant heterogeneity, however: for deep-level mines the figure can be over 60 percent, and for open cast mines about 30 percent, a fact we make use of in the subsequent analysis. The wage burden has increased over time. From 2007 to 2012, negotiated wage increases have exceeded inflation, putting more pressure on the industry and leading to staff reductions (Antin, 2013).

4 Data

4.1 Mining

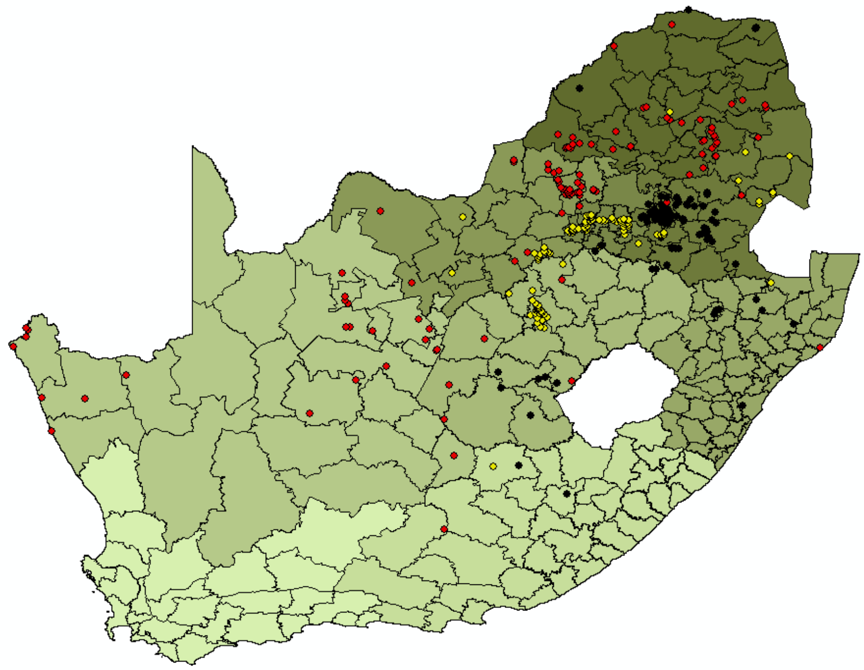
We have data on all large-scale mining operations across South Africa from 1975 to 2012. The data is licensed and provided by IntierraRMG.[9] For each mine we know the minerals produced during the sample period. We also know the exact geographic location and ownership structure.[10] The panel dataset consists of 320 mines across South Africa that produce 23 different minerals. The majority of mines produce either coal or gold (as many as 245 of the mines produce, at least partly, one of these two minerals). A large number of mines also produce the minerals palladium, platinum, and rhodium. The geographic locations of all mines in South Africa are illustrated in Figure 1. Aggregate annual production in these mines fluctuates substantially over time as depicted in Figure 2. The industry is both expanding and contracting at the same time. Production of gold,

[8] These are the largest mineral groups in terms of employment and sales (Antin, 2013).

[9] http://www.intierrarmg.com/Products/SNL_MnM_Databases.aspx

[10] The geographic location provided is double-checked against information available from http://mining-atlas.com.

Figure 1: Mines in South Africa



Notes: This map shows the location of all mines in South Africa for which data is available. Gold mines are illustrated with yellow points and coal mines with black points, whereas all other mines are illustrated with red points. The map also shows municipality borders as defined in the 2011 census and provinces are color coded.

copper, silver, and zinc decreased during the sample period, whereas production of iron ore, cobalt, and platinum increased.

However, the production levels reported are not always comparable, since reporting standards differ across mineral types and companies. To deal with this, we define our main variable of interest as a dummy variable indicating whether a mine is an active producer of a particular mineral in a given year. In a sense, this variable captures the extensive margin of mining activity. Similar strategies have previously been employed within the economic geography literature by Currie et al. (2015), who examine U.S. plants that produce toxic waste, and by Kotsadam and Tolonen (2016).

The mining data from IntierraRMG has previously been employed in a few recent papers: Berman et al. (2015) use it to explore the links between mineral deposits and conflict in Africa; von der Goltz and Barnwal (2014) explore the effects of polluting mining industries on child health in developing countries; and Kotsadam and Tolonen (2016) focus on local economic development and structural shifts in Africa.

Figure 2: Production of Minerals in South Africa

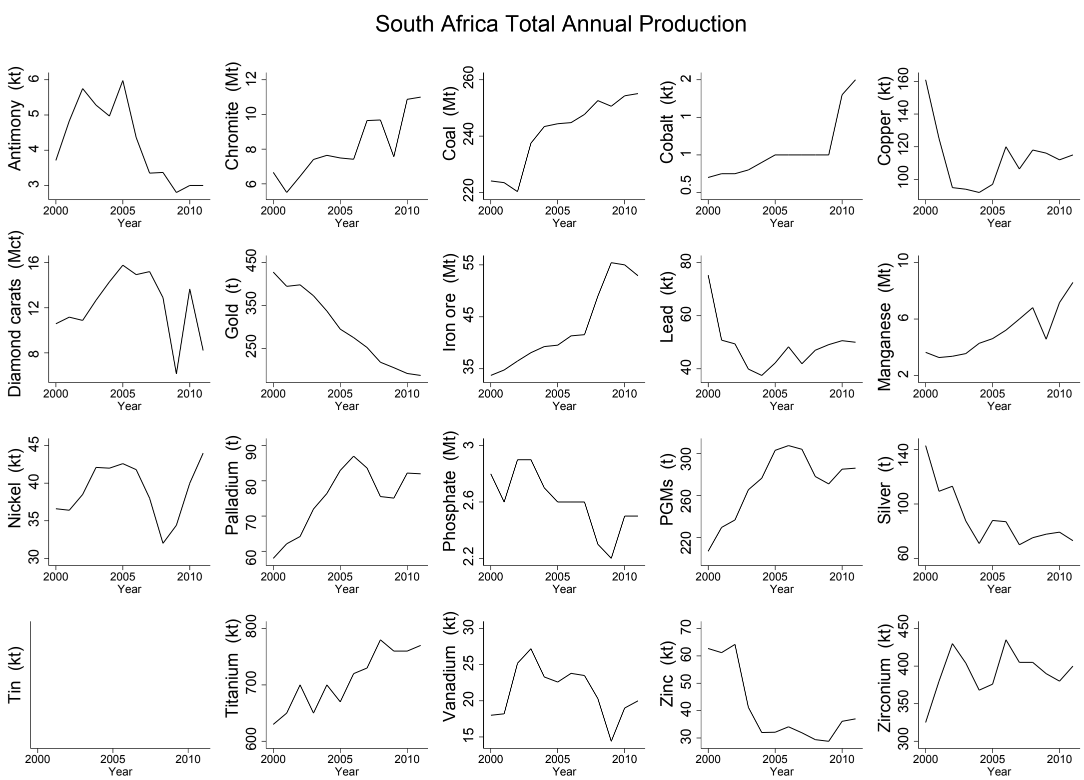
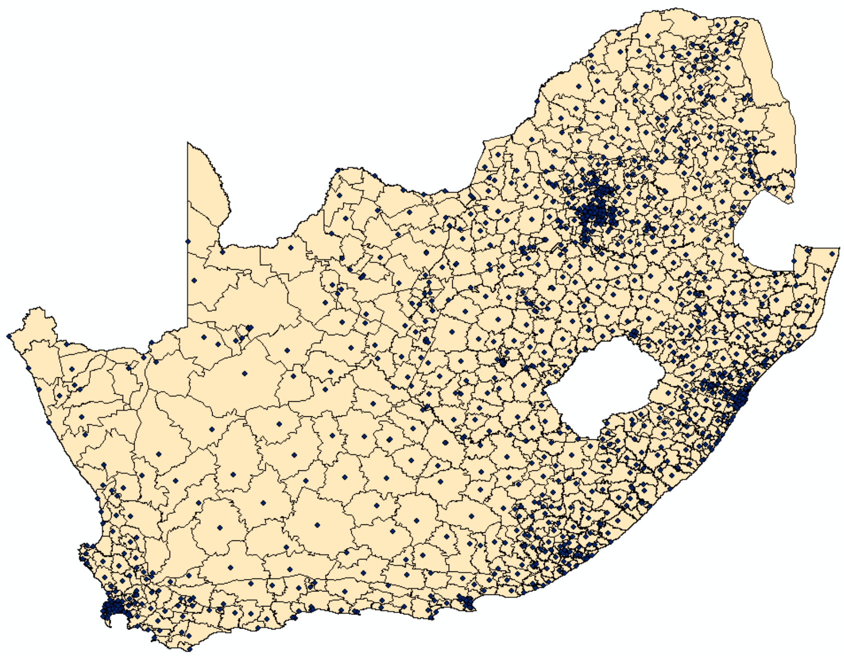


Figure 3: Police Stations in South Africa



Notes: This map shows the geographical location of all police stations in South Africa. The map also shows the borders of the police precincts in 2003.

4.2 Crime and Police Expenditure

The crime data used in this paper is for the years 2003 to 2012 and is provided by the South African Police Service. The data set includes recorded crimes from all 1083 police stations in South Africa. The geographic locations of these police stations are illustrated in Figure 3. Crimes are reported for each financial year (April to March) and divided into 29 different categories. Highlighting some of the variables, there were 177,593 recorded murders, 125,759 carjackings, 29,839 kidnappings, and 668,038 sex crimes over the course of the ten year period. Comparing 2003 and 2012, reported murders and carjackings, for example, went down, while kidnappings and sex crimes increased. However, the overall crime rates went down. Theft, residential burglary and assault show the greatest number of reported incidents.

We create three main outcome variables: property, violent, and total crime.[11] These categories

[11] **Property crime** consists of theft, burglary at non-residential premises, burglary at residential premises, common robbery, robbery at non-residential premises, robbery at residential premises, shoplifting, stock theft, theft of motor vehicle and motorcycle, and theft out of or from motor vehicle. **Violent crime** consists of arson, assault with the intent to inflict grievous bodily harm, attempted murder, common assault, culpable homicide, malicious damage to property, murder, public violence, robbery with aggravating circumstances, and sex crimes. In the context of South Africa, violence might not always be illegal, but rather a phenomenon of its own, that at times overlaps with criminality. Research has found that violence is ingrained in South African society and that it is often both legal and socially acceptable, such as in childrearing and in intimate relationships (Collins, 2013), which further motivates analyzing this as a separate category. **Total crime**, in addition to property and violent crime, also includes carjacking, crimen injuria, driving under the influence of alcohol or drugs, drug-related crime, illegal possession of firearms and ammunition,

have been defined ex-ante to avoid the multiple testing concerns of investigating a large group of similar outcomes.

Crime data in South Africa, as in many other countries, is likely to suffer from under-reporting. However, previous validations comparing the police data with information from the Victims of Crime Survey conducted by Statistics South Africa have shown that this does not seem to be a major problem (such validations have been carried out by Demombynes and Özler (2005) and the Institute for Security Studies). Since we use the data as the outcome variable, our results should be unbiased as long as reporting of crime is unrelated to mining activity.

This might not be the case if mining activity affects the amount of resources dedicated to the police. To investigate this potential concern and to be sure that our results are not explained by higher investments in local policing as mining intensity increases, we collect data on crime-prevention expenditure. This data is from the National Treasury's yearly budget reports and is available at the provincial level (National Treasury, 2015).

4.3 Population, Migration, Night Lights, Local Audits, and Mineral Prices

The population data comes from Statistics South Africa's 2001 and 2011 censuses. Since the crime data covers the years 2003-2012, we need to extrapolate the population estimates to be able to create a per capita outcome variable for each year. Although this proceeding is of course not ideal, the census data is the most reliable and, to our knowledge, most commonly used source on the size of the South African population. We assume a constant growth rate for each geographical unit from 2003 to 2012 based on the average annual growth rate according to the two censuses for that particular unit.[12] These growth rates are then used to obtain estimates of the annual population level. In the subsequent results section, we also show that our results are robust to not taking the local population size into account.

From the 2011 census, we also construct an annual measure of international migration to a municipality. This is possible since respondents in the census need to provide information on how long they have lived in their current municipality and from what country they moved.[13] The question is thus only asked to persons who moved from another country to South Africa. The fact that it is asked in 2011 yields a retrospective entry. Consequently, we will unfortunately not have information on migration outflows between each year. That is, we only capture immigrants for 2011 and thus not, for example, a person who migrated to South Africa in 2004 and then moved out of the country in 2007. Subsequently, to deal with the fact that areas with a high population

kidnapping, neglect and ill-treatment of children and truck hijacking.

[12] For the precincts we only have information about the population in 2011. To calculate the population figures for the other years we use the population growth rate in the municipality.

[13] Respondents answer the following question: ”In which year did [you] move to South Africa?”

also tend to have higher migration flows, we combine this information with the aforementioned population data to construct the share of migrants in a given municipality and year.

As with the population data, reliable employment and income data is available from the South African census. Unfortunately, this data is only available for 2011 and is not provided at a sufficiently disaggregated level to enable us to match it with police precincts. To understand employment and income over time, we make use of estimates of light density measured by satellites at night as a proxy for economic activity, in line with several recent studies. This high-resolution data comes from the National Oceanic and Atmospheric Administration and is suitable for estimation of localized effects, such as in this paper.

Given that the many studies that have found detrimental effects of natural resources on the social fabric have done so in poor settings with weak institutions, it is important for this study to take institutional quality into account[14]. We proxy for institutional quality with audit reports produced by the Auditor General of South Africa. Each municipality (i.e. an administrative area above the police precinct) is given an audit score that ranges in six steps from "adverse" to "qualified". We create a binary variable that takes on the value of zero if a municipality ends up in one of the three top categories ("sound institutions"), and one if it ends up in one of the bottom categories ("poor institutions"). This classification is done based on audit scores in 2006, the earliest year for which audit data is available.

Finally, the data on international mineral prices is available for 20 different minerals and comes from two different sources: the U.S. Geological Survey and IntierraRMG.[15] The price data covers the same years as those for which we have crime data (2003-2012) and is measured in U.S. dollars per gram. The price trend per mineral is shown in Figure 4.

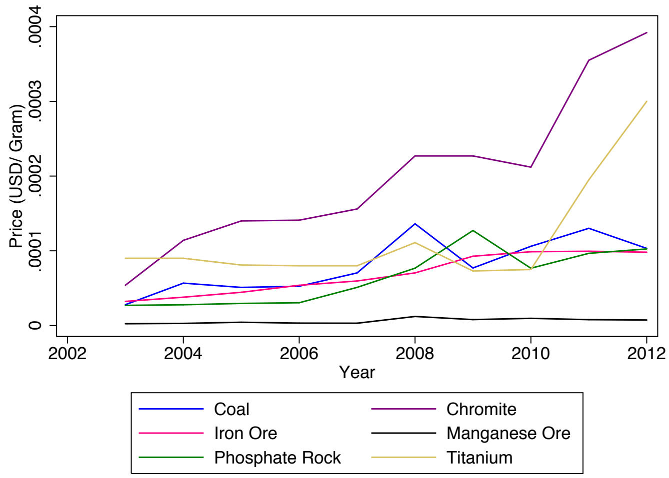
4.4 Sample Construction

Since the above data is provided at different geographical levels, it is necessary to aggregate the information in order to carry out the analysis. Administrative areas (police precincts and the larger municipalities) are matched to all mines within 20 km from their borders. The matching procedure is illustrated in Figure B2 in the appendix and has been designed to take potential spillover effects into account. Previous studies on mining in Africa have found that both local labor markets and agricultural productivity are affected within 20km from the mine (e.g., both Aragón and Rud, 2013; Kotsadam and Tolonen, 2016, use a 20 km radius around the mine as their main specification). We

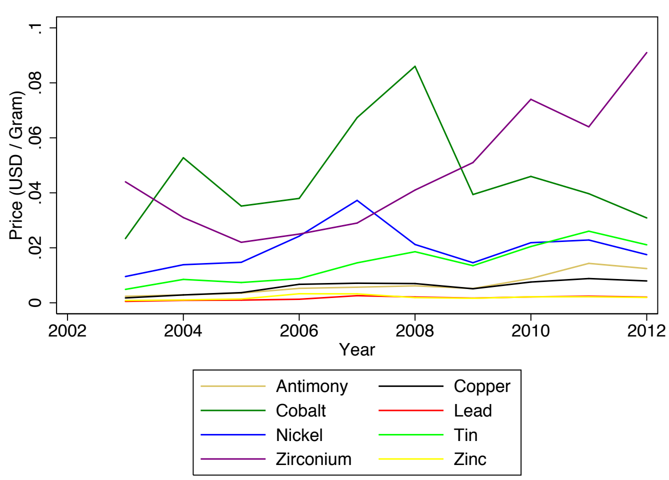
[14] Analysis of Afrobarometer data for sub-Saharan Africa shows that mining increases bribe payments (Knutsen et al., 2016)

[15] In the instrumental variable analysis, we only make use of each mine's main mineral, which leaves us with 15 minerals. USGS is the source for for antimony, cobalt, manganese ore, phosphate rock, titanium, vanadium, zirconium, chromite and iron ore. IntierraRMG is the source for gold, silver, platinum, aluminum, copper, lead, nickel, tin and zinc.

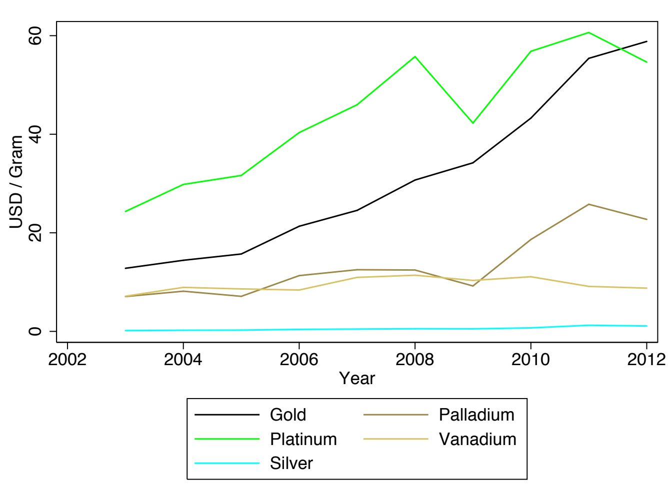
Figure 4: International Mineral Price Trends



(a) Low Price Minerals



(b) Medium Price Minerals



(c) High Price Minerals

follow the literature and use the same distance.[16] Since a number of mines are located close to administrative borders in South Africa, this matching strategy is important in order to capture the full effect of mining activity on criminality.

Using this approach, three different samples are constructed. Two samples use the police precincts as the geographical unit of observation and one sample uses the municipalities. Summary statistics for all samples are presented in Table 1. The sample in Panel A is constrained by the availability of international mineral price data and only includes precincts with mines that are main producers of any of these minerals. This sample is used for the IV analysis described below. The samples presented in Panels B and C are used in the fixed effect strategy and include all mines and minerals as well as all administrative units. Overall, we see that crime rates are high, with total crimes ranging from 39.8 to 88.9 per 1,000 inhabitants, with a majority of these crimes being classified as property crime. Crime levels are notably higher in precincts with mines, reflecting a positive correlation between the number of mines in a location and the crime rate. However, the crime rates decrease over time in both mining and non-mining precincts as illustrated in Figure 5. Property crime has fallen more than violent crime, and mining districts see larger reductions than non-mining areas. Crime levels converged for mining districts and non-mining districts around 2011 and 2012. For total crime, which contains more crime categories than property and violent crimes, non-mining areas have even surpassed mining areas in crime levels. This is during a time period when the number of mines has increased substantially as also illustrated in the figure.[17]

Table C1 in the appendix shows that there is substantial variation in the data. Fifty-four precincts move from zero to one mine, 48 move from one mine to zero mines, 46 move from one mine to two mines, and 43 move from two mines to three mines, etc. These are net flows: if a precinct sees one mine close and one mine open between year t-1 and year t, it will have a net effect of zero and place along the diagonal.

[16] In this analysis, we consider as a mining district any precinct with a border within 20 km from a mine. The treatment area is thus somewhat larger than in aforementioned analyses since it covers the whole precinct. However, we argue that this is sensible since South Africa has a more extensively developed infrastructure network, which allows for longer commuting distances as well as economic integration of larger geographic areas.

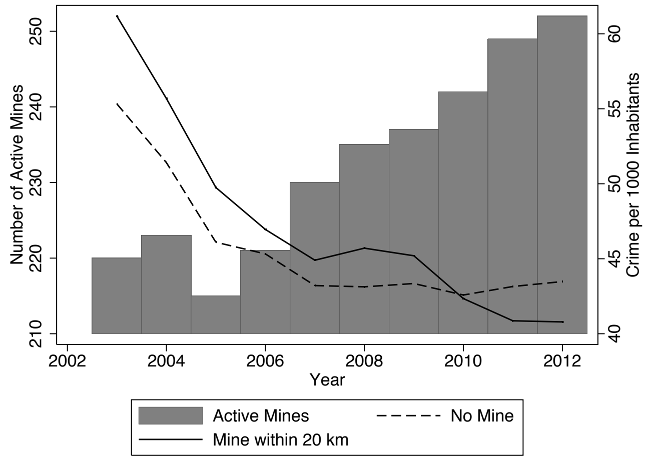
[17] We take the fact that mining and non-mining police precincts seem to have very similar time trends in criminality during the time period when mining is relatively low as support for the way we implement the FE strategy, i.e. that we include non-mining precincts in the sample to estimate our time fixed effects.

Table 1: Summary statistics

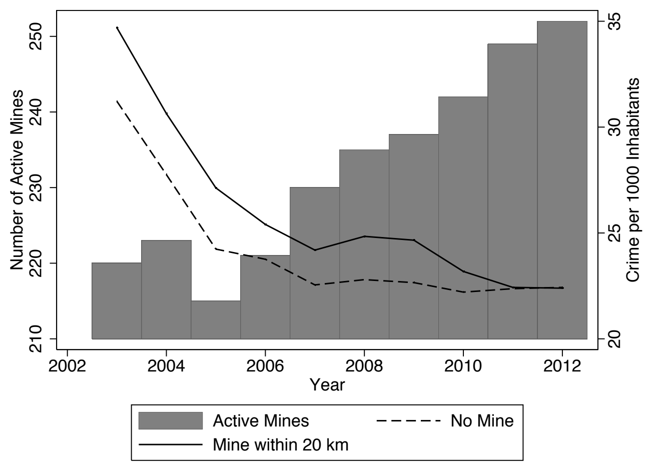
	MEAN	SD	MIN	MAX	OBS
A: Price Sample					
International Mineral Price (USD/gram)	16.6	20.1	0.0000024	60.6	5260
Lights at Night	15.4	20.6	0	63	5260
Population (1000')	55.1	58.6	0.14	592.3	5260
Active Mine 20km	2.89	4.04	0	35	5260
# Start Producing 20km	0.12	0.42	0	5	4733
# Stop Producing 20km	0.061	0.28	0	3	4733
Total Crime per 1000	88.9	914.5	3.49	24794.3	5260
Property Crime per 1000	59.6	740.7	1.22	21531.7	5260
Violent Crime per 1000	19.9	56.2	1.39	1544.7	5260
Log(Total Crime per 1000)	3.71	0.70	1.25	10.1	5260
Log(Property Crime per 1000)	3.02	0.86	0.20	9.98	5260
Log(Violent Crime per 1000)	2.73	0.59	0.33	7.34	5260
Expenditure per capita (Rand)	7.11	9.08	0.062	43.4	5260
B: Precinct Sample					
Lights at Night	13.3	20.8	0	63	10830
Population (1000')	45.5	53.6	0.14	592.3	10830
Active Mine 20km	1.66	3.77	0	36	10830
# Start Producing 20km	0.062	0.29	0	5	9747
# Stop Producing 20km	0.030	0.19	0	3	9747
Total Crime per 1000	72.2	641.8	2.24	24794.3	10830
Economic Crime per 1000	44.5	519.6	0.58	21531.7	10830
Violent Crime per 1000	19.1	41.3	0	1544.7	10830
Log(Total Crime per 1000)	3.66	0.77	0.80	10.1	10830
Log(Economic Crime per 1000)	2.90	0.93	-0.54	9.98	10830
Log(Violent Crime per 1000)	2.69	0.64	0.18	7.34	10825
C: Municipality Sample					
Migrants' Share of Pop	0.0015	0.0026	0	0.062	2106
SADC Male Migrants' Share of Pop	0.00056	0.0011	0	0.026	2106
Male Migrants' Share of Pop	0.0010	0.0015	0	0.035	2106
Population (1000')	210.8	482.0	6.98	4555.7	2340
Active Mine 20km	2.86	5.93	0	44	2340
# Start Producing 20km	0.097	0.36	0	4	2340
# Stop Producing 20km	0.059	0.27	0	3	2340
Total Crime per 1000	39.8	22.3	4.50	145.1	2340
Property Crime per 1000	19.2	12.0	1.44	90.1	2340
Violent Crime per 1000	15.7	8.50	2.19	55.4	2340
Log(Total Crime per 1000)	3.50	0.64	1.50	4.98	2340
Log(Property Crime per 1000)	2.74	0.70	0.37	4.50	2340
Log(Violent Crime per 1000)	2.59	0.60	0.79	4.01	2340

Notes: This table reports summary statistics for the three main samples used in the analysis. Columns (1) through (4) reports the mean, standard deviation, minimum and maximum values of the listed variables, whereas column (5) show the number of observations. The construction of these variables are explained in sections 4.

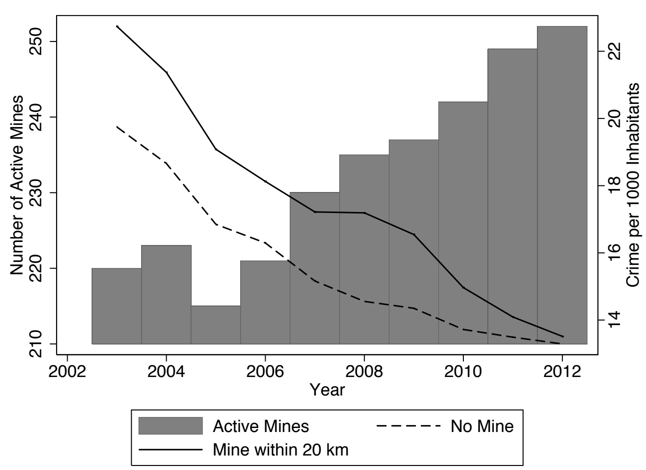
Figure 5: Active Mines and Crime Rates in Mine and Non-mine Precincts



(a) Total Crime



(b) Property Crime



(c) Violent Crime

Notes: Sample is split by precincts that never have a mine, or have at least one mine during the sample period.

5 Empirical Strategy

5.1 Fixed Effect Approach

As a first step we estimate a fixed effect (FE) model. We use the following equation:

$$ln(y_{jt}) = \theta a_{jt} + \gamma_j + \lambda_t + \varepsilon_{jt}, \quad (1)$$

where $ln(y_{jt})$ is the log of the crime rate and a_{jt} the number of active mines in precinct/municipality j and year t. Time and location fixed effects are represented by λ_t and γ_j, respectively. The parameter of interest is θ, which captures the effect of the number of active mines on the local crime rate. We estimate the same equation (at the municipal level) when analyzing the effect of mining activity on migration.

This specification deals with some of the most obvious selection problems that arise when comparing crime levels in areas with and without mines.[18] However, the strategy relies upon the timing of mining activity to be exogenous to other changes in a police precinct. In order to relax this assumption, we use an instrumental variables (IV) approach.

5.2 Instrumental Variable Approach

To estimate the causal effect of mining activity on the local crime rate, we need to overcome a potential reverse causation problem: that mine production could be affected by changes in crime in the proximity of the mine. In other words, we risk misinterpreting our effects if lower crime rates lead to higher mineral production, rather than higher mineral production leading to lower crime rates. Although we do not have any evidence that this is the case in South Africa, it seems likely that investment decisions are affected by local and regional security issues. It can be assumed that multinational mining companies prefer stable environments, as has been shown for investment in the gold sector (Tole and Koop, 2011). Contrary to this assumption, however, the cross-sectional results illustrate that mines are located in police precincts with higher crime levels (see OLS in Table 4).

We use an IV approach where we instrument mining production with international mineral prices.[19] The idea is that production decisions are largely influenced by the exogenously deter-

[18]The mining industry has historically been a catalyst behind the growth of urban areas in South Africa. Therefore comparing crime levels in mining and non-mining areas is likely to be muddled by, among other things, a comparison of areas with different levels of urbanization. Looking at more recent development, there is likely to be selection into which areas that are exploited for mining (even if mineral deposits are known to be geological anomalies and random across space).

[19]One limitation of the IV strategy is that we do not have world prices for all minerals, which means that we do not use all the variation we have in mining activities in the data set. However, all variation is used in the FE approach.

mined possibility of profitably selling the minerals on the international market.[20] The exogeneity of international mineral prices is motivated by the fact that demand elasticities are typically low since minerals are generally inputs in industrial production and only constitute a small share of the consumer price. At the same time, the income elasticity of demand is often high, and hence changes in economic activities in other countries, such as among large Asian manufacturers, can have significant effects on mineral prices (Slade, 1982). Similar identification strategies have been used previously by, e.g., Sanchez de la Sierra (2015) and Berman et al. (2015), and are particularly suitable for South Africa with its diverse mineral exports. The main identification assumption is that international mineral prices affect crime through mine production and not through any other channels (the exclusion restriction). We have no reason to believe that South African crime levels are directly affected by international mineral prices. However, a potential concern is that South Africa influences the international market price for those minerals where it has market power. In order to rule this out, we exclude all such minerals in the robustness section.

We estimate the following first stage regression:

$$a_{ijt} = \delta p_{it} + \gamma_{ij} + \lambda_t + u_{ijt}, \tag{2}$$

where a_{ijt} is the number of active mineral i mines in precinct j, year t. The regression controls for mineral by precinct (γ_{ij}) as well as year (λ_t) fixed effects. The main variable of interest is p_{it} which captures the world market price of mineral i in year t in USD per gram. In the second stage analysis we regress the log of the total, property and violent crime rate in precinct j and year t on the instrumented number of mineral i mines in the precinct:[21]

$$ln(y_{ijt}) = \beta a_{ijt} + \gamma_{ij} + \lambda_t + \varepsilon_{ijt}. \tag{3}$$

The parameter of interest is β, which captures the local average treatment effect (LATE) of price-induced changes in mining activity on the crime rate under the identification assumptions discussed above. Standard errors are clustered at the precinct level in order to account for serial correlation of the errors over time.[22] The same equations are estimated when we investigate the effect of mining activity on economic activity, proxied by light density.

[20] We mainly expect price changes to affect production stops or fluctuations rather than the openings of new mines considering the large investment costs and time required to start up a new mine.

[21] Note that the local crime rate varies by precinct j and year t and not by the mineral type i. Hence, the mineral i subscript for the outcome variable is only used to show that the same crime rate is used for all mineral i observations in precinct j and year t.

[22] However, to deal with mineral-time specific shocks, two-way clustered standard errors on the precinct and mineral-time dimension are also reported for the main specifications.

5.3 Production Shocks

In order to understand the dynamics of how mining activity affects crime, we investigate how production shocks affect crime rates. We implement a fixed effect strategy using the following equation:

$$ln(y_{jt}) = \beta_1 start_{jt} + \beta_2 stop_{jt} + \gamma_j + \lambda_t + \varepsilon_{jt} \quad (4)$$

where $start_{jt}$ / $stop_{jt}$ is the net number of mines that start/stop producing in year t (in relation to whether they were producing in year $t-1$) in precinct/municipality j.[23] As in all previous specifications all mines within 20 km from the geographical unit of observation are considered. Time and location fixed effects are captured by λ_t and γ_j, respectively. Moreover, to investigate the possibility that mining affects crime both before and after starts and stops in production (e.g., through linkages and changes in production volume), we also allow for leads and lags in versions of this specification.

6 Results

6.1 Main Effects

This section reports the results from the main analysis. Table 2 and 3 display the results from the FE specification, while Table 4 shows the corresponding results from the IV strategy. The effect of production shocks is reported in Table 5.

As stated earlier, we implement a fixed effect strategy at both police precinct and municipality level. Since crime statistics are given at precinct level, we need to aggregate them to match with the larger municipalities (the level at which we have information on migration statistics from the censuses). The effects of mining activity on crime in a municipality are then based on an area approximately five times as large as the precinct on average. Thus, we view such estimations as the effect of mining activity on crime at an aggregate level. Tables 2 and 3 both display negative estimates when including fixed effects.[24] The estimated effects of mining activity on total crime

[23] Note that since we only have one instrument, we cannot use an IV-strategy to estimate this equation.

[24] Column 1 shows the unadjusted correlation in the data, revealing that mining districts have higher total crime rates. However, the fixed effects model shows that the association between more active mines and criminality is negative. The main treatment variable *Active Mine 20 km* is zero in 88%, but can be as high as 10 active mines, in a given year and precinct. We refrain from using the log of this variable due to the high number of zeros. To test the constant semi-elasticity of the model assumed, we include the square of the mining activity variable in Table C11 in the appendix. We note that in the cross section, the positive association between the number of active mines and criminality is concave. However, in the fixed effects model the square terms are very small and insignificant, which increases our belief in the assumption of constant semi-elasticity.

Table 2: Precinct fixed effects

	OLS	FE		
	Total Crime	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)	(4)
Active Mine 20 km	0.0239***	-0.0171**	-0.0124	-0.0184**
	(0.00484)	(0.00713)	(0.00798)	(0.00786)
Observations	10830	10830	10830	10825
R-Squared	0.0136	0.955	0.952	0.905
Mean of Outcome	3.665	3.665	2.898	2.694
Precinct FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes

Notes: Column (1) presents the OLS cross-sectional results. Column (2)-(4) report the results of a fixed effect regression of the log of the local crime rate in a precinct on the number of active mines within 20 km from the precinct, with controls for precinct and year fixed effects. Standard errors in parenthesis are clustered at the precinct. For inclusion of the square term of the treatment variable, see Table C11 in the appendix. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

rate are quite similar in size at both levels (1.6-1.7 percent), but the effects differ for property and violent crime. Specifically, violent crime is significantly negatively affected by mining activity at the precinct level, while property crime is negative but insignificant. The reverse holds true at the municipal level.

Table 3: Municipality fixed effects

	OLS	FE		
	Total Crime	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)	(4)
Active Mine 20 km	0.0193***	-0.0157**	-0.0157**	-0.0139
	(0.00398)	(0.00732)	(0.00758)	(0.00960)
Observations	2340	2340	2340	2340
R-Squared	0.0314	0.969	0.959	0.957
Mean of Outcome	3.501	3.501	2.737	2.593
Municipality FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes

Notes: This table reports the results from a fixed effect regression of the log of the local crime rate in a municipality on the number of active mines within 20 km from the municipality. All regressions control for municipality and year fixed effects. Standard errors in parenthesis are clustered at the municipality. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

As discussed above, there are a number of reasons why we may not be willing to trust the above fixed effect estimate. To overcome potential reversed-causation and omitted variable problems, we implement our IV strategy. The results from this are presented in Table 4. The table shows that the first-stage estimate is positive and highly significant: as world market mineral prices increase, so does the number of active mines producing those particular minerals in a police precinct.[25] More specifically, we find that as the mineral price increases by ten dollars per gram, the number of active mines increases by about nine percent of the mean number of active mines. Contrary to previous literature investigating the effect of extractive industries on social conflict, the resulting second-stage analysis displays a significant negative point estimate on crime. In particular, as the number of active mines increases, induced by higher international prices, total crime rates decrease by around seven percent for each additional active mine. The effect is somewhat bigger for property crimes than for violent crimes but is highly statistically significant in both cases. All results are robust to two-way clustering of standard errors at the precinct and mineral-year level, as shown in brackets.

Table 4: Precinct IV

	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)
2SLS	-0.073*** (0.020) [0.024]	-0.088*** (0.022) [0.027]	-0.066*** (0.024) [0.027]
Reduced Form	-0.00192*** (0.000504)	-0.00230*** (0.000551)	-0.00174*** (0.000615)
First Stage	0.026*** (0.0018) [0.0024]		
F Statistic (one way cluster)	206.9		
F Statistic (two way cluster)	121.1		
Observations	5260		

Notes: This table reports the result of an IV regression using the world market price to instrument the number of mines that produce a given mineral within 20 km from a precinct. The IV estimate for each of the three crime categories (log of crime per capita in the precinct) is presented in the first row and the corresponding reduced form estimates in the second row. The first stage relationship is reported in the final row. All these regressions are carried out at the mineral-precinct level and include mineral by precinct fixed effects as well as year fixed effects. Standard errors in parenthesis are clustered at the precinct and standard errors in brackets are clustered at the precinct and the mineral-year level. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

Comparing the IV results and the FE results, it is clear that the estimated effects are larger using the IV approach. This discrepancy might stem from the fact that the IV results rely on price shocks and thus could be considered the local effects of a mining-production shock on crime. That is, in

[25]These results are robust to logging the price variable as reported in Table C8 in the appendix.

the IV specification we capture the effect of less expected production changes, compared with the FE specification.[26]

Next, we delve further into the dynamics of how mining activity affects crime by investigating the effect of production shocks using a FE strategy.[27] Here, we define a production shock as a start or a stop in mining production. Table 5 reports the results and shows that starts in production are not associated with changes in crime, whereas stops in production are associated with increases. Results are statistically significant for total and property crime. In turn, Table C2 in the appendix shows that the positive effect on crime of a stop in production on crime is stronger for the current year than if the mine stops producing in $t-1$ or $t+1$. However, we find significant effects of mining stops with both leads and lags on criminality. Mines that are about to close may phase out production over time, especially if they are closing down because of depletion of the mineral source. Hence, this is likely a consequence of the fact that we are capturing the extensive margin effect of mining activity. Similar patterns are seen for a start in production, but here the results are insignificant.

Table 5: Start & Stop Producing Precinct FE

	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)
Start Producing 20 km	-0.00182	0.00659	-0.0138
	(0.0101)	(0.0115)	(0.0137)
Stop Producing 20 km	0.0232**	0.0280**	0.0106
	(0.00999)	(0.0113)	(0.0124)
Observations	9747	9747	9742
R-Squared	0.957	0.954	0.907
Mean of Outcome	3.638	2.864	2.664

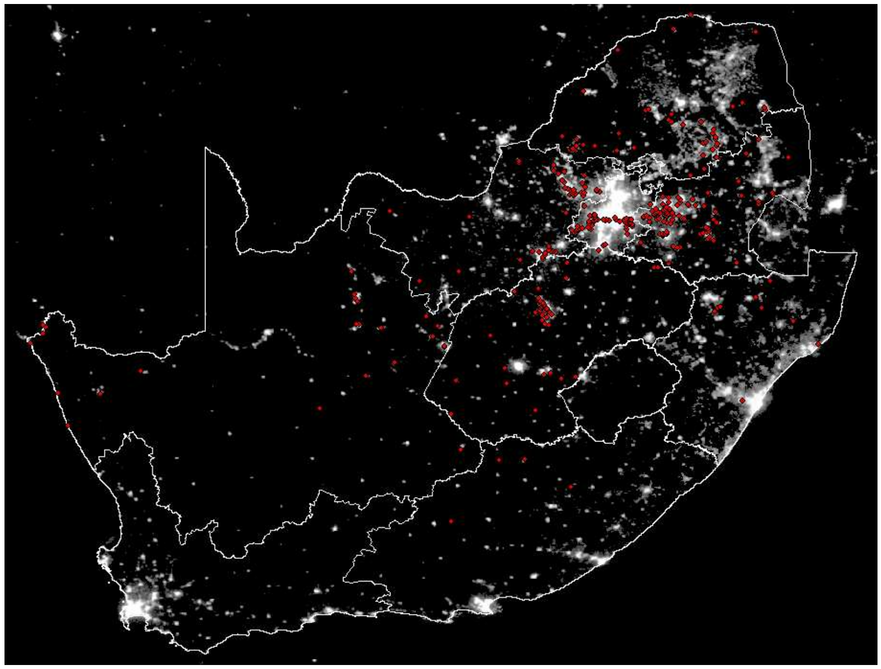
Notes: This table reports the result from a fixed effect regression of the log crime rate in a precinct on the number of mines that start and stops producing within 20 km from that precinct. All regressions include precinct fixed effect as well as year fixed effects. Standard errors clustered at the precinct level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

Lastly, Tables C3, C4 and C5 in the appendix report the results for all subcategories of crime using the IV approach. As would be expected given the results on the compound variables (total, property and violent), most crimes have a negative coefficient. It is however interesting to note that the effect of mining activity on public violence tends to be positive, albeit insignificant using the IV approach. This subcategory of crime is much like what has been explored in earlier papers

[26] If precinct level decreases in crime rates caused mines to open, the FE estimates would likely suffer from bias and be more negative. We notice however the IV estimates are in fact larger than the FE estimates.

[27] Note that since we only have one instrument, we cannot use an IV-strategy to estimate this equation. This is a reason to interpret these results with caution. However, the relatively similar results obtained in the previous FE and IV analysis should lend credibility also to this analysis.

Figure 6: Mine Location and Lights at Night in 2012



on extractive industries and social conflict. To investigate this further we run regressions with this outcome also using the FE strategy for both the municipality and the precinct sample. Table C6 reports the results and shows that we find a positive and highly statistically significant impact of mining on public violence. Hence, we seem to, at least suggestively, find similar effects as previous studies also for South Africa. This implies that extractive industries may have differing effects dependent on the type of crime investigated.

6.2 Income Opportunities

We have found that mining activity has a negative effect on crime rates and that crime rates go up as mining activity stops. These results are in line with economic theories saying that income opportunities are important determinants of crime rates. In other words, when mining activity increases, economic opportunities are likely to increase as a consequence. This in turn lowers the incentives to commit crimes. Likewise, when a mine stops producing, income opportunities may fall and crime incentives increase. Ideally, we would want to test these channels with yearly data on employment and income at the police precinct level, but such data does not exist for our period of analysis. Thus, we make use of the light density at night as a proxy for economic activity. Figure 6 illustrates mine locations and lights at night density in South Africa in 2012 and Table 6 reports the results from the analysis.

We find that an increase in the number of active mines leads to increased economic activity, proxied by night lights. More specifically, the results from a precinct FE analysis show that one additional active mine increases the mean light density by about five percent of the mean value. Likewise, when a mine stops producing, economic activity decreases by about 2.6 percent. Again, we see no significant effects for a start in mining activity with the FE strategy. Furthermore, in the third column of Panel A in Table 6, we show that the effect of mining activity also is present in precincts without a mine, but with a mine 20 km from its borders. Thus, there are clear economic spillover effects from mining activity that underline the importance of the 20 km radius used in this paper. The estimate is larger in the third column than in the fourth column, but so is the mean light density, a result of the fact that cities are usually situated in precincts neighboring mining areas. Further, this analysis ensures that the results in this section are not driven by lights emitted from the mine. The last column in Table 6 reports the results from using the IV strategy to estimate the effect on light density. Results are substantially larger and highly statistically significant.

Table 6: Lights at Night

	Lights at Night				
	FE				IV
	(1)	(2)	(3)	(4)	(5)
Active Mine 20 km	0.648***		0.649***	0.603***	0.987***
	(0.106)		(0.168)	(0.132)	(0.260)
Start Producing 20 km		0.00701			
		(0.0839)			
Stop Producing 20 km		-0.358**			
		(0.173)			
Observations	10840	9756	2640	1410	5260
Mean of Outcome	13.36	13.52	20.20	9.951	15.37
Sample	Full	Full	No mine	≥1 mine	Full

Notes: This table reports the result from a set of regression of the average light intensity at night in a precinct on mining activity. The first four columns report results from fixed effects regressions. Column (1) reports the effect for the number of active mines within 20 km from the precinct, whereas column (2) shows the effect for the number of mines that starts and stops producing within 20 km from the precinct. Column (3) display the same effect as in column (1), but excludes all precincts with a mine within the precinct; i.e. only precincts with mines within 20 km from its borders (but not within the precinct) are included. Column (4) limits the sample to precincts with a mine within the borders of the precinct. All these regressions include precinct fixed effect as well as year fixed effects. The last column reports results from an IV regression and include precinct by mineral fixed effects as well as year fixed effects. Standard errors clustered at the precinct level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

In Table 7 we split the sample and explore the effect of mining on crime for open-pit mining and underground mining respectively. The idea is that open-pit mining and underground mining differ in capital and labor intensity, with underground mining being more labor intensive due to the difficulty of getting heavy machinery into these mines. Looking at these heterogeneity results, we are thus able to say something about how our setting relates to the theory developed by Dal Bó and Dal Bó (2011). In line with the theory, we find that our results seem to be driven by positive shocks to labor-intensive mines (Panel B). For capital-intensive mining, the results are not significant, but it is interesting to note that the signs are positive for all crime categories.

Table 7: Precinct IV heterogeneous effects by mine type

	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)
A: Open-pit mining (capital intensive)			
2SLS	0.132	0.0690	0.143
	(0.313)	(0.305)	(0.385)
First Stage	0.00993***		
	(0.00329)		
F Statistic	9.142		
Observations	1105		
B: Underground mining (labor intensive)			
2SLS	-0.0923***	-0.116***	-0.0548*
	(0.0251)	(0.0293)	(0.0305)
First Stage	0.0275***		
	(0.00216)		
F Statistic	162.9		
Observations	3169		

Notes: This table reports the result from splitting the sample into precincts with primarily (defined as at least half) open-pit mines and precincts with primarily underground mines. Precincts with an equal number of open-pit and underground mines have been excluded from the analysis. All regressions include mineral by precinct fixed effect as well as year fixed effects. Standard errors clustered at the precinct level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

In summary, this analysis suggests that mining activity does significantly affect local economic opportunities. In turn, since much of the South African mining industry is labor intensive, a positive shock to the industry reduces the incentives to commit crimes.

6.3 Local Institutional Quality

Earlier studies have found detrimental effects of natural resources on development, not least going through violent grabbing and appropriation. Above, we find that the overall negative effects of mining on crime in South Africa may be driven by the income opportunities provided by the industry. Since the income channel does not seem to dominate in poorer settings, it is reasonable to assume that what differs between, say, D.R. Congo (c.f. Sanchez de la Sierra, 2015) and South

Africa is the institutional quality[28]. We thus interact the number of active mines and international mineral prices with a binary variable that indicates whether a municipality received a poor audit score in 2006 or not. The sample is restricted to the post 2006 period and only includes areas that received an audit score. Results are displayed in Table 8.

Table 8: Precinct IV, Institutional Quality

	Total Crime	Property Crime	Violent Crime
	(1)	(2)	(3)
2SLS			
Active Mines 20km	-0.2540***	-0.2334***	-0.4644***
	(0.0770)	(0.0859)	(0.1254)
Mines × Poor institutions	0.2042*	0.1372	0.4992***
	(0.1069)	(0.1153)	(0.1590)
Reduced Form			
Price	-0.0048***	-0.0043***	-0.0091***
	(0.0013)	(0.0016)	(0.0020)
Price × Poor institutions	0.0044***	0.0034*	0.0097***
	(0.0016)	(0.0019)	(0.0024)
F-Stat (Mine)	23.62	23.62	23.62
F-Stat (Mine * Poor)	16.96	16.96	16.96
Observations	2317	2317	2317
Mineral by Precinct FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table reports the result of an IV regression using the world market price to instrument the number of mines that produce a given mineral within 20 km from a precinct. The IV estimate for each of the three crime categories (log of crime per capita in the precinct) is presented in the first row and the corresponding reduced form estimates in the second row. Mines and prices are interacted with a dummy variable indicating whether or not a municipality received a bad audit in the baseline year of 2006. All these regressions are carried out at the mineral-precinct level and include mineral by precinct fixed effects as well as year fixed effects. Standard errors in parenthesis are clustered at the precinct.

The main negative effect is clearly driven by areas with good institutional quality. Estimates are substantially larger for these areas and highly statistically significant for all crime categories.[29] On the contrary, the interaction between the number of active mines and the "poor institutions" indicator is positive. It is evident from the third column that the positive coefficient in front of the interaction is driven by the result on violent crime. This is not surprising if we believe that areas of South Africa with poorer institutions can be compared to other, poorer settings in Africa, where

[28] Caselli and Tesei (2016) find heterogeneous effects of natural resource windfalls on political regimes depending on pre-existing institutional quality. Democracies and deeply entrenched autocracies do not change; moderately entrenched autocracies change for the worse.

[29] Note that the overall effect differs from the baseline estimate presented in Table 4, due to the above described sample restrictions

natural resources have been shown to have positive effects on violence. We thus find suggestive evidence of detrimental effects of mining activity on violent crime, similar to earlier studies. However, when looking at South Africa as a whole, these effects seem to be dominated by the fact that an active mine provides income opportunities. In that sense, this result gives an indication of how South Africa – and potentially other middle-income countries – differ from poorer settings. In other words, natural resources may be beneficial, but sound institutions are a prerequisite for mitigating any violent grabbing.

6.4 Migration

Migration plays a paramount role in the South African mining industry and the size of the migratory influx determines whether employment rates increase or decrease. Moreover, the migrant-labor system and the informal settlements that it is associated with, have historically been associated with high unemployment, lack of services and high crime rates and are thus a potential mechanism behind our findings.

In Table 9, we start out by showing that total and male migration as well as migration from SADC[30] countries increase due to mining activity. In particular, when the number of active mines increases by one mine, migration as a share of the municipality's population increases by approximately 23 percent of the mean. Looking at the effect of starts and stops in productions, it is found that starts in production leads to an 18 percent increase in the migration share (second panel). We do not find significant estimates from stops in production, which is probably explained by the fact that the data does not allow us to capture migration outflows (see data section above).

Geography, such as distance from border and persistence of migration movements may determine migration patterns in the wake of a mining boom. We explore if effects are different in precincts with higher than median rate of migration from precincts with lower than median rates of migration. Table 10 shows the results.[31] The results for municipalities with migration shares below the median are reported in Panel A. There are no significant effects of the number of active mines within 20 km on the log crime rates in these municipalities, but point estimates are positive. However, looking at production shocks we see that production starts in low migration areas are associated with lower crime rates (total crimes go down by about 2.45 percent) and typically small and insignificant effects on crime when a mine stops producing. Panel B shows the results for municipalities with above-median migration shares. These results indicate that an increase in the number of active mines leads to lower crime rates, while both starts and stops in production are

[30]SADC stands for the Southern African Development Community and includes Angola, Botswana, Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

[31]The median migrant share of the population in the sample is about 0.1 percent.

Table 9: Effects on Migration

	Total Migration	Male Migration	SADC Male
	(1)	(2)	(3)
A: Number of Active Mines			
Active Mine within 20 km	0.000360**	0.000180**	0.000134**
	(0.000146)	(0.0000770)	(0.0000573)
Observations	2106	2106	2106
R-Squared	0.775	0.772	0.761
Mean of Outcome	0.00154	0.00100	0.000563
B: Start and Stop Producing			
Start Producing 20 km	0.000275***	0.000148**	0.000102**
	(0.000106)	(0.0000582)	(0.0000441)
Stop Producing 20 km	0.000263	0.000144	0.000109
	(0.000340)	(0.000193)	(0.000146)
Observations	2106	2106	2106
R-Squared	0.771	0.770	0.758
Mean of Outcome	0.00154	0.00100	0.000563

Notes: This table reports the results from a fixed effects regression of the share of migrants in a municipality on the mining activity within 20 km from a municipality. The sample covers all years for which migration data is available (2003-2011). Panel A reports the results for the total number of active mines, whereas Panel B reports the results for the number of mines that starts or stops producing in a given year. Column (1) reports the effect on the total migrants' share of the population, column (2) on male migrants and column (3) on male migrants from the SADC countries. All regressions control for municipality and year fixed effects. Standard errors clustered at the municipality level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

associated with higher crime rates. Notably, the increase in crime when a mine stops producing is statistically significant for both total and property crime. A potential explanation for these results is that production shocks in high migration areas affect individuals with weaker ties to the local labor market, hence the income opportunities provided by the mine are more important for this group. The positive (but mostly insignificant) estimates when the mine starts production could potentially be driven by an over-supply of migrant workers.

Table 10: Heterogeneous effects by Average Migration

	Number of Active Mines			Start and Stop Producing		
	Total Crime	Property Crime	Violent Crime	Total Crime	Property Crime	Violent Crime
A: Below Median Migration						
Active Mine 20km	0.0188	0.0177	0.0313			
	(0.0211)	(0.0228)	(0.0202)			
Start Producing 20 km				-0.0245**	-0.0152	-0.0199
				(0.0115)	(0.0156)	(0.0134)
Stop Producing 20 km				0.0105	0.00495	-0.00371
				(0.0171)	(0.0184)	(0.0204)
Observations	1230	1230	1230	1230	1230	1230
R-Squared	0.964	0.949	0.960	0.964	0.949	0.960
Mean of Outcome	3.303	2.471	2.462	3.303	2.471	2.462
B: Above Median Migration						
Active Mine 20km	-0.0190**	-0.0219***	-0.0155			
	(0.00815)	(0.00814)	(0.0113)			
Start Producing 20 km				0.0111	0.0140*	0.00787
				(0.00702)	(0.00827)	(0.00897)
Stop Producing 20 km				0.0275***	0.0298**	0.0186
				(0.0105)	(0.0117)	(0.0144)
Observations	1110	1110	1110	1110	1110	1110
R-Squared	0.966	0.957	0.949	0.966	0.956	0.949
Mean of Outcome	3.720	3.033	2.738	3.720	3.033	2.738

Notes: This table reports the results from carrying out the municipality fixed effect analysis in Table 3 on two different samples. All regressions control for year and municipality fixed effects. Panel A reports the results for municipalities with below median migration during the sample period. Panel B reports the results for municipalities with above median migration. Standard errors clustered at the municipality level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

6.5 Robustness Checks

All main specifications include year fixed effects. In Table 11 we show that the results are not sensitive to including linear and quadratic price trends.[32] The size of the effect goes down somewhat when including province specific time trends, but is still similar in terms of magnitude and significant at the 5 percent level.

Table 11: IV Model: Trends and Fixed Effects

	Total Crime					
	(1)	(2)	(3)	(4)	(5)	(6)
2SLS	-0.29***	-0.073***	-0.075***	-0.073***	-0.054**	-0.056**
	(0.026)	(0.020)	(0.020)	(0.020)	(0.025)	(0.025)
	First Stage					
First Stage	0.027***	0.026***	0.026***	0.026***	0.026***	0.025***
	(0.0019)	(0.0018)	(0.0018)	(0.0018)	(0.0028)	(0.0028)
F Statistic	208.2	206.9	207.4	206.9	80.5	80.8
Observations	5260	5260	5260	5260	5260	5260
Mineral by Precinct FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	No
Linear price trend	No	No	Yes	Yes	No	Yes
Quadratic price trend	No	No	Yes	No	No	No
Province time trend	No	No	No	No	Yes	Yes

Notes: This table reports the results from an IV regression of the log of the local crime rate in a municipality on the number of active mines within 20 km from the precinct. The instrument is the international mineral price. Clustered standard errors at precinct level in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

The preferred specification uses international mineral prices as instrument. A potential concern with this approach is that South African production may affect international prices, since the country has a high share of the world production for some minerals (see Figure B1 in appendix). If that is the case, local crime levels could affect production, which in turn would affect international prices and thus invalidate the instrument. In Table C7 in the appendix we deal with this concern by dropping minerals for which South Africa contributed more than 20 percent of the world production during the period of analysis.[33] We still find strong negative and significant effects of mining activity on crime. Even though this analysis drops 1,500 observations, it still produces

[32] Figure B3 in the appendix shows that the year dummies capture a quadratic trend. See Table C12 in the appendix for the corresponding table for the FE specification.

[33] For our period of analysis, these minerals are palladium, chromite, platinum, zirconium, vanadium, manganese ore and titanium.

estimates that are very similar in size and with a nearly identical first-stage estimate of the effect of international prices on mining production. Another potential concern with the IV strategy might be that the different price levels of minerals is somehow affecting the results. In Table C8 in the appendix we show that the results from the instrumental variable model are robust also to a log-log specification, where the log of the mineral price is used as the instrument.

The price instrument would be problematic if it is reflecting overall changes in the global economy, rather than shocks to a specific mineral mine. If this is the case, then our strategy might capture changes in general economic trends that could affect criminal activity directly, which would invalidate our identification assumptions. To investigate this potential concern, we follow Hsiang and Jina (2014) and randomly match our mineral price data (preserving the time-ordering of the data) to the mineral-precinct units and re-estimate our first stage equation on this new sample. This procedure is then carried out 10,000 times with the purpose of testing whether temporal trends in our data are generating spurious correlations. Panel A of Figure B4 shows the density of first stage coefficients using this randomization strategy. As can be seen from the figure, the randomization procedure produces a distribution of coefficients centered at zero, indicating that the model is unlikely to generate biased results. Further, the figure show a vertical line indicating the coefficient obtained when using the true data. An exact test shows that the probability that our estimate is generated by chance is less than 0.01. The concern that our results are driven by economic trends also applies to the FE specification. In order to check this we employ a similar randomization strategy as above but instead randomize the mining activity variable in equation (1). Panel B of Figure B4 in the appendix shows the results from this test. Also in this case are we able to reject that our estimate is from the randomly generated distribution of coefficients, indicating that the results are not driven by spurious economic trends.

As mentioned in Section 4.3, we need to extrapolate the population estimates from Statistics South Africa's censuses to be able to create per capita outcome variables for each year. To test the concern that this data issue is affecting our results, we show that the negative and significant estimates hold also for count data in Table C9 in the appendix.

We also investigate the importance of the strategy employed to deal with spillovers in Table C10 in the appendix, where we run the same regression as earlier, but without a 20 km radius around each mine. This means that if, for example, a mine closes in a municipality near the border of another municipality, we do not take into account that the mine closing could affect the neighboring municipality's crime rate. Even with this restriction we find a negative significant effect on total crime with a point estimate similar in size to when a 20 km radius was used, but less precisely estimated.

There is a possibility that the negative effect of mining activity on crime found in this paper stems from the fact that the mining industry makes use of private security companies. An increased mining activity would then result in more private security forces which in turn would result in lower crime rates. However, we do not have any indications of mining security working outside the immediate mining facilities. Rather, as outlined by the director of the global security company G4S when discussing South Africa, "the priority is to control access in order to counter external criminal threats against the company's equipment and infrastructure, while maintaining order among the large workforce" (Mining Technology, 2014). Thus, since this paper explores the effect of mining activity on crime in a larger area around a mine, we do not expect private mining security to be driving the results.

Table 12: Crime Prevention Expenditure

	Expenditure			
	Per Capita	Log Per Capita	Total Crime	
	(1)	(2)	(3)	(4)
Active Mines	-0.529	-0.137	-0.0731***	-0.0889***
	(0.561)	(0.0789)	(0.0196)	(0.0199)
Expenditure (Rand)				-0.00495***
				(0.00125)
Observations	90	90	5260	5260
R-Squared	0.752	0.857	0.345	0.341
Mean of Outcome	7.987	1.355	3.707	3.707
Province FE	Yes	Yes	No	No
Mineral by Precinct FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes: This table reports the results using province data on crime prevention expenditure. Columns (1) and (2) regress per capita crime prevention expenditure on the number of active mines within a province in a given year using a fixed effect setup similar to equation (3). Column (3) replicates the main IV specification and column (4) add expenditure per capita as a control to this specification. Standard errors in parenthesis are clustered at the province level in the first two columns and at the precinct in columns (3)-(4). Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

Lastly, and similar to the aforementioned, a potential concerns is that our results are explained by higher crime-prevention expenditures when mining activity increase (or lower expenditures when they close down). If so, we cannot say with certainty that the negative effects of mining on crime actually stems directly from mining. In Table 12, the first two columns explore the effect of the number of active mines on crime-prevention expenditure in a fixed effect setting. Unfortunately, to our knowledge, this data is only available at province level, which leaves us with very few observations. This is due to the fact that the policing responsibility lies at this administrative level. We find no significant effects of mining activity on police expenditure. If anything, the estimates are negative, regardless of whether the outcome is logarithmized or not. The third column shows the main (negative) result from instrumenting the number of active mines with international mineral prices. The last column reports the results from the same specification, adding provincial crime-prevention expenditure per capita as a control variable. The main estimate remains virtually the same in terms of both size and significance (and even increases somewhat) while the coefficient on police expenditure is negative and significant. Bearing in mind the limitations of these tests, we do not find any evidence for the concern that our results are driven by crime-prevention expenditure. Police activity directly related to local mining is restricted to the so called Diamond and Gold Branch of the South African Police Service (Gastrow, 2001). Their main responsibility is to investigate cases where mining materials are suspected to be stolen, rather than crimes as defined in this paper.

7 Discussion

It is a much studied question whether natural resource economies are more vulnerable to social conflict and civil war. To our knowledge, this is the first paper to look at social instability at another level: criminality. We explore the link between South Africa's mining sector and crime rates. The question is of particular interest in this context for two main reasons. First, South Africa is one of the world's most important mining countries and one of the most crime-ridden countries in the world. Second, South Africa is a middle-income country with relatively stable political institutions. Previous hypotheses are mostly applicable to low-income countries or countries with political volatility, and are therefore not informative regarding the relationship between criminality and mining in this context. Since many natural-resource rich economies are middle-income countries – for example Botswana, Brazil, Mexico, and Romania – this is an issue of great relevance.

We explore the causal link between large-scale mining activities and criminality using different definitions of mining areas and two different identification strategies: a fixed-effects approach and an instrumental variable approach. With these strategies we explore how criminality changes with the number of active mines of a certain mineral within a precinct or at the larger municipality level, and how criminality changes with stops and starts in mining production. To overcome concerns regarding reversed causality, where companies choose to invest or disinvest in certain areas because of crime rates, we instrument the number of active mines with changes in international mineral prices. We have detailed information on various types of criminality, but to limit the risks of drawing the wrong conclusions due to multiple hypothesis testing, we focus on a pre-determined set of outcomes: total crime, property crime, and violent crime.

In contrast to the general conclusion of the literature, we find an overall negative and significant relationship between mining and criminality for total, property and violent crime. Total crime rates decrease by around seven percent with each additional mine. However, the analysis shows that mining areas may be at risk of suffering from increased levels of criminality when a mine stops producing. This indicates that the negative relationship that we see between mining and criminality could be driven by the positive shocks on criminality that mine closures could have. Such an effect could be explained through an income opportunity channel, as income opportunities likely decrease when a mine stops producing (both from the mine itself and from other industries that rely on incomes from the mining industry).

We explore three main channels: income opportunities, institutional quality, and migration. Using night lights data, we find supportive evidence that the local economic activity contracts when mines stop producing, leading to changes in opportunity costs that spur criminality. In line with predictions from Dal Bó and Dal Bó (2011), our results seem to be driven by labor-intensive underground mining, indicating that increased mining activity provides better income opportunities that lowers the incentives to commit crimes. Given this result, it is natural to ask why such effects have not been present in other settings, such as D.R. Congo, where increased mining has lead to increased violence. One explanation might be the institutional differences between South Africa and other, poorer settings in Africa. Indeed, when taking the institutional quality into account, we find that South African areas with poorer institutions have lower beneficial effects from mining. At the same time, the overall negative relationship between mining activity and criminality shows that the income opportunities dominate, and that South African institutions might be sound enough for them to do so. We also note that mining causes inward migration, as the migrant share increases by 18 percent with a mine opening. Subsequently, we try to understand how migration rates may affect criminality. In this analysis we split the sample into municipalities with high and low shares of migrants in their population, respectively. The results indicate that in areas with high migration, the relationship between mines and criminality is stronger. We interpret this as an indicator that created job opportunities matter relatively more for crime rates in high migration areas.

To sum up, we show that the effect of natural resources for development is highly context specific. The structure of the industry and institutional quality are two important determinants of which mechanisms that will dominate and therefore how natural resources affect criminal activity. In light of this, the detrimental effects of natural resources found in earlier studies can partly be understood through the particularities of the setting studied.

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8 History of Mining, Migration and Criminality

Recently, media has focused on uprisings in South African mining communities. A demonstration for wage increases in the Marikana platinum mine in 2012 led to violent clashes and the death of 34 workers. The incident was one of the most violent ever in the democratic South Africa. NGO's have pointed to the clash as a result of the widespread poverty and grievances among migrant mine workers (Human Rights Watch, 2013). Such a narrative of grievances is far from new in the South African mining industry. The history of mining dates long back and so does its history of violence and criminality. In fact, to some extent they may be interconnected.

The gold deposits in present-day Johannesburg were long the destinations of fortune seekers from Europe and other parts of the African continent. The migration movement was sudden and strong: from a mining camp worthy of 3,000 individuals in 1887, Johannesburg grew to a city of 100,000 in only 22 years. Migrant gangs formed in the mining communities during the early 20th century, and defined what was to be the criminal landscape of Johannesburg (Kynoch, 2005). Social exclusion of migrants is thought to be part of the reason why migrants on the fringe of the mining communities turned to criminality: migrant workers were the lowest on the hierarchical social ladder, confined to the roughest and most menial jobs (Kynoch, 1999). Moreover, the migrant workers employed in the mine were kept aside from the rest of the urban South Africa, as part of British colonial policy (Antin, 2013), and later of apartheid policy. Gang activity became prevalent within the mining compounds and in adjacent urban living spaces open for black South Africans and migrants, such as townships and squatter camps (Kynoch, 1999).

After first relying on imported Australian, British, and Chinese mine workers, the industry became reliant on black migrant workers from rural South Africa and neighboring countries such as Lesotho, Mozambique, Malawi, and as far away as Tanzania (Bezuidenhout and Buhlungu, 2011). During apartheid, the influx control policy forced black migrant workers to settle in peri-urban areas in Bantustans (homelands) and commute to mines and industries (Collinson et al., 2003; Cox et al., 2004), instead of in the industrial areas. Arguably that was to ensure that industries were not responsible for workers' welfare, rather than to give them local autonomy, which was the official reason behind the creation of homelands (Collinson et al., 2003). The threat of urbanization of blacks might have been part of the appeal of apartheid among white South Africans since the National Party promised to stop the development (Cox et al., 2004). However, the policy was also supported by the gold industry, in whose interest it also was to stop the burgeoning urbanization movement (Cox et al., 2004).

One result of the influx control policy was the single-sex hostel system. The hostels served as temporary housing for black migrant workers, who did not have the right to settle permanently in the area (Bezuidenhout and Buhlungu, 2011). At the advent of democracy, attempts were made to diminish the reliance on the migrant system. Such attempts were partly motivated by the risks of spread of HIV/AIDS and labor unrest associated with the single-sex hostel systems (Hamann and Kapelus, 2004). However, the process away from migrant-labor was slow, especially in the mining industry. In 1991, over 97 percent of the mining workforce (about half a million people) lived in single-sex hostels (Crush and James, 1991), but in 1997 the figure had dropped by only two percentage points to 95 percent (Campbell, 1997).

9 Additional Figures

Figure B1: South Africa Share of World Production

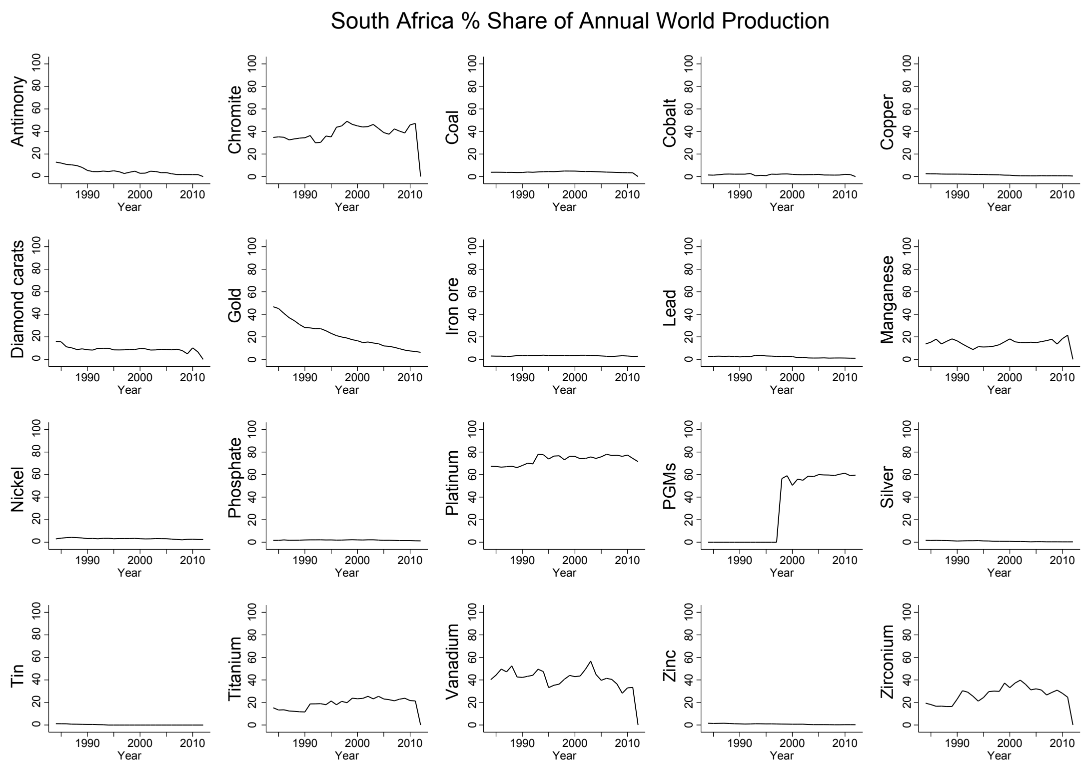
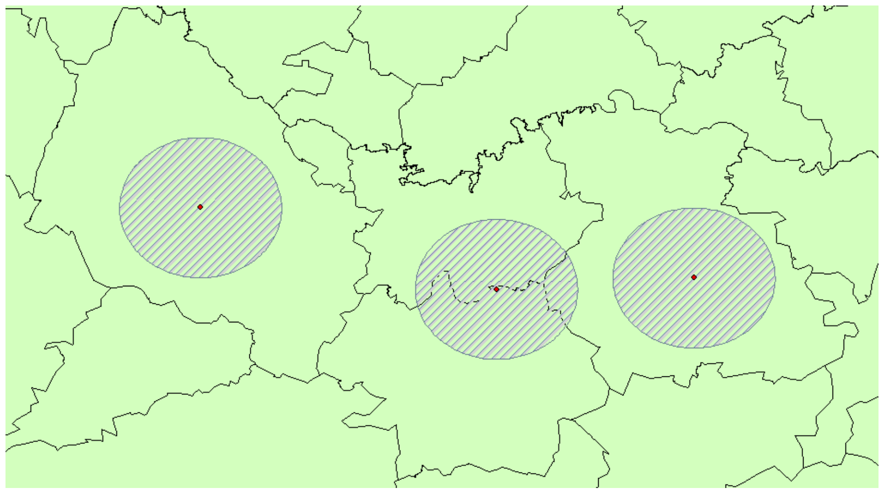
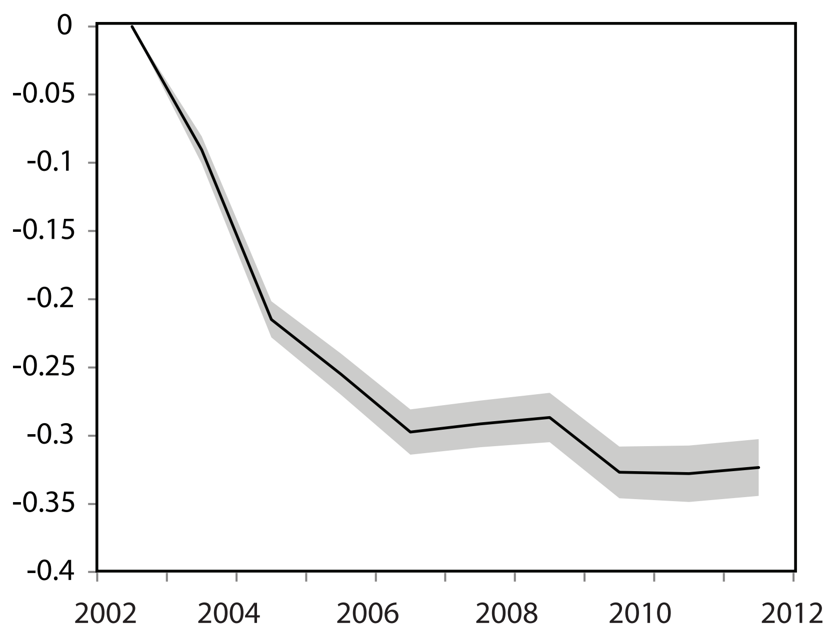


Figure B2: Matching mines and police precincts



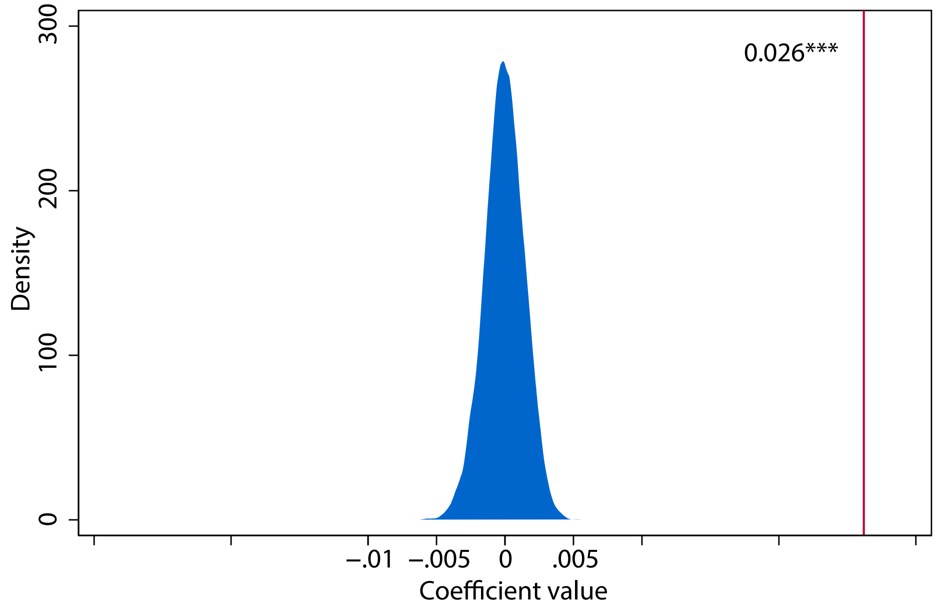
Notes: This map shows how administrative areas are matched to all mines that lie within 20 km from their borders. For example, the mine shown in the middle will be matched to three precincts while the other two only maps to the same precinct as they are situated in.

Figure B3: Year Fixed Effects

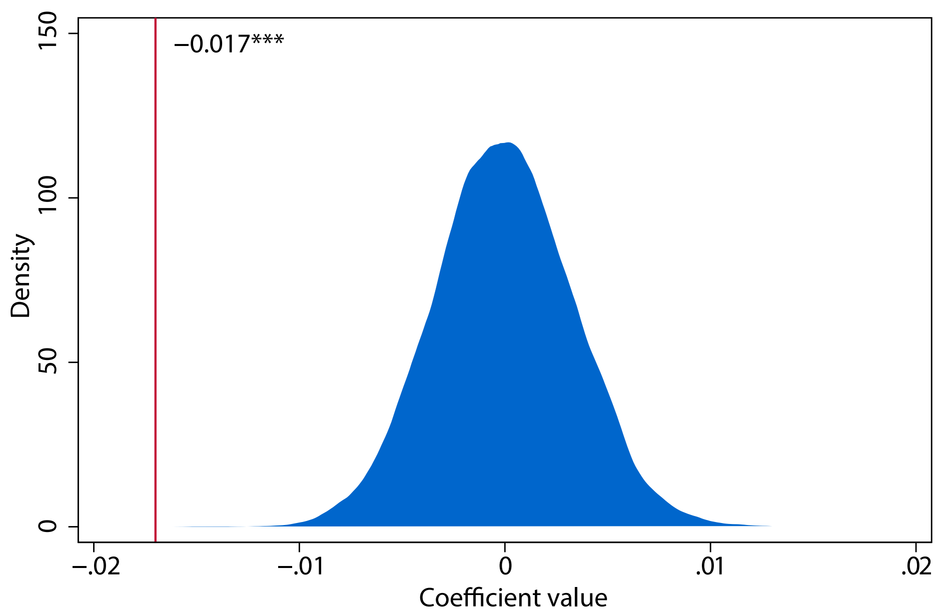


Notes: This figure plots the year fixed effects coefficients estimated in the baseline model.

Figure B4: Coefficient Densities from Randomization Tests



(a) First Stage Coefficient



(b) Fixed Effect Coefficient

Notes: These density plots show the distribution of coefficients from running the main specification with randomly assigning data between panel units. The first figure shows the distribution of the first stage coefficients (the effect of the mineral price on mining activity) from estimating equation (1) with randomly matched price data to a mineral-precinct pair (preserving the time structure of the data). Panel B shows the distribution of the fixed effect coefficient (the effect of mining activity on the log of the total crime rate) from estimating equation (3) with randomly matched mining activity data to a precinct (preserving the time structure of the data). Both randomizations have been carried out 10,000 times. *** indicate that exact p-values are < 0.01.

10 Additional Tables

Table C1: Transition matrix

t-1/ t	0	1	2	3	4	5	6	7	8	9	10	Total
0	6,227	54	7	0	0	0	0	0	0	0	0	6,288
1	48	984	46	1	0	0	0	0	0	0	0	1,079
2	5	29	481	43	0	0	0	0	0	0	0	558
3	0	0	32	334	35	3	0	0	0	0	0	404
4	0	0	3	13	208	31	4	0	0	0	0	259
5	0	0	0	2	12	111	28	3	0	1	0	157
6	0	0	0	0	0	15	110	26	4	1	0	156
7	0	0	0	0	0	0	15	113	27	5	2	162
8	0	0	0	0	0	0	2	10	58	27	6	103
9	0	0	0	0	0	0	0	1	17	76	35	129
10	0	0	0	0	0	0	0	1	1	16	443	461
Total	6,280	1,067	569	393	255	160	159	154	107	126	486	9,756

Notes: This table reports the frequencies of transition for the main independent variable active mine (20km) year t-1 to year t for each precincts. The reported values are net values of openings of closings that are happening in the same year. Values are censored at 10 and the maximum is 36.

Table C2: Start & Stop Producing Precinct FE with lags and leads

	Total Crime	Property Crime	Violent Crime
Stop 20 km t-1	0.0243**	0.0319**	0.0159
	(0.0114)	(0.0132)	(0.0149)
Stop 20 km	0.0300**	0.0354***	0.0193
	(0.0122)	(0.0133)	(0.0147)
Stop 20 km t+1	0.0209	0.0325**	-0.00399
	(0.0129)	(0.0145)	(0.0203)
Start 20 km t-1	0.00126	-0.00491	-0.00220
	(0.0125)	(0.0139)	(0.0164)
Start 20 km	-0.0181	-0.0146	-0.0258
	(0.0134)	(0.0144)	(0.0180)
Start 20 km t+1	-0.00681	0.00380	-0.0215
	(0.0127)	(0.0157)	(0.0156)
Observations	7581	7581	7576
R-Squared	0.964	0.961	0.919
Mean of Outcome	3.620	2.845	2.652
Precinct FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table reports the result from a fixed effect regression of the log crime rate in a precinct on the lags and leads of the number of mines that start and stops producing within 20 km from that precinct. All regressions include precinct fixed effect as well as year fixed effects. Standard errors clustered at the precinct level are reported in parenthesis. Statistical significance is indicated by *** at 1%, ** at 5%, and * at 10%.

Table C3: IV: Property Subcategories

All theft not mentioned elsewhere	-0.0724***
	(0.0228)
Burglary at non-residential premises	-0.0178
	(0.0217)
Burglary at residential premises	-0.0719***
	(0.0240)
Commercial crime	-0.0384*
	(0.0232)
Common robbery	-0.135***
	(0.0221)
Robbery at non-residential premises	-0.0250*
	(0.0151)
Robbery at residential premises	-0.0383***
	(0.0131)
Shoplifting	0.0221
	(0.0230)
Stock-theft	0.0187
	(0.0183)
Theft of motor vehicle and motorcycle	-0.0910***
	(0.0233)
Theft out of or from motor vehicle	-0.0811***
	(0.0222)

Notes: This table reports coefficients from estimating the IV strategy for all subcategories of property crime. Each row represent a separate regression with the outcome listed in the left column. The outcome is defined as the log of the crime rate plus one to avoid dropping data with no crime for that particular category. All regressions control for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.

Table C4: IV: Violent Subcategories

Arson	-0.0425***
	(0.00892)
Assault with grievous bodily harm	-0.0274
	(0.0234)
Attempted murder	-0.0403**
	(0.0160)
Common assault	-0.0112
	(0.0267)
Culpable homicide	-0.0164*
	(0.00896)
Malicious damage to property	-0.0762***
	(0.0220)
Murder	-0.0355***
	(0.00912)
Public violence	0.00203
	(0.00672)
Robbery with aggravating circumstances	-0.189***
	(0.0277)
Total Sexual Crimes	-0.0520***
	(0.0176)

Notes: This table reports coefficients from estimating the IV strategy for all subcategories of violent crime. Each row represent a separate regression with the outcome listed in the left column. The outcome is defined as the log of the crime rate plus one to avoid dropping data with no crime for that particular category. All regressions control for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.

Table C5: IV: Other Subcategories

Carjacking	-0.0912***
	(0.0152)
Crimen injuria	0.000493
	(0.0282)
Driving under the influence of alcohol or drugs	0.0859***
	(0.0323)
Drug-related crime	0.0102
	(0.0290)
Illegal possession of firearms and ammunition	-0.0260**
	(0.0110)
Kidnapping	0.00969**
	(0.00482)
Neglect and ill-treatment of children	-0.00809
	(0.00709)
Truck hijacking	-0.00164
	(0.00483)

Notes: This table reports coefficients from estimating the IV strategy for all other subcategories of crime (not included in violent or property crime). Each row represent a separate regression with the outcome listed in the left column. The outcome is defined as the log of the crime rate plus one to avoid dropping data with no crime for that particular category. All regressions control for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.

Table C6: Public Violence

	Municipality FE	Precinct FE	IV
Active Mine 20km	0.00387***	0.00510***	0.00203
	(0.00120)	(0.00178)	(0.00672)
Observations	2340	10830	5260
R-Squared	0.304	0.190	0.0221
Mean of Outcome	0.0243	0.0246	0.0243
Location FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table reports the results on the log of public violence per capita using the three different samples. Columns (1) and (2) report the results from the fixed effect strategy, whereas column (3) reports the results from the IV strategy. All regressions include location and year fixed effects. Standard errors clustered at the geographical unit of observation are reported in parenthesis.

Table C7: IV excl. minerals where SA is a large producer

	Total Crime	Property Crime	Violent Crime
2SLS	-0.0841***	-0.0956***	-0.0774***
	(0.0218)	(0.0246)	(0.0266)
Reduced Form	-0.00219***	-0.00249***	-0.00201***
	(0.000550)	(0.000615)	(0.000679)
First Stage	0.0260***		
	(0.00207)		
F Statistic	158.5		
Observations	3760		
Mineral by Precinct FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: The results in this table corresponds to those reported in Table 4, but exclude minerals for which South Africa is a major producer. The minerals excluded are palladium, platinum, zirconium, vanadium, chromite, manganese ore and titanium.

Table C8: IV Model: Trends and Fixed Effects Log Price

	Total Crime					
	(1)	(2)	(3)	(4)	(5)	(6)
2SLS	-0.55***	-0.22***	-0.25***	-0.22***	-0.35**	-0.70**
	(0.053)	(0.069)	(0.074)	(0.069)	(0.14)	(0.30)
	First Stage					
First Stage	0.41***	0.28***	0.27***	0.28***	0.083*	0.044
	(0.035)	(0.060)	(0.059)	(0.060)	(0.049)	(0.049)
F Statistic	139.2	22.6	21.6	22.6	2.87	0.80
Observations	5260	5260	5260	5260	5260	5260
Mineral by Precinct FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	Yes	No
Price trend	No	No	Yes	Yes	No	Yes
Quadratic Price trend	No	No	Yes	No	No	No
Province trend	No	No	No	No	Yes	Yes

Notes: This table reports the results from an IV regression of the log of the local crime rate in a municipality on the number of active mines within 20 km from the precinct. The instrument is log mineral price.

Table C9: IV: Crime in Levels as Outcome

	Total Crime	Property Crime	Violent Crime
Active Mine 20 km	-0.0493***	-0.0639***	-0.0424**
	(0.0180)	(0.0209)	(0.0215)
Observations	5260	5260	5260
R-Squared	0.170	0.129	0.281
Mean of Outcome	7.134	6.450	6.153

Notes: This table reports the results from IV strategy using the number of crimes as the outcome variable. All regressions include the same fixed effects as the baseline specifications and standard errors are clustered at the precinct level.

Table C10: FE: Only mines within Municipality borders

	Total Crime	Property Crime	Violent Crime
Active Mine	-0.0182*	-0.0178	-0.0132
	(0.00952)	(0.0110)	(0.0128)
Observations	2340	2340	2340
R-Squared	0.968	0.959	0.957
Mean of Outcome	3.501	2.737	2.593

Notes: The results in this table corresponds to those reported in Table 3, but only considers mines that are located within the municipality. All regressions include location and year fixed effects. Standard errors clustered at the municipality are reported in parenthesis.

Table C11: FE: Nonlinear effects of mining

	OLS	FE		
	Total Crime	Total Crime	Property Crime	Violent Crime
Active Mine 20 km	0.0403***	-0.0250**	-0.0259*	-0.0249*
	(0.0114)	(0.0122)	(0.0138)	(0.0149)
Active Mine 20 km square	-0.000907**	0.000432	0.000735	0.000355
	(0.000447)	(0.000493)	(0.000580)	(0.000612)
Observations	10830	10830	10830	10825
R-Squared	0.0157	0.955	0.952	0.905
Mean of Outcome	3.665	3.665	2.898	2.694
Precinct FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes

Notes: Column 1 presents the OLS cross-sectional results. Column 2-4 report the results of a fixed effect regression of the log of the local crime rate in a precinct on the number of active mines within 20 km from the precinct, with controls for precinct and year fixed effects. Standard errors in parenthesis are clustered at the precinct.

Table C12: Fixed Effects Model: Trends and Fixed Effects

	Total Crime				
	(1)	(2)	(3)	(4)	(5)
Active Mine 20 km	-0.0632***	-0.0171**	-0.0171**	-0.0155**	0.000923
	(0.00856)	(0.00713)	(0.00713)	(0.00712)	(0.00724)
Observations	10830	10830	10830	10830	10830
R-Squared	0.937	0.955	0.955	0.954	0.957
Mean of Outcome	3.665	3.665	3.665	3.665	3.665
Precinct FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	Yes
Linear time trend	No	No	Yes	Yes	No
Quadratic time trend	No	No	No	Yes	No
Province time trend	No	No	No	No	Yes

Notes: This table reports the results from a fixed effects regression of the log of the local crime rate in a municipality on the number of active mines within 20 km from the precinct. Standard errors in parenthesis are clustered at the precinct.