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

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Abstract

Extractive industries are key to development in many countries, accounting for large shares of government revenue and GDP. However, there is a vast and growing literature that links extractive industries to conflicts and war in countries with weak institutions. We are, to our knowledge, the first to investigate whether extractive industries can cause property and violent crime in a setting with stronger institutions. We focus on South Africa, a country with a significant mining industry and high levels of criminality, similar to Botswana, Brazil and Mexico. Our empirical strategy exploits time and geographic variation, in addition to fluctuations in international mineral prices, to estimate the effect of mining activity on crime. In contrast to earlier findings on other forms of social conflict, we find that areas endowed with higher levels of natural resources show no increase in crime when a mine opens and in fact has lower levels of crime when the mine is active. However, the closure of a mine leads to a large and significant increase in both property and violent crime. Subsequently, we show that the migration flows and income opportunities created by the mining industry are two important channels through which mining affects criminality.

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1 Introduction

Extractive industries are key to economic development in many countries. Mineral resources, in particular, play a dominant role in 81 countries that collectively account for nearly 70 per cent of those in extreme poverty (World Bank 2014). Many have discussed this association in terms of the resource curse (see van der Ploeg 2011 for an overview), but fewer have looked at the extractive industry as an inherent feature of many developing economies which presents both potential harms and potential benefits. In developing countries, mining is economically important, and approximately one per cent of the global labor force works in mining (ILO, 2010). Mining has been found to spur local structural change, benefiting local labor markets (Aragon and Rud 2013; Kotsadam and Tolonen 2013), and the industry has been crucial for countries such as Botswana and Namibia in the transition from poor to middle income.

However, there is a large and growing literature that link extractive industries, such as the mining industry, to conflict and civil war in contexts with weak institutions.[1] The main mechanism emphasized in this literature is that a shock to an extractive industry might alter the incentives for appropriation since the increase in potential rents can drive social conflict (see e.g. Dal Bó and Dal Bó 2011). However, extractive industries also generate job opportunities which could affect the opportunity cost of illegal activity, as outlined by Becker (1968). The latter of these two mechanisms 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. There are a number of countries that have both considerable natural-resource endowments and high rates of criminal activity, such as South Africa, Botswana, Brazil and Mexico, which highlights the need of empirically investigating this relationship in such a setting. Thus, 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. Violent crime is a major factor behind the emigration of skilled labor, gated communities and a flourishing private security sector. At the same time, South Africa has the fifth largest mining industry in the world which contributes to around 8 per cent of GDP (Chamber of Mines 2014). Recently, media as well as government attention have been directed towards the link between mining and violence, not least since the 2012 Marikana massacre where 44 miners were killed. A New York Times report (NYT 2013) suggests that violent crime has risen as townships have "fallen on hard times as gold mines have closed". In addition, previous studies

[1] Collier and Hoeffler (1998, 2004 & 2005) were pioneers of the literature examining linkages between natural resources and civil war. Recent work include Berman, Couttenier, Rohner & Thoenig (2014), Buonanno et al. (2013) & Maystadt et al. (2014).

have claimed that the conditions in the mining industry have spurred criminality in South Africa (Kynoch 1999, 2005).

The empirical analysis exploits several different estimation strategies to examine the causal effect of mining activity on crime between 2003 and 2012 in South Africa. Specifically, we explore the effect on crime rates at different spatial scales from mining activity and production shocks, what types of crimes that are affected, and lastly we try to disentangle the mechanisms behind our findings. One concern when estimating the impact of mining activity 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 (c.f. Allcott and Keniston 2014; Berman et al. 2014; Tolonen 2015) have used international prices as exogenous variation in mining production, but we instrument mining activity with prices rather than rely on the reduced-form relationship. The first stage coefficient is positive and highly statistically significant: the higher the international price of a given mineral, the larger the number of mines actively producing such minerals. In the second-stage analysis, we investigate how a change in mining activity affects the crime rate in police precincts.[2] We find a negative and significant effect of mining production on both property and violent crime. In particular, as mining activity increases, induced by a higher international mineral price, crime rates fall by approximately seven per cent for each additional mine. This negative association is further supported by the results from a fixed-effects estimation of the relationship between the number of active mines in a police precinct on local crime rates. To capture effects at a higher aggregate level we replicate the results at the larger municipality level and find similar effects.

Subsequently, we make an additional contribution to the literature by investigating the dynamic effects of production shocks through allowing for assymetric effects of starts and stops in mining production. We find that when a mine stops actively producing, crime rates increase substantially. This finding argues for the opportunity-cost channel: when a mine closes, direct and indirect income opportunities decreases locally, and the incentives to commit a crime increase. Similarly, we find suggestive evidence that as a mine starts producing, crime rates fall. Poor availability of mine employment numbers and labor market information at a sufficiently disaggregated geographic level makes it hard to further asses the viability of the income channel. However, following recent economic literature (Bleakley and Lin 2012; Henderson et al. 2012; Michalopoulos and Papaioannou 2013; Lowe 2014; Storeygard 2012; Pinkovskiy 2013), 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. However, when a mine closes, local economic activity falls. These findings support the hypothesis that the causal effect of mine closure on crime goes through

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

an income channel. Furthermore, following the theory outlined by Dal Bó and Dal Bó (2011), we show that our results seem to be driven by mining that is relatively more labor intensive, a finding that also speaks for the income channel.

In addition, we consider to what extent labor migration to mining areas can be a mechanism through which crime rates are affected. Prior to democratization, the labor in South African mines was supplied by domestic and international migrants, enforced by apartheid policy. However, labor migration remains important in the mining sector also today.[3] There are two main reasons why we believe migration to be important. First, the migrant-labor system[4] is associated with serious social concerns, such as single-sex hostels and informal settlements, characterised by lack of social services, high crime rates and unemployment (Aliber 2003; Hamann and Kapelus 2004). From a historical perspective, the association between the migrant-labor system and crime has been emphasized (Kynoch 1999, 2005).[5] Second, the size of the mine-induced migration flow will determine if the employment rate increases or decreases, and determine the local wage rate.

We establish that the number of active mines in a municipality increase the share of migrants in the population with 23 per cent for each additional mine. In fact, when a mine starts producing (a positive shock in mining activity), migration increases by 18 per cent. Thereafter, we compare the effect of mining activity on crime in municipalities with high and low average migration rates. Results from this analysis are imprecisely estimated but provide suggestive evidence for migration patterns playing a role in which mining activity affect crime. We find that production starts in low-migration areas are associated with lower crime rates and 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: first, because inward migration increases competition over jobs. Second, because production shocks in high migration areas affect individuals with weaker ties to the local labor market. Hence, the income opportunities provided by the mine is more important for this group.

Previous literature on extractive industries and social conflict find detrimental effects. Likewise, looking at the effect of mining activity on public violence (the outcome most closely related to what has been used in related studies), we display suggestive evidence that earlier findings also apply to South Africa. However, the main conclusion is that extractive industries affect overall criminality in a different way. Increases in mining activity leads to lower crime rates, whereas a stop in production increases them. In contrast to a weak institutional setting, where mining oppor-

[3] In 1997, a few years after the advent of democracy, 95 per cent of all mine workers were still 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.

[5] See appendix A for a description of the historical relationship between mining, migration and criminality.

tunities can increase the risk of conflict by providing funding for criminal gangs or rebel groups, we show that in a middle-income setting with better institutions, the mineral base can lead to lower crime rates, presumably by affecting local income opportunities.

The next section looks at previous literature on extractive industries and violence. Section 3 gives a background on the mining industry and crime in South Africa. Section 4 describes the data used in the estimations and Section 5 goes through the empirical strategies. The results from our main specifications, mechanism checks and tests of robustness are given in Section 6. Section 7 concludes the paper.

2 Previous Literature

In this paper, we use production changes in mineral and coal mines to identify the effects of mining activity on crime. It is, to our knowledge, the first paper to investigate the effect of extractive industries on various types of crime, and using official records from the police. 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 for example Caselli et al. 2013; Maystadt et al. 2013; Rohner 2006). Couttenier et al. (2014) find that minerals play a role historically and presently for homicide rates in the US; and Buonanno et al. (2013) 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. Aragon 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. (2014) who explore the impact of mining on conflict for all African countries between 1997 and 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 collected 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 patterns of detrimental effects stemming from extractive industries described above also is true for a middle-income country, using official police records for economic and violent crime, rather than multi-origin data sets on conflict. Thus, apart from public violence which we have data on, we test the predictions from the literature on extractive industries and conflict for idiosyncratic violent crimes such as murder and assault, and property crime such as burglary. An additional contribution of this paper is that we can instrument mining production with international prices, while Berman et al. (2014) 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), providing 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) increase it. The intuition is that a positive shock to a capital-intensive industry will cause it to expand while the labor-intensive industry contracts, which make labor relatively more abundant resulting in lower wages. Since wages decrease relative 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 coffee prices, which might be considered a labor-intensive product, and an increase in oil prices, which might be considered a capital-intensive product. Similarly, we test this channel by splitting mining into open-pit (more capital intensive) and underground (more labor intensive).[6]

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 that of Dal Bó and Dal Bó (2011). Crime is a type of job chosen in competition with regular wage work and in this case, an increase in mining activity leads to an increase in the opportunity cost of crime if certain requirements are fulfilled.[7] In other words, the closure of a mine or lower production will lead to lower incomes among mine workers and societies that are dependent on the mine. The driving forces behind burglary, robbery and car hijackings, for example, should then become stronger.

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-1990's, the country is one of

[6]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 less common. The South African mining industry is therefore relatively more labour intensive compared to other mining countries, including its African neighbors.

[7]Specifically that mining increases the supply of jobs, and/or 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 and crowd out other industries, such as manufacturing, these two relationships need not hold.

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”. Recorded crime levels increased during the last decade of apartheid rule and peaked in the early 1990’s. The hope that these levels would decrease after 1994 was not met. Rather, in the period between 1994 and 2000, crime increased. For example, the annual increase in the number of crimes was higher in 1999 than all previous years after 1994. These changes were mainly driven by huge rises in common robbery (121 per cent), residential burglary (25 per cent), assault (22 per cent), rape (21 per cent) and car hijacking (20 per cent). In general, violent crime stands out as the one category where South Africa saw a consistent increase from 1994. The country was considered having the highest per capita rates of murder and rape and the second highest rate of robbery and violent theft (Louw and Schönteich 2001). It should however be noted that South African crime follows a geographical pattern. Burglaries, for example, are more common in police precincts (police-station jurisdictions) that are wealthier than neighboring precincts, pointing toward migratory criminal behavior (Demombynes and Ozler 2005)

Poverty, unemployment and labor migration are common South African experiences: chronic poverty exists (Aliber 2003), and unemployment is high. In 2004, the beginning of our study period, unemployment was 41 per cent (broad definition) or 30 per cent (narrow definition) (Kingdon and Knight 2004). In 2012 the unemployment rate had decreased somewhat, to an average of 25.2 per cent. There is thus a lack of income opportunities for many South Africans, which could potentially be a partial explanation for the high crime rates.

3.2 The Mining Industry

Large-scale mining is a notable element in South Africa’s history. It first started in 1867 when alluvial diamonds were found along the Orange River, soon followed by the Kimberley diamond discovery and the Witwatersrand Gold Rush in the 1880’s. 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. Today the South African mining industry is the fifth largest in size globally (Chamber of Mines 2012), and the country may have what is the largest mineral endowment despite a long history of extraction (Carrol 2012). South Africa is a producer of many different metals and minerals, and the economically most important mineral groups are platinum (platinum group metals, PGMs), gold, coal and iron ore.[8] The country is the biggest global producer of PGMs and gold, as well as manganese and chromium, although the latter two are smaller shares of the South African economy (Antin 2013).

525,000 people were employed in mining in 2012, increasing from 436,000 in 2003 (Chamber

[8] These are the largest mineral groups in terms of employment and sales.

of Mines, 2013). Only roughly 15 per cent of the workforce in 2013 was women (StatsSA 2013). The employment opportunities are concentrated to certain regions, such as the North West (141 thousand miners in 2012), Mpumalanga (79 thousand), Limpopo (73 thousand), and Gauteng (32 thousand) but also Free State, KwaZulu-Natal, Northern Cape has significant mining employment (StatsSA 2013).

Despite generating many employment opportunities, the sector's economic importance relative GDP exceeds its importance in terms of employment. In 2011, the sector employed 0.7 per cent of the workforce, but made up 8.8 per cent of national GDP. However, while in the latter years the sector has contributed to on average 8 per cent of GDP, it constitutes as much as 18 per cent of all economic activity, if upstream and downstream industries are included.

Despite the small share of employment to value created, labor constitute a significant share of the production costs, making up roughly 40 per cent. That however masks heterogeneity: for deep-level mines it can be over 60 per cent, and open cast mines about 30 per cent, a fact that we make use of in the subsequent analysis. The wage burden has increased over time. From 2007 to 2012, negotiated wage increases have been above inflation rates, putting more pressure on the industry and leading to staff reductions (Antin 2013; PWC 2011).

4 Data

4.1 Mining

We have data on all large-scale mining operations across South Africa that have been in production between 1975 and 2012. The data is licensed and provided by InterraRMG.[9] For each mine we know the minerals produced during the sample period as well as the exact geographic location and ownership structure.[10] The panel dataset consists of a total 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 are at least partly producing one of these two minerals). However, a large number of mines produce minerals such as palladium, platinum and rhodium. The geographical location of all mines in South Africa is illustrated in Figure 1. Production in these mines fluctuates substantially over time as depicted in Figure 3. As can be seen from the figure, the industry is both expanding and contracting at the same time. The production of gold, copper, silver and zinc decreased during the sample period, whereas the 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

[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.

as a dummy variable indicating if 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. (2012) examining U.S. plants that produce toxic waste, and by Kotsadam and Tolonen (2014).

The RMD data has previously been employed in the literature by a few recent papers: Berman, Couttenier, Rohner and Thoenig (2014) 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 effects in developing countries; and Kotsadam and Tolonen (2014), and Tolonen (2014) focus on local economic development and structural shifts in Africa.

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 (SAPS). The data set includes recorded crimes from all 1,083 police stations in South Africa.[11] The geographical location of these police stations is illustrated in Figure 2. Crimes are reported for each financial year (April to March) and is divided into 29 different categories. Highlighting some of the variables for the ten years in our data set, there are 177,593 recorded murders, 125,759 car hijackings, 29,839 kidnappings, and 668,038 sexual crimes. Comparing 2003 to 2012, reported murders and car hijackings, for example, have gone down while kidnappings and sexual crimes have increased. However, overall crime rates have gone down as illustrated in Figure 6. The greatest number of reported incidents come from theft, residential burglary and assault.

We create three main outcome variables: property [12], violent[13] and total crime[14].[15] These categories 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

[11]A crime enters the official statistics through two mechanisms: first, a victim or witness report an incident to the police. Second, the police record it in their records.

[12]Property crime is constituted by 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.

[13]Violent crime is constituted by 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 sexual crimes.

[14]In addition to the categories in property and violent crime, total crime also includes carjacking, crimen injuria, driving under the influence of alcohol or drugs, drug-related crime, illegal possession of firearms and ammunition, kidnapping, neglect and ill-treatment of children and truck hijacking.

[15]In the context of South Africa, violence might not be a specific case of criminality, but a phenomena on its own, which 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 analysing this as a separate category.

Crime Survey conducted by Statistics South Africa have shown that this does not seem to be a major problem (such validation 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 not correlated with mining activity. This might be the case if mining activity affect the amount of resources dedicated to the police. To investigate this potential concern and 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 a provincial level (National Treasury 2015).

4.3 Population, Migration, Night Lights and Mineral Prices

The data on population comes from Statistics South Africa's 2001 and 2011 censuses. Since the crime data covers the years between 2003 and 2012, we need to extrapolate the population estimates to be able to create a per capita outcome variable for each year. This proceeding is of course not ideal, but 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 between 2003 to 2012 based on the average annual growth rate according to the two censuses for that particular unit.[16] These growth rates are then used to get 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[17]. The question is thus only asked to persons who were born outside South Africa. The fact that it is asked in 2011 yields a retrospective entry. By consequence, 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, we combine this information with the aforementioned population data to construct the share of migrants in a given municipality and year, to deal with the fact that areas with a high population also tend to have higher migration flows.

As with the population data, reliable employment and income data is only available from the South African census (Statistics South Africa). Unfortunately, this data is only available for 2011 and is not provided at a sufficiently disaggregated level in order for us to match it with police

[16] 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.

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

precincts. To understand employment and income over time we, in line with several recent studies (Bleakley and Lin 2012; Henderson et al. 2012; Lowe 2014b; Michalopoulos and Papaioannou 2013; Pinkovskiy 2013; Storeygard 2012), we make use of estimates of light density measured by satellites at night as a proxy for economic activity. This high-resolution data comes from the National Oceanic and Atmospheric Administration and is suitable to use when interest is in estimating localised effects (Lowe 2014a), such as in this paper.

Finally, the data on mineral prices is available for 20 different mineral.[18] This data is from two different sources: US Geological Survey[19] and InterraRMG[20]. The price data covers the same years as those for which we have crime data (2003 to 2012) and is measured in US dollars per gram. The price trend per mineral is shown in Figure 5.

4.4 Sample Construction

Since the above data is provided at different geographical levels, it is necessary to aggregate the data in order to carry out the analysis. Administrative areas (municipalities and police precincts) are matched to all mines that lie within 20 km from their borders. The matching procedure is illustrated in Figure 7 and has been done to take potential spillover effects into account. Previous studies on mining in Africa have found that both local labour markets and agricultural productivity are affected within 20km from the mine (e.g. both Aragon and Rud [2012] and Kotsadam and Tolonen [2013] use a 20 km radius around the mine as their main specification). 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 the municipalities. Summary statistics for all these 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 is a main producer of any of these minerals. This sample is used for the IV analysis described below. The samples presented in Panels B and C include all mines and minerals as well as all administrative units and is used in the fixed effect strategy. Overall, we see that crime rates are high, with total crimes ranging between 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 the positive correlation between the number of mines and the crime rate.

[18] In the IV analysis, we only make use of each mine's main mineral, which leaves us with 15 minerals.

[19] USGS gives us price data for antimony, cobalt, manganese ore, phosphate rock, titanium, vanadium, zirconium, chromite and iron ore.

[20] InterraRMG gives us price data for gold, silver, platinum, aluminium, copper, lead, nickel, tin and zinc.

5 Empirical Strategy

5.1 Instrumental Variable Approach

To estimate the causal effect of mining activity on the local crime rate, we need to overcome a potential reversed-causation problem: namely that mine production could be affected by surges in crime in the proximity of the mine. In other words, we risk misinterpreting our effects if lower crime rates leads to higher mineral production, rather than higher mineral production leading to lower crime rates. We do not have any evidence for this being the case in South Africa, but it seems likely that investment decisions, including foreign direct investment decisions, are affected by local and regional security issues and corruption. It can be assumed that multinational mining companies prefer stable political environments with low corruption, which has been shown for investment in the gold sector (Tole and Koop, 2011).

We use an instrumental variable approach (IV) where we instrument mining production with international mineral prices. The idea is that production decisions are largely influenced by the exogenously determined possibility of profitably selling the minerals on the international market.[21] The exogeneity of international mineral prices are 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 so that changes in economic activities in other countries, such as large producers in Asia, can have large effects on mineral prices (Slade 1982). Similar identification strategies have been used previously, by e.g. Sanchez de la Sierra (2014) and Berman, Couttenier, Rohner and Thoenig (2014), but is especially suitable for South Africa with its large mineral exports (CoM 2012). 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 affect 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.[22]

We estimate the following first stage regression:

$$a_{ijt} = \delta p_{it} + \gamma_{ij} + \lambda_t + u_{ijt}, \tag{1}$$

[21] 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. However, in the subsequent analysis we test whether our results change for starts in production by excluding new mines.

[22] South Africa has significant market power for palladium, platinum, zirconium, vanadium, manganese ore and titanium.

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:[23]

$$ln(y_{ijt}) = \beta a_{ijt} + \gamma_{ij} + \lambda_t + \varepsilon_{ijt}. \tag{2}$$

The parameter of interest is β, which captures the 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.[24] The same equations are estimated when we investigate the effect of mining activity on economic activity, proxied by light density.

5.2 Fixed Effects Approach

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. As an alternative, we implement a fixed-effects strategy taking into account all mines and minerals. We use the following equation:

$$ln(y_{jt}) = \theta a_{jt} + \gamma_j + \lambda_t + \varepsilon_{jt}, \tag{3}$$

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 captured 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 (on the municipal level) when analyzing the effect of mining activity on migration.

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 this analysis both using an instrumental variable and a fixed effects strategy. The IV strategy estimates the following equations:

[23] 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.

[24] 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.

(4) $$shock_{ijt} = \kappa p_{it} + \gamma_{ij} + \lambda_t + u_{ijt},$$

(5) $$ln(y_{ijt}) = \pi shock_{ijt} + \gamma_{ij} + \lambda_t + \varepsilon_{ijt}.$$

where $shock_{ijt}$ is the net number of mines that either start or stop producing the mineral i in year t (compared to whether they were producing the mineral in year $t-1$) within 20 km from precinct j. The start and stop regressions are estimated separately to allow for non-symmetric effects. All other variables are the same as in the IV specification above. We expect κ to be positive when estimating the impact on production starts (a higher international mineral price would lead a larger number of mines to start producing that mineral), whereas we expect κ to be negative when estimating the effect on production stops (if the international price becomes sufficiently low a larger number of mines will stop producing that mineral). The effect of production starts/stops on the log of the crime rate is captured by π.

We also implement a fixed effect strategy using the following regression:

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

where $start_{jt}$ / $stop_{jt}$ is the net number of mines that start/stop producing in year t (compared to whether they were producing in year $t-1$) in precinct/municipality j. 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 affect crime both before and after production shocks (e.g. through linkages and changes in production volume), we allow for leads and lags in this specification.

6 Results

6.1 Main Effects

Table 2 displays the results from the IV specification, while Table 3 and Table 4 show the corresponding results from the FE strategy. In Table 5, we report the results on crime rates from production shocks in an IV setting, backed up by a similar specification in a FE setting in Table 6. Table 7 shows the same type of results, using lags and leads in production shocks.

The top panel in Table 2 show the unadjusted correlation between mining and crime. We see a strong positive association between the number of active mines in a police precinct and the crime level. As discussed above, there are a number of reasons why we should not trust such an estimate, e.g. that mining activity may be affected by crime levels and that the industry has historically been a catalyst behind the growth of towns and cities, which today are the major crime hubs. To overcome potential reversed-causation and omitted variable problems, we implement our IV strategy. The same table show 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 dollar per gram, the number of active mines increase by about nine per cent of the mean number of active mines. Contrary to previous literature that investigates the effect of extractive industries on social conflict, the resulting second-stage analysis displays a big and significant *negative* effect from mining. In particular, as the number of active mines increase, induced by higher international prices, total crime rates decrease by around seven per cent for each additional active mine. The effect is somewhat bigger for property crime compared to violent crime but highly statistically significant for both outcomes.

As stated earlier, we do not have price data for all minerals and therefore also implement a fixed-effects strategy, both at a police-precinct level and a municipality level to use the full set of mines. Since crime statistics are given at the precinct level, we need to aggregate it to match with the larger municipalities, at what level we have information on migration flows 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 on an aggregate level. Similar to the aforementioned results from the IV specification, Table 3[26] and Table 4 display negative results. The estimated effects of mining activity on the total crime rate are quite similar in size at both levels (between 1.5-2 per cent), 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. Comparing the IV results to 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 on crime from a mining-production shock. That is, in the IV specification we capture

[25] These results are robust to logging the price variable.

[26] Column 1 shows the unadjusted correlation in the data, revealing that mining districts have higher total crime rates. However, the fixed effects model show 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. The high levels of zeros mean that we do not want to use the log of this variable. To test the constant semi-elasticity of the model assumed here, we include the square of this term in Appendix Table B5. 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.

the effect of less expected production changes, compared to the FE specification.

The above results are supported by Figure 6 that shows how the number of active mines have increased during our period of study while criminality in mining precincts has fallen.[27] In fact, crime rates have been on a negative trend overall in South Africa, with property crime falling more than violent crime, and mining districts seeing 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.

Next, we delve further into the dynamics of how mining activity affects crime by investigating the effect of production shocks. Here, we define a production shock as a start or a stop in mining production. Table 5 shows the results from this specification, using the IV strategy discussed above. Apparent from Panel A in the table, we find no significant effects of international mineral price changes on production starts. This might not come as a surprise since production starts also include the opening up of new mines (in contrast to the reopening of a temporarily closed mine) which is a very costly and time consuming process that might not react to current world-market prices. To deal with this we ignore positive changes in production for mines that prior to that change had no production during our sample period, since these changes are likely to represent the opening of a new mine. We keep all changes from no production to positive production for which we have indications that the mine has been previously active. Accordingly, looking at Panel B, we now find that as prices increase, so does the probability that a mine starts producing. In the second-stage analysis, we find a negative effect of mine openings on crime rates. However, these effects are unprecisely estimated and not significant at conventional levels. Furthermore, in line with the results on the number of mines, we find a significant and sizeable positive effect from a stop in mining production on all crime categories (intuitively, the first-stage estimate is now negative) in Panel C. This effect is precisely estimated with clustered standard errors, but less precise when standard errors are clustered on both the precinct and mineral-time dimension. This may be a result of the limited variation in the dependent variable for this analysis. We display support for this result in Table 6 that gives the estimates for a FE strategy, also looking at the effect of starts/stops in mining activity. Here, however, violent crime is not significant and we find no significant effect from starts in mining production. In turn, Table 7 shows that the positive effect on crime stemming from a stop in production is stronger for the current year than if the mine stops producing in $t-1$ or $t+1$. The fact that we do find effects of mining activity on property crime also prior to when the mine stops producing is not surprising since production volumes are likely

[27] 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.

to be affected in the time period around when the mine stops producing. 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 again insignificant.

Lastly, Table B6, Table B7 and Table B8 in Appendix give the results for all subcategories of crime using the IV approach. As would be expected given the results on the compiled variables (total, property and violent), most crimes have a negative coefficient. It is however interesting to note, from Table B1, that the effect of mining activity on public violence tend to be positive, albeit insignificant using the IV approach. This subcategory of crime is much alike what has been explored in earlier papers on extractive industries and social conflict. To investigate this further we run regressions with this outcome also using the fixed effect strategy for both the municipality and precinct sample. Using this strategy, we find positive and a highly statistically significant impact 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 Potential Mechanisms

6.2.1 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 determine 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 incomes 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. Table 8 reports the results.

As expected, 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 an additional active mine increases the mean light density by about five per cent. Likewise, when a mine stops producing, economic activity decreases by about 2.6 per cent. Using the IV strategy we find effects in the same direction but substantially larger, especially for production shocks. Again, we see no significant effects for a start in mining activity with the fixed effect strategy, but when using the IV approach and excluding new mines in Panel B, we find a positive and significant effect. Furthermore, in the third column of Panel A in Table 8, 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 compared to 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.

In Table 9 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. 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.

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.

6.2.2 Migration

Migration plays a paramount role in the South African mining industry and the size of the migratory influx will determine if 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 10, we start out by showing that total and male migration as well as migration from SADC countries increase due to mining activity.[28] In particular, when the number of active mines increase by an additional mine, migration as a share of a municipality's population increase by approximately 23 per cent of the mean. It thus seems to be the case that the mining industry is still seen as a potential employer by migrant workers from countries such as Mozambique and Lesotho. In turn, this finding might be driven by the increase of around 18 per cent that comes from a start in mining production (second panel). The fact that we do not find significant estimates from stops in production is not too surprising since the data does not allow us to capture migration outflows (see data section above).

Next, in Table 11, we explore heterogeneous effects between municipalities where the average

[28]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.

migrant share of the population is above and below the median in the sample.[29] The results for municipalities with migration shares below the median are reported in Panel A. The results show that there are no significant effect of the number of active mines within 20 km on the log crime rate 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 reduce by about 2.45 per cent) and typically small and insignificant effects on crime when a mine stops producing. Panel B show the results for municipalities with above the median migration shares. These results show that an increase in the number of active mines leads to lower crime rates, but both starts and stops in production are associated with higher crime rates. Notably, the increase in the crime rate when the 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 is 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.

6.3 Robustness Checks

As discussed earlier, we use international mineral prices as an instrument for mining production. Table 2 reports results using prices on all minerals. In Table B2 we deal with the potential concern that South African production could affect international prices since the country has a high share of world production for some minerals. If that was the case, local crime levels could affect production that in turn would affect international prices and thus invalidate the instrument. We thus drop minerals for which South Africa contributes to more than 20 per cent of world production for the time period of analysis.[30] We still find strong negative and significant effects from mining activity on crime. Although we drop 1500 observation with this specification, the estimates are very similar in size with a nearly identical first-stage estimate of the effect of international prices on mining production.

Another potential concern is that the price instrument 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, i.e. our identification assumptions are not valid. 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.

[29] The median migrant share of the population in the sample is about 0.1 per cent.

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

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 9 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 show 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 fixed effect specification. Hence, in order to check this we employ a similar randomization strategy as above, but randomize the mining activity variable in equation (3) instead. Panel B of Figure 9 show 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 results are not driven by economic trends.

We also investigate the importance of the strategy employed to deal with spillovers in Table B3, 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 close 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.

As mentioned in section 4.3, we need to extrapolate the population estimates from StatSA's censuses to be able to create per capita outcome variables for each year. To test for the worry that this data issue is somehow affecting our results, we show that the negative and significant estimates hold also for count data in Table B4.

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 2013). 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.

Lastly, and similar to the aforementioned, a potential concerns it that our results are explained by higher crime-prevention expenditures as mining activity increases (or lower expenditures when they close down). If that was the case, we cannot say with certainty that the negative effects of mining on crime actually stems from mining in itself. 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 on a province level, which leaves us with very few observations. This is due to the fact that the responsibility of policing lies on that administrative level. We find no significant effects of mining activity on police expenditure. If anything, the estimates are negative, independent 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 gives the same estimation, but here we include provincial crime-prevention expenditure per capita as a control variable. Apparent from the column, the main estimate remains virtually the same both in terms of 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 worry 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 SAPS (ISS 2015). Since their main responsibility is to investigate cases where mining materials are suspected to be stolen, rather than investigating crimes as defined in this paper, our findings from this analysis might not be too surprising.

7 Discussion

It is a much studied question if natural resource economies are more vulnerable to social conflict and civil wars. 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 extra interest here: first, because South Africa is one of the world's most important mining countries, and one of the most crime ridden countries in the world. Second, because 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 not informative regarding the relationship between criminality and mining in this context. Many natural-resource rich economies are middle-income countries, for example Botswana, Brazil, Mexico, and Romania, why this is a question of great relevance.

In this paper 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-variables 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 and the start and stop in production with 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 reading of the literature, we find an overall negative and significant relationship between mining and criminality, for total, property as well as violent crime. Total crime rates decrease by around seven per cent 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, but also from other industries that rely on incomes from the mining industry).

We explore two main channels, income opportunities and migration. We find supportive evidence using night-lights data that the local economies contract when mines stop producing, which risk inducing higher levels of unemployment and a substitution of income from wage labor to income from crime. In line with predictions from Dal Bó and Dal Bó (2011), our results seem to be driven by labor-intensive underground mining. We also note that mining causes inward migration, as the migrant share increases with 18 per cent 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 on average high versus low shares of migrants in their population. The results indicate that in areas where migration is important, 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.

Despite the overall negative relationship between mining and criminality, we want to highlight two caveats. First, in line with previous literature, we note a positive relationship between mining and public violence. Second, the dynamic relationship between criminality and mining needs further analysis. Mining could change the underlying crime potential that will then only materialise when a certain situation arises. In the case of South African mining, we might expect the mining sector to cause inward migration of young men to informal settlements around mines. If the job opportunities within the sector are suddenly withdrawn, it could spur a criminality shock. Given the sector's volatile nature, in that it is dependent on depletable resources and sensitive to commodity price shocks, this is potentially of high relevance. The dynamic relationship between mining, migration and criminality is the next step for this research project.

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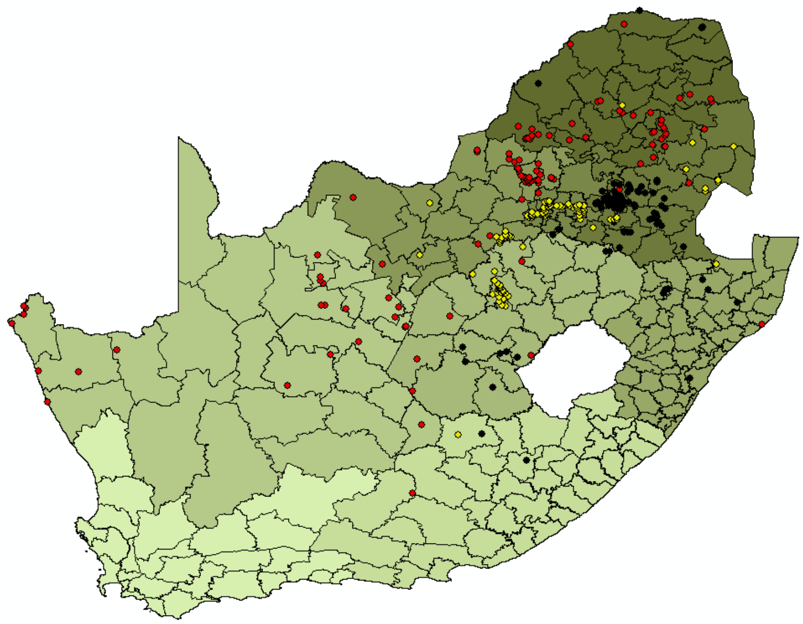
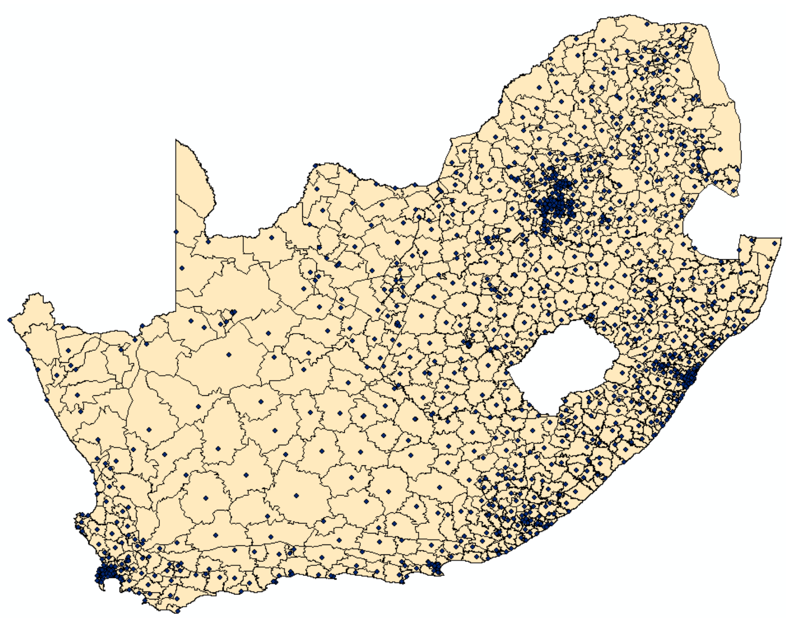
Figure 1: Mines in South Africa



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.

Figure 2: 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.

Figure 3: Production of Minerals in South Africa

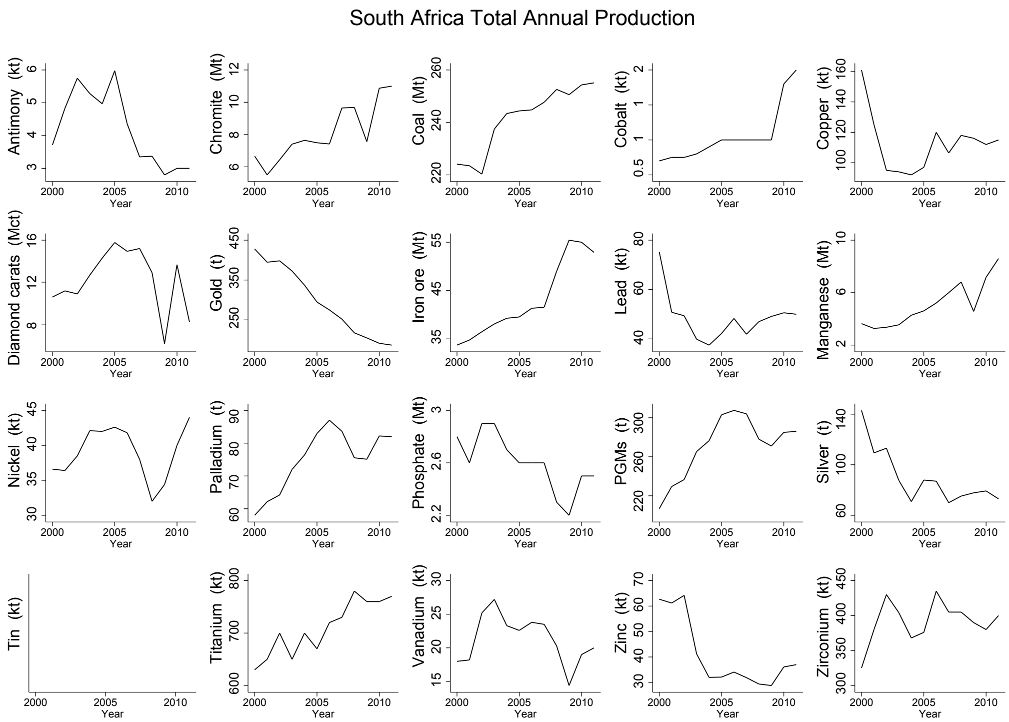


Figure 4: South Africa Share of World Production

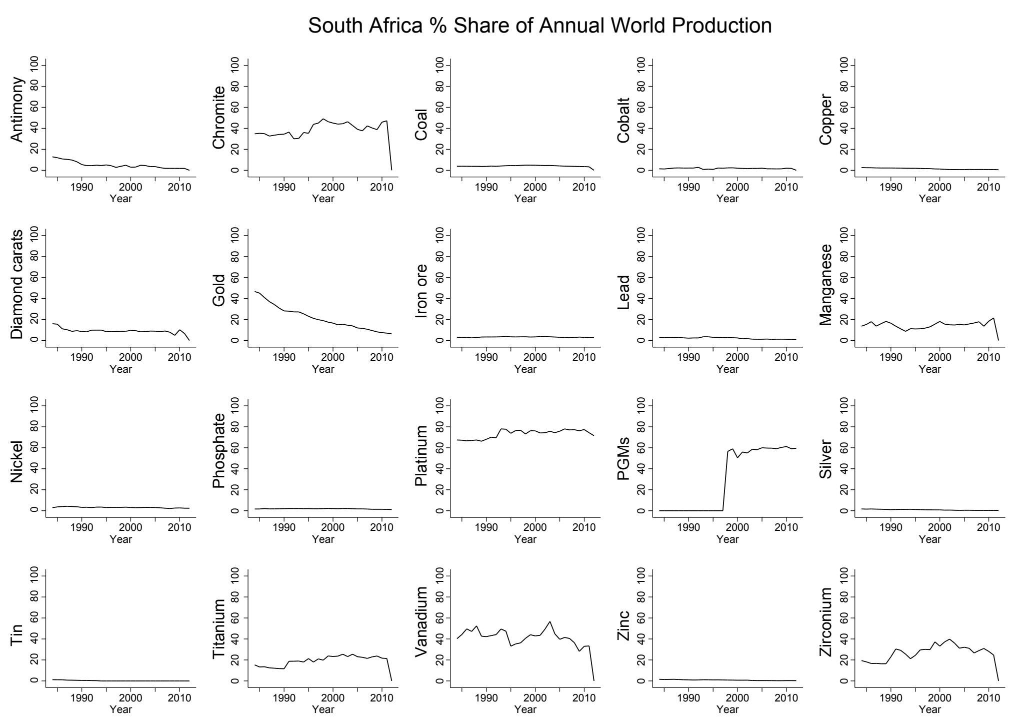
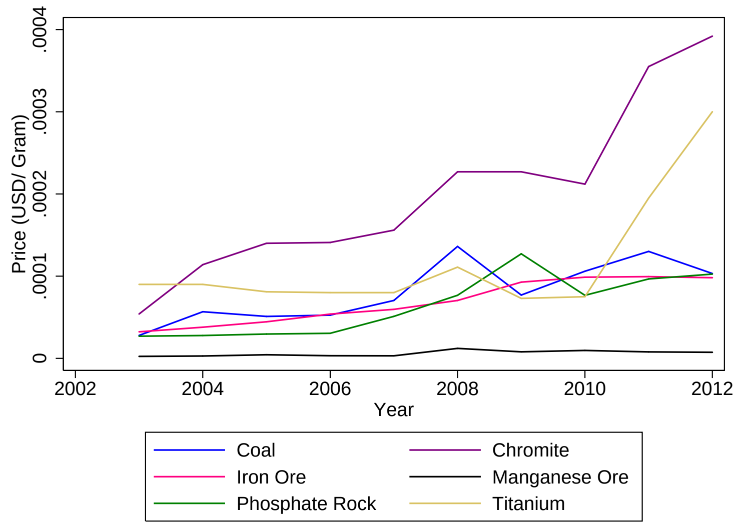
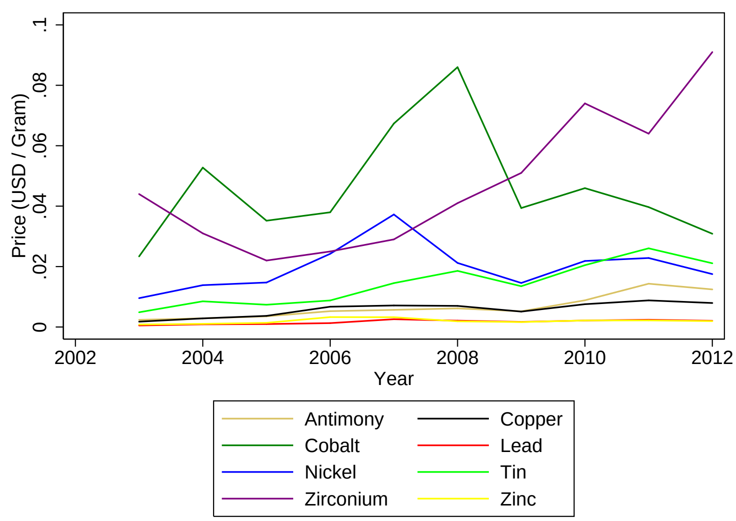


Figure 5: International Mineral Price Trends

(a) Low Price Minerals



(b) Medium Price Minerals



(c) High Price Minerals

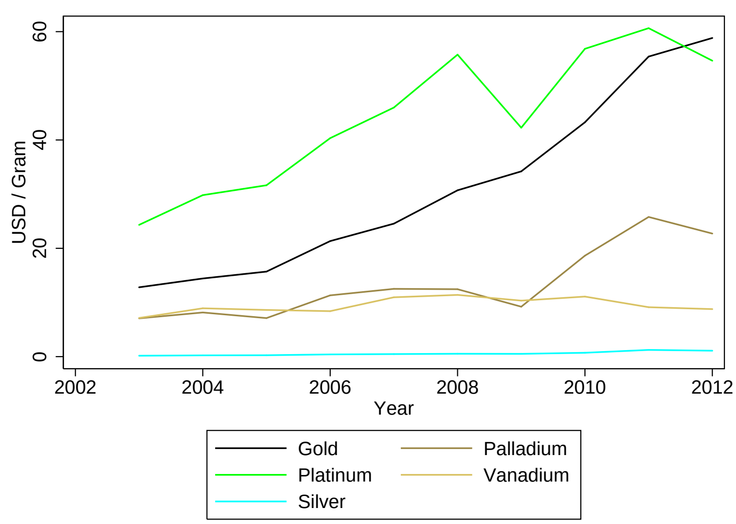
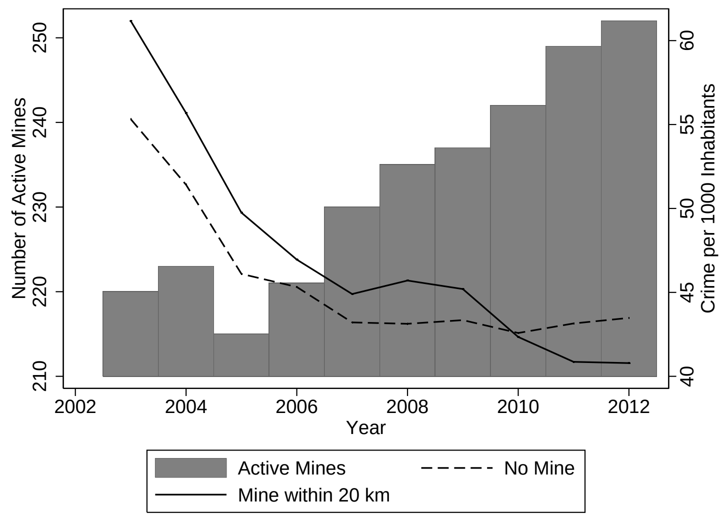
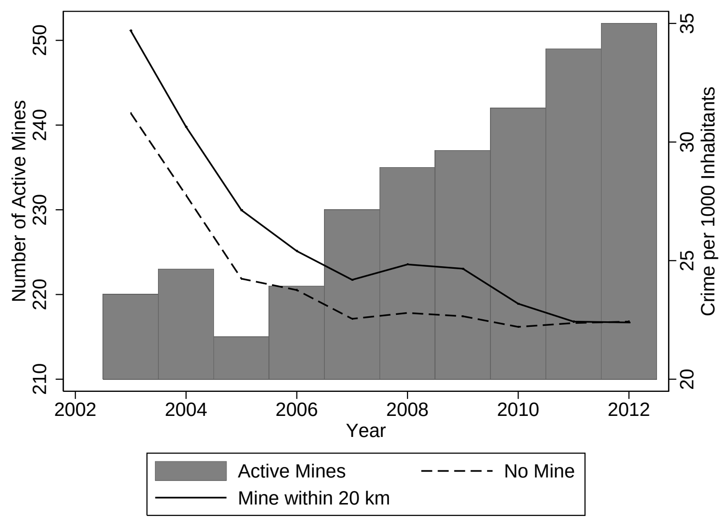


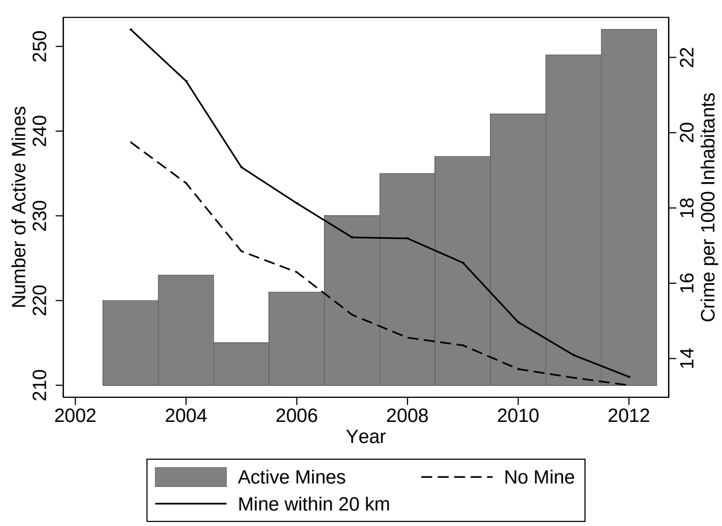
Figure 6: Active Mines and Crime Rates in Mine and Non-mine Precincts



(a) Total Crime

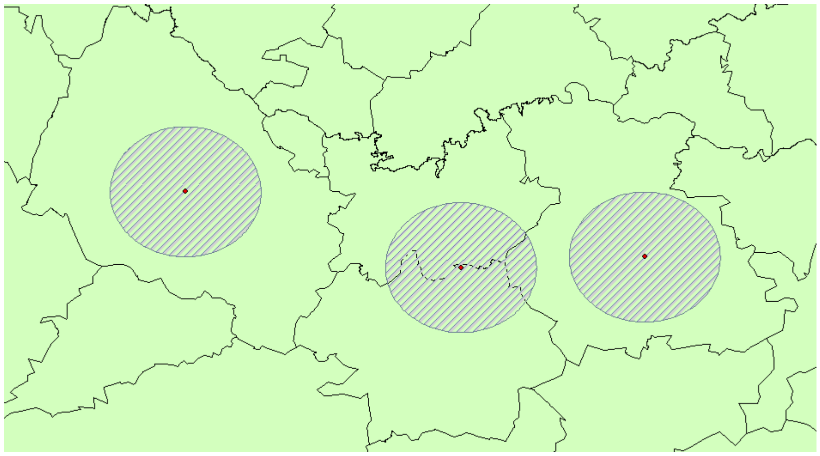


(b) Property Crime



(c) Violent Crime

Figure 7: 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 8: Mine Location and Lights at Night in 2012

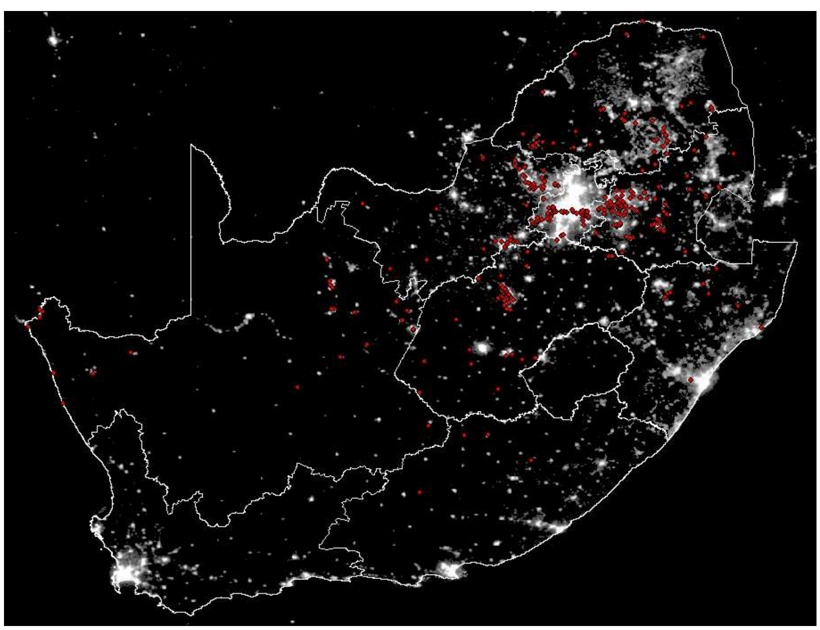
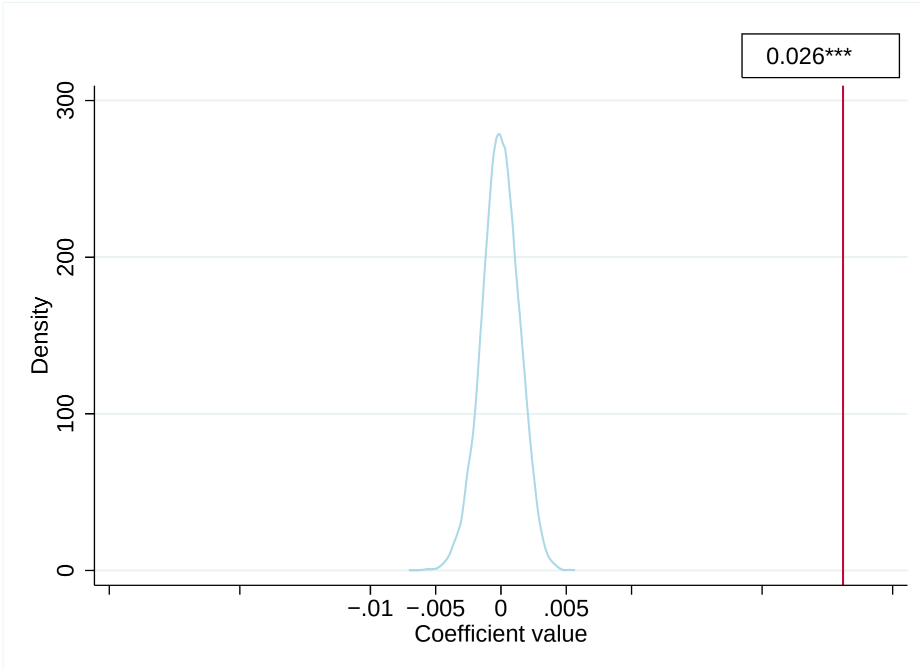
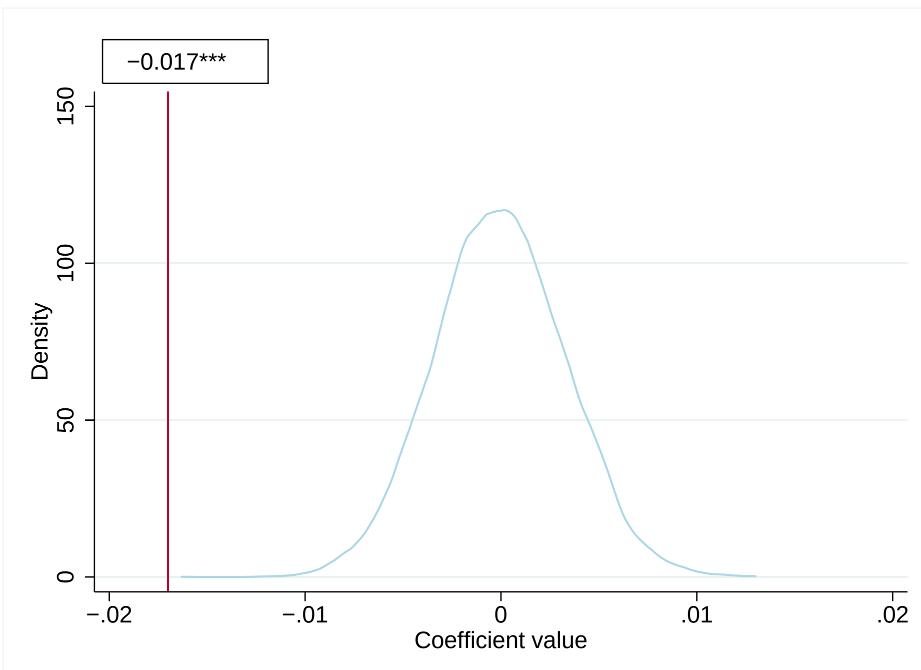


Figure 9: Coefficient Densities from Randomization Tests



(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 acticvity 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.

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
Property 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(Property 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.

Table 2: Precinct IV

	Total Crime	Property Crime	Violent Crime
OLS	0.0284***	0.0351***	0.0212***
	(0.00604)	(0.00722)	(0.00478)
2SLS	-0.073***	-0.088***	-0.066***
	(0.020)	(0.022)	(0.024)
	[0.024]	[0.027]	[0.027]
Reduced Form	-0.00192***	-0.00230***	-0.00174***
	(0.000504)	(0.000551)	(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		
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. 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.

Table 3: Precinct fixed effects

	OLS	FE		
	Total Crime	Total Crime	Property Crime	Violent Crime
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 B5.

Table 4: Municipality fixed effects

	OLS	FE		
	Total Crime	Total Crime	Property Crime	Violent Crime
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 resports 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 precinct. All regressions control for municipality and year fixed effects. Standard errors in parenthesis are clustered at the precinct.

Table 5: Start & Stop Producing IV

	Total Crime	Property Crime	Violent Crime
A: Start Producing (incl. all mines)			
2SLS	2.323	2.746	2.182
	(1.890)	(2.193)	(1.865)
First Stage	-0.000893		
	(0.000675)		
F Statistic	1.748		
Observations	4733		
B: Start Producing (excl. new mines)			
2SLS	-2.086*	-2.465*	-1.959*
	(1.077)	(1.294)	(1.059)
First Stage	0.000994**		
	(0.000464)		
F Statistic	4.594		
Observations	4733		
C: Stop Producing			
2SLS	0.86***	1.02***	0.81***
	(0.27)	(0.31)	(0.31)
	[0.54]	[0.64]	[0.56]
First Stage	-0.0024***		
	(0.00048)		
	[0.0015]		
F Statistic (one way cluster)	24.77		
F Statistic (two way cluster)	2.689		
Observations	4733		
Mineral by Precinct FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: This table reports the result from instrumenting production shocks (i.e. whether a particular mineral mine starts or stops producing in a given year) with the international mineral price. The outcome is the log of the crime rate in a precinct and the instrumented variable the number of mines that start or stop producing a given mineral within 20km from a precinct. Panels A instruments production starts for all mines, Panel B instruments production starts for already existing mines and Panel C instruments mine closures for all mines. 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.

Table 6: Start & Stop Producing Precinct FE

	Total Crime	Property Crime	Violent Crime
Start Producing 20 km (excl. new)	-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
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 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.

Table 7: 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 (excl. new)	0.00126	-0.00491	-0.00220
	(0.0125)	(0.0139)	(0.0164)
Start 20 km (excl. new)	-0.0181	-0.0146	-0.0258
	(0.0134)	(0.0144)	(0.0180)
Start 20 km t+1 (excl. new)	-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.

Table 8: Lights at Night

	(1)	(2)	(3)	(4)
A: Precinct Fixed Effects				
Active Mine 20 km	0.648***		0.649***	0.603***
	(0.106)		(0.168)	(0.132)
Start Producing 20 km		0.00701		
		(0.0839)		
Stop Producing 20 km		-0.358**		
		(0.173)		
Observations	10840	9756	2640	1410
R-Squared	0.992	0.992	0.993	0.990
Mean of Outcome	13.36	13.52	20.20	9.951
Sample	Full	Full	No mine	$\geq$ 1 mine
B: Precinct IV				
Active Mine 20 km	0.987***			
	(0.260)			
Start Producing (all mines)		-29.51		
		(23.86)		
Start Producing (excl. new)			26.49**	
			(13.07)	
Stop Producing				-10.95***
				(3.493)
F Statistic	206.9	1.748	4.594	24.77
Observations	5260	4733	4733	4733

Notes: This table reports the result from a set of regression of the average light intensity at night in a precinct on mining activity. Panel A reports results from fixed effects regressions. Column (1) estimates the effect for the number of active mines within 20 km from the precinct, whereas column (2) estimates the effect for the number of mines that starts and stops producing within 20 km from the precinct. Column (3) estimates the same effect as in column (1), but excludes all precincts with a mine within the precinct; i.e. only mines within 20 km that are not located within the precinct are included. Column (4) limit the sample to precincts with a mine within the borders of the precinct. All regressions in Panel A include precinct fixed effect as well as year fixed effects. Panel B reports results from IV regressions and all include precinct by mineral fixed effects as well as year fixed effects. Standard errors clustered at the precinct level are reported in parenthesis.

Table 9: Precinct IV heterogeneous effects by mine type

	Total Crime	Property Crime	Violent Crime
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		
Mineral by Precinct FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

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.

Table 10: Effects on Migration

	Total Migration	Male Migration	SADC Male Migration
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
Municipality FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

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 report the results for the total number of active mines, whereas Panel B report 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. Standard errors clustered at the municipality level are reported in parenthesis.

Table 11: Heterogenous 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
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the results from carrying out the municipality fixed effect analysis in Table 4 on two different samples. 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.

Table 12: Crime Prevention Expenditure

	Expenditure		Log Total Crime Per Capita	
	Per Capita	Log Per Capita		
Active Mines	-0.529	-0.137	-0.0731***	-0.0889***
	(0.561)	(0.0789)	(0.0196)	(0.0199)
Expenditure per capita (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 resports 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).

A South African 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 in the democratic South Africa. NGO's have pointed to the clash as a result of the widespread poverty and grievances among the migrant mine workers (Human Rights Watch 2013). Such a narrative of grievances is far from new within 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 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 employments (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 part 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), rather than to settle in the industrial areas. Arguably that was to ensure that industries were not responsible for worker's welfare, rather than ensuring 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), but the policy was also supported by gold industry, in whose interest it also was to stop the burgeoning urbanization movement (Cox et al. 2004).

A 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 in part motivated by the risks of spread of HIV/AIDS and labor unrest associated with the single-sex hostels systems (Hamann and Kapelus 2004). However, the process away from migrant-labor was slow, especially in the mining industry. In 1991, over 97 per cent of the mine workforce (about half a million people) lived in single-sex hostels (Crush and James 1991), but in 1997, 95 per cent of all miners were still migrant workers living in the same hostels (Campbell 1997).

B Additional Tables

Table B1: 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 B2: 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 Mine FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: The results in this table corresponds to those reported in Table 2, 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 B3: 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
Municipality FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: The results in this table corresponds to those reported in Table 4, 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 B4: 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 carrying out the fixed effect (Panel A) and instrumental variable (Panel B) strategies 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 B5: 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 B6: 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 controll for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.

Table B7: 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 controll for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.

Table B8: 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 controll for time and municipality fixed effects. Standard errors clustered at the precinct are reported in parenthesis.