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The regional economics of mineral resource wealth in Africa

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Abstract

We study the regional economics of mineral resource activity in Africa. Using geocoded data on mine openings and closures in Africa, we document that mining regions experience local economic booms while a mine is in operation. We then explore how mineral resources affect non-mining regions. Non-mining regions might be affected by mining activity due to deliberate government policies (e.g. regional redistribution) or due to various inadvertent country-level macroeconomic adjustments (e.g. Dutch-Disease-type effects or declining institutional quality). Our results suggest that mineral resources have heterogeneous effects on non-mining regions. Politically important regions benefit economically, while generic non-mining regions are, in general, worse off. Exploring mechanisms, we find that these spatial patterns arguably emerge due to both deliberate government policies as well as Dutch-Disease-style macroeconomic adjustments that harm regions specializing in sectors other than mining.

1 | INTRODUCTION

Even though the macroeconomic importance of the mineral resource sector is undeniable, its local economic implications across different geographies—within both mining and non-mining regions—are not well understood. One strand of the relevant literature explores the economic implications of mineral resources for mining regions (Cust and Poelhekke 2015).¹ However, the evidence remains ambiguous. Some studies find that mineral resources have positive short-run effects on local economic development and household income (Michaels 2011; Loayza *et al.* 2013; Allcott and Keniston 2017; Feyrer *et al.* 2017; Mamo *et al.* 2019; Benshaul-Tolonen 2019; de la Sierra 2020), while others find evidence for environmental and societal damages (James and

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Aadland 2011; Aragón and Rud 2013; Kotsadam and Tolonen 2016), with potentially adverse long-run economic effects.²

Besides their economic effects within mining regions, another important question regarding the spatial economic implications of mineral resources is how they affect economic outcomes in non-mining regions. It is important to study how mineral resources affect such regions in order to better understand why—in many cases—mineral resources are associated with aggregate economic decline and political instability rather than prosperity, and why countries with significant mining revenues perform worse across a range of standard measures for welfare (nutrition, literacy, life expectancy) than their non-resource neighbours (Chuhan-Pole *et al.* 2017). Yet there is almost no literature on this question.³

The extraction of mineral resources can affect non-resource regions for two main reasons.

First, national governments, which are typically the primary claimant to mineral resource revenues (Brosio and Singh 2014), could redistribute mining revenues spatially either explicitly through inter-governmental transfer schemes or implicitly through general government spending and nationally provided public goods. How natural resource revenues are shared between resource-producing and non-producing regions is thus often politically contentious and a major source of conflicts (Fearon and Laitin 2003).

Second, mineral resources can cause inadvertent macroeconomic adjustments that affect different subnational regions in a heterogeneous fashion. For example, the Dutch Disease literature suggests that when resource-rich regions experience booms, non-resource regions can be negatively affected by adverse terms of trade effects (Corden 1984). Another possible macroeconomic consequence of mineral resource wealth is general political instability or declining quality of government (Humphreys *et al.* 2007; Maystadt *et al.* 2014; Berman *et al.* 2017).⁴ For non-resource regions, such adverse effects might outweigh the (potentially) positive effects of inter-regional transfers funded by higher resource revenues. In fact, as there are typically more non-resource than resource regions in a given country, such explicit and implicit negative spillovers of mining activity into non-resource regions might result in negative aggregate effects at the country level, even if minerals induce booms locally.

This paper is the first to shed light on the broader spatial implications of mineral resources. It explores how and why mineral resources affect various types of non-mining regions by combining cross-country data with spatially disaggregated microdata on Africa. Specifically, we use georeferenced data on the operation of mines for different minerals combined with luminosity data over the period 1992–2013, and study how the operation of mines affects luminosity in mining and non-mining regions in African countries.

With respect to non-mining regions, we define three types: capital cities, birth regions of national leaders, and generic non-mining regions. Capital cities and leaders' birth regions are natural candidates for regional favouritism by national governments. Policymakers might favour these two types of regions because they themselves or close acquaintances could benefit directly from any disproportionate resource allocations. In contrast, generic (non-mining) regions are the remainder of the country, and, depending on circumstances, might or might not benefit from more mineral activity. For example, they might receive additional resources through inter-governmental equalization. On the other hand, as discussed above, they might be worse off due to adverse macroeconomic effects.

Implementing several variants of difference-in-differences designs at the grid level, we find that the opening of a mine leads to visible and persistent economic booms in the mining regions. This effect is centred around the location of the mine and is observable up to a distance of 30 km. The effect is robust across a range of sensitivity tests.

To explore how mines affect non-mining regions, we exploit cross-country variation in the number of operating mines. We find that an additional mine anywhere in the country increases luminosity in the capital city. This suggests that a share of the proceeds from mineral resources is shifted from mining regions to capital cities. We also observe that additional mines increase

luminosity in the current national leader's birth region when the country in question is under autocratic rule. However, we observe no such effect in democracies. This evidence suggests that the distribution of mineral resource wealth is subject to regional favouritism towards leaders' birth regions in non-democratic settings, but not when countries are democratic. This finding is in line with the cross-country evidence suggesting that the natural resource curse emerges only in countries with weak institutions (Collier and Hoeffler 2009; Boschini *et al.* 2007).

We also observe that the opening of additional mines in a given country decreases luminosity in generic non-mining regions compared to similar regions in adjacent countries. Exploring this finding further, we find that the number of conflict events increases in generic non-mining regions when mineral activity expands elsewhere. This result suggests that governments might use mineral revenues to fund conflicts in other (non-mining) parts of the country. We also find that mines have weaker economic effects on luminosity in regions inhabited by ethnicities that are 'politically weak'—that is, considered to be discriminated against in their country—and more positive effects in regions with politically powerful ethnicities. Overall, these results suggest that deliberate government actions can provide a partial explanation for the adverse effects of mineral resource activity on generic non-mining regions.

On the other hand, macroeconomic adjustments appear to be important as well. While we observe no decline in country-level institutional quality when mineral resource activity expands, subnational regions specializing in manufacturing, agriculture or the hospitality industry are ostensibly worse off (in contrast to regions that have a relatively large mining sector). These results indicate further that exchange rate adjustments due to increased mineral resource exports disadvantage non-mining regions and contribute to a decline in economic activity—a finding in line with the Dutch Disease literature.

Apart from the general literature on the economic implications of mineral resources discussed above, this paper primarily contributes to a recent literature that studies the link between mineral resources and inter-governmental transfers.⁵ Existing studies tend to focus on the implications of inter-governmental transfers funded by resource revenues allocated specifically to the mining regions. For example, Cust and Ridwan (2014) discuss evidence from Indonesia that fiscal transfers related to oil production boost local GDP in oil-producing regions. The direct effect from project investments, on the other hand, appears to be small. Caselli and Michaels (2013) study the effect of oil revenue windfalls in Brazil on municipalities that benefit from fiscal sharing rules. However, only municipalities that are close to the offshore production facilities are considered in this study.

This paper is also related to the emerging literature on regional favouritism. The seminal contribution by Hodler and Raschky (2014) uses nighttime luminosity as a proxy for local economic development to show that national leaders favour their birth towns. Subsequent contributions explore regional favouritism in more detail. For example, Do *et al.* (2017) find that bureaucrats in Vietnam favour their home towns in infrastructure investments. In institutionally more mature settings, Baskaran and da Fonseca (2021) show that German state ministers allocate more state employment to their place of residence, while Asatryan and Havlik (2020) show similar home bias in the allocation of loans in Europe. Another closely related paper is Dreher *et al.* (2021). This paper adopts an empirical strategy similar to ours to study the sub-national economic effects of Chinese aid flows. Specifically, it identifies subnational impacts of country-level variation in Chinese aid flows, and shows that Chinese aid tends to have positive local economic effects.

Another related strand of literature explores the importance of artisanal or small-scale mining. Bazillier and Girard (2017) show that in Burkina Faso, artisanal mining can have positive local effects. For example, an increase in the gold price increases the consumption level of households that live near artisanal mines. Industrial mines, on the other hand, have no effect on local consumption. Pokorny *et al.* (2019) report similar results regarding artisanal and industrial mining. One reason for these findings might be that the proceeds from artisanal mines are harder

to tax than those from industrial mines, and thus are less likely to be redistributed to non-mining regions.

2 | BACKGROUND

2.1 | Mineral resources and their exploitation in Africa

Minerals are materials with economic value in or on the Earth's crust. They can be extracted and applied as inputs for various productive uses, including industrial applications. Mineral resources of significant value typically belong to the state, and their proceeds often constitute a large fraction of public revenues (besides contributing to overall GDP).

Minerals are exploited by either state-owned corporations or private firms that have acquired a licence from the government and thus pay royalties or are taxed according to production (Land 2009). In Africa, most countries tend to rely on private investors due to limited domestic mining capacity (Laporte and Quatrebarbes 2015). Government taxation of mineral resources and the cost of licences are thus the main means by which African governments tap into resource rents.

The rules by which revenues are shared between governments and private corporations vary between countries. Due to the idiosyncrasies of the mineral resource sector, corporations and investors often receive unique tax treatments. The share of the resource rent that accrues to the public sector thus varies depending on such factors as global market conditions or the bargaining power of governments. It is estimated that the rent captured by governments can range from 25% to 65% (Land 2009).⁶

2.2 | Regional distribution of mineral resource revenues

Governments are complex organizations in which power is shared vertically and horizontally. Power is shared vertically between the national and subnational governments, and horizontally among various subnational governments. This raises the issue of how resource rents to which the 'government' is entitled are shared across governmental units.

The traditional fiscal federalism literature suggests that resource rents should accrue to the national government (Oates 1999). National governments are better equipped to deal with the inherent volatility of resource revenues, which are, for example, subject to global demand shocks. Subnational governments may also lack sufficiently competent staff and the absorptive capacity to make adequate use of resource rents. Consequently, subnational governments might make inefficient investments or waste resources on vanity projects (Brosio and Singh 2014).

Countries in Africa broadly follow the recommendations given in the traditional fiscal federalism literature.⁷ While national constitutions tend to only make vague statements regarding ownership, proclaiming that resources belong to the 'people' or the 'state', both legislation that adds detail to the constitution and administrative reality suggest that it is the national government that is the first claimant of any resource revenues.⁸ Therefore it is the national government that typically negotiates with the private corporations and decides on their tax treatment.

There are various taxes that national governments levy on mineral resources, ranging from income and profit taxes, to royalties and licensing fees, sales and excise taxes, value-added taxes on goods and services, and stamp duties (Otto 2001).⁹ The share of the rent that accrues to the national government is then distributed across governmental units, and thus either explicitly or implicitly across different regions of the country. Whether this regional distribution takes place according to predetermined rules or in a discretionary fashion depends on the institutional arrangements in a given country.

Many African countries have formal revenue sharing schemes by which regional governments participate in national government revenues (from both resource rents and other revenue sources).¹⁰ A general feature of revenue sharing in Africa is that the resource-producing regions receive a relatively large share of the rents (Brosio and Singh 2014). This is often justified as a compensation for the environmental or societal damages due to the mining activities. There are, however, also cases where the distribution of resource revenues is not tied to where the natural resources are produced. Chuhuan-Pole *et al.* (2017), for example, note that in Tanzania, a fiscally highly centralized country, public revenues accrue exclusively to the central government and are then allocated according to priorities unrelated to the location of mines. Arora *et al.* (2017) report that in Ghana, about 80% of resource revenues is retained by the (national) government and used for general budget support.

Accordingly, non-producing regions also often receive a share of the resource rents through formal revenue sharing mechanisms. One normative reason for why non-mining regions should benefit from resource rents is a standard insurance argument. *Ex ante*, it is unclear which regions will have valuable mineral resources. Under the veil of ignorance, it is thus welfare-increasing to share resource revenues. However, national governments also allocate resource revenues discretionarily to non-resource regions. Such discretionary transfers may be normatively justifiable if they are granted to achieve desirable economic, societal, or environmental goals. On the other hand, discretionary transfers might be granted to pursue narrow political or electoral agendas or due to clientelism and favouritism. In general, there is a lack of evidence about the motives that would lead national governments to redistribute resource rents to non-mining regions.

Besides explicit transfers that affect subnational revenues, national governments may also use a share of the resource rents to fund national expenses. National government spending has typically distributional consequence across space, with some regions benefiting more than others (Berry *et al.* 2010). In general, it is opaque and dependent on idiosyncratic country-specific political and institutional circumstances which regions will benefit from any higher national spending, either due to newly found mineral resource wealth or for other reasons (Reingewertz and Baskaran 2020).

While inter-governmental flows of public funds might appear as an appealing outcome to study the wider spatial economic effects of mineral revenues, it is difficult to identify these effects using only fiscal data. Without knowledge of the entirety of transfers that flow from the national to subnational governments (vertical transfers) and between subnational governments (horizontal transfers), and a spatial disaggregation of national government spending, it is not possible to arrive at an accurate assessment. In addition, inter-governmental transfer schemes in Africa are generally not sufficiently developed to transparently transfer resource rents across regions (Brosio and Singh 2014). Transfers as such must also not have broad positive welfare effects if funds are wasted locally due to mismanagement (Brollo *et al.* 2013; Standing and Hilson 2013). Finally, mineral revenues could affect the local economy of non-mining regions for reasons other than the inter-governmental redistribution of public funds, notably macroeconomic adjustments that have heterogeneous impacts across geographies. For these reasons, we rely in this paper on nighttime luminosity as a catch-all measure of the economic implications of the redistribution of mineral resource rents beyond the mining regions.

3 | DATA

3.1 | Grid

Most analyses below are conducted at the grid level. To this end, we overlay the African continent with a grid of 0.5×0.5 degree cells (0.5 degrees corresponds to about 55 km at the equator) (Berman *et al.* 2017). We then intersect this grid with a map of country borders to identify within

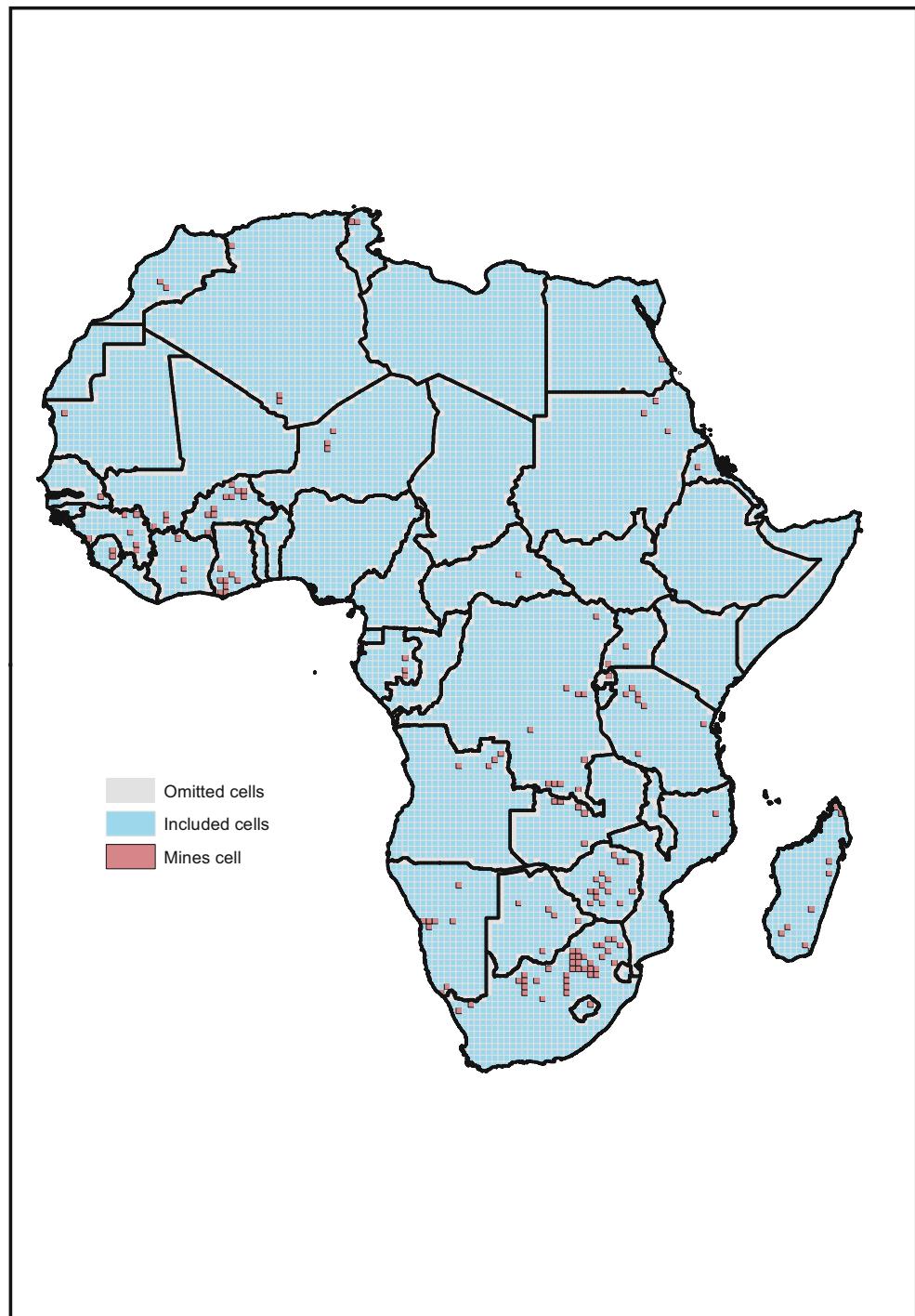


FIGURE 1 Mining regions across Africa. *Notes:* This figure shows the location of mineral deposits included in our estimation sample plotted to the grid of Africa.

which country a particular cell is located. We then drop from this grid all cells that are located in more than one country. The final sample consists of 9068 cells over the period 1992–2013 (see Figure 1).¹¹

3.2 | Mineral resource data

Previous research has used mine openings and closures to approximate the amount of mineral resource revenues that accrues to the government (Kotsadam and Tolonen 2016; Knutsen *et al.* 2017). Another strand of the literature has also used variation in mineral resource prices (Berman *et al.* 2017).

In this paper, we rely on mine openings and closures as our main approach, but also explore the effects of price variations. We use openings and closures as our baseline approach since variation in prices is less suitable in our context. First, it is difficult to estimate effects for non-mining regions when a country has several minerals, and prices for each mineral evolve differently (for some minerals, price data are also unavailable). That is, it is difficult to assess whether overall mineral revenues increase or decline without knowledge of export volumes for each mineral. Second, temporary variation in prices might induce only short-term resource reallocations rather than long-term adjustments, which in turn would persistently affect luminosity in non-mining regions.

We obtain historical data on mineral resource activity in Africa from MinEx Consulting, which is a private mining consulting company. The database contains a comprehensive list of *significant and unique* deposits in Africa. In terms of minerals, the database covers all commodities except bulk minerals (i.e. coal, iron ore, bauxite, potash and phosphate). In terms of size, MinEx Consulting estimates that its data cover 99% of all giant-sized deposits, 95% of all major deposits, 70% of moderate deposits, and 50% of minor deposits.¹² The information on mineral resource deposits and activity is derived from various (proprietary and free) sources, and is more comprehensive and up to date than most alternative datasets.¹³

The database lists 519 mines of (non-bulk) minerals that were potentially in operation for at least one year during the 1992–2013 period. Of these 519 mines, we lack information on the startup or shutdown date for 228 mines. We omit these mines from the analysis, which leaves us with a final sample of 291 mines of any size, a coverage of 56% of all mines potentially in operation.¹⁴ However, the actual sample coverage relevant for the sample period is likely higher than 56%. For example, of the 115 mines with information on the year of discovery but no information on the startup year, 100 had been discovered before 1992 (the beginning of the sample period); 76 mines had been discovered even before 1950. As such, it is unlikely that many of the mines with missing startup dates were started up during the sample period. Similarly, of the 90 mines that were recorded as closed during the sample period but for which we lack information on the exact shutdown date (but have information on the startup date), 56 were started up before 1950. It is unlikely that many of these mines were closed during the sample period. Also, mines with missing information on startup or shutdown dates tend to be smaller and thus in all likelihood less economically consequential.

Table 1 lists the types of minerals and the number of respective mines included in our sample. The most common mineral in the sample is gold, which makes up 46% of all mines. Diamond and copper mines also constitute large shares of all mines.

We project the latitude and longitude coordinates of the 291 mines in our sample onto the grid included in our sample (see Figure 1). Figure 2(a) shows the number of operational mines across Africa included in each year of our sample period. Figures 2(b) and 2(c) show the numbers of mine openings and closures per year in our sample, respectively. There is significant variation in mining activity. It is apparent that openings generally outnumber closures, particularly in the second half of the sample period.

TABLE 1 Types of mines and their frequency in the sample.

Mine	Frequency	Percentage
Andalusite	1	0.352
Asbestos	3	1.056
Chromium	1	0.352
Cobalt	1	0.352
Copper	26	9.155
Diamonds	48	16.90
Fluorine	1	0.352
Gold	131	46.13
Lead	2	0.704
Manganese	7	2.465
Mineral sands	5	1.761
Nickel	9	3.169
Platinum group elements	13	4.577
Platinum	2	0.704
Ruby	3	1.056
Sapphire	7	2.465
Tin	3	1.056
Tungsten	2	0.704
Uranium	10	3.521
Zinc	9	3.169

Notes: This table shows the types of minerals used in the estimations, and the frequency of their mines in the sample.

We also obtain prices for most of the minerals listed in Table 1 from the World Bank, the IMF, and the US Geological Survey (USGS). See [Online Appendix Section A.2](#) for details on the price data for each of the minerals.

3.3 | Luminosity data

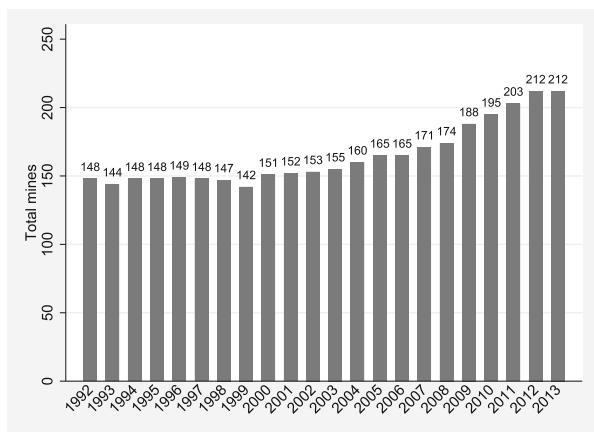
Following previous literature, we use nighttime luminosity as a proxy for economic activity at the local level (Alesina *et al.* 2016; Hodler and Raschky 2014; Michalopoulos and Papaioannou 2016; Martínez 2022). These data are based on images of the Earth at night obtained by satellites of the US Air Force Defense Meteorological Satellite Program Operational Linesman System (DMSP-OLS). The original imagery is processed by the National Oceanic and Atmospheric Agency, and released to the public as raster datasets.

The raster datasets consist of annual average stable night lights between 8.30pm and 10pm, and are available at resolution 30 arc-seconds (about 0.86 km² at the equator) for all years after 1992. Each pixel of the dataset stores a digital value ranging from 0 to 63 indicating the amount of average light of an area covering 30 arc-seconds. Higher values imply that a pixel emanates more light (Henderson *et al.* 2012).

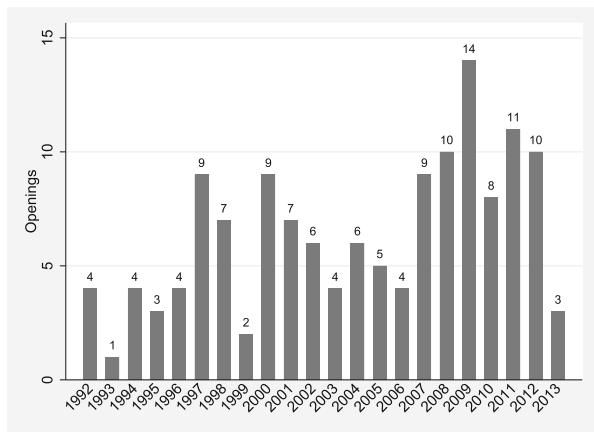
To obtain a cell-level measure of economic development, we overlay the grid of cells over the raster datasets. We then calculate the area mean of the digital values of each cell with size 30 arc-seconds that falls within the boundaries of each of the 0.5 × 0.5 degree cells.¹⁵

While the DMSP-OLS luminosity dataset have been used as a proxy for local economic activity in previous research, it has important limitations (Gibson *et al.* 2021). First, it may suffer from measurement error. For example, light in dimly lit areas might not be detected by the satellites due to limited dynamic range of their sensors. Second, luminosity might not reflect economic

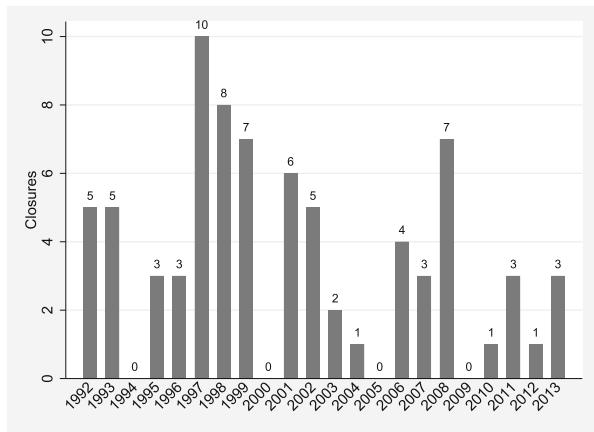
(a) Total



(b) Openings



(c) Closures

**FIGURE 2** Number of mines over time.

Notes: This figure shows, for mines with non-missing data on openings and closures, (a) the total number of mines, (b) the number of mine openings, and (c) the number of closures, in each year during the sample period.

activity if the satellites pick up mainly ephemeral phenomena that emit light at night (e.g. forest fires). However, Brueckner and Hodler (2018) find that luminosity accurately reflects human wellbeing and thus local economic development by comparing night lights with individual-level outcomes as reported by survey data from 29 African countries. Similar results are reported by Määttä *et al.* (2022). In any case, we address concerns regarding sensor sensitivity in a robustness test and also verify the suitability of luminosity as proxy for economic activity by relating luminosity to other proxies for local economic development (see [Online Appendix Section A.3](#)).¹⁶

3.4 | Capital regions

We retrieve information on the location of national capitals from the CEPPII's GeoDist database (Mayer and Zignago 2011). To identify cells that belong to capital regions, we draw a buffer of 10 km size across the longitude and latitude coordinates for capital cities noted in the CEPPII's GeoDist database. All cells that fall within each buffer are indicated as capital regions; see [Online Appendix Figure A.5](#).¹⁷

3.5 | Leader regions

We use information on the birth cities of national leaders from the Archigos database (Goemans 2016); in cases where information on birth regions was missing, we collect this information ourselves. We then geocode the birth cities using ArcGIS.

To identify cells covering a leader's birth region, we draw, as for capital cities, a buffer of 10 km around each leader's birth city's longitude and latitude coordinates. We then classify all cells that fall within this buffer as a leader region (see [Online Appendix Figure A.6](#)).

3.6 | Other data

We obtain further data for robustness tests and extensions, notably proxies for the level of democracy in a country from Freedom House, proxies for institutional quality as well as gross mineral revenues from the World Bank's World Development Indicators, survey-based proxies for local economic development from the Development and Health Surveys, data on population counts from WorldPop¹⁸, data on conflicts from the Armed Conflict Location and Event Data Project (ACLED), and data on employment per economic sector from the Integrated Public Use Microdata Series (IPUMS). We discuss these data in more detail below as the need arises.

4 | MINES AND ECONOMIC ACTIVITY IN MINING REGIONS

4.1 | Empirical model

We start by exploring the local effect of mines within mining regions. The baseline model to estimate the local effect of mines is

$$y_{it} = \alpha_i + \sum_c \gamma_t \times c + \text{Mine}_{i,t} + \epsilon_{i,t}, \quad (1)$$

where y_{it} is the log of the mean of luminosity¹⁹ in cell i in year t , α_i are cell fixed effects, γ_t are year fixed effects, and c stands for country dummies (i.e. we include country-specific year fixed effects); $\text{Mine}_{i,t}$ is a dummy that is 1 when there is at least one operating mine in cell i in year t , and 0 otherwise.

The key identifying assumption is that the opening and closure of mines is exogenous to local economic trends. Naturally, the setup and operation of a mine in a given locality is not a random event. In the [Online Appendix](#), we report event studies to further validate the parallel trends assumption and to assess whether potential violations are economically meaningful (see [Online Appendix Figures A.2](#) and [A.3](#)). In any case, cell fixed effects can account for time-constant geographical or environmental characteristics of different geographies. Similarly, country-specific year fixed effects account for country-level developments that might be correlated with startups or closures of mines.

In addition, we estimate an extension of equation (1) where we interact the mines dummy with the price of the respective mineral. These specifications make use of variation in (global or US) mineral resource prices on top of the variation in opening and closures of mines.²⁰

4.2 | Main result

In Table 2, we report the results from estimating equation (1). To evaluate statistical significance, we rely on heteroscedasticity-robust standard errors. Standard errors are also clustered at the cell level.²¹

In model (1) of Table 2, we collect the baseline estimate and observe large positive effects. An operating generic mine increases luminosity by about 86% in the mining cell. In models (2)–(5), we estimate variations of equation (1) where we focus on mines of different sizes. That is, the mine dummy is 1 only if a cell has a mine of the indicated size. We find that larger mines have stronger effects on luminosity. Overall, these results suggest that mineral resource activity induces significant local economic booms.²²

In model (6) of Table 2, we report the results from the specification where we include an additional interaction between the dummy for operating mines with the price of the respective mineral. The estimate for the interaction effect is positive and significant, and suggests a 0.1% increase in nighttime luminosity when global prices for the respective mineral being produced in the cell increase by 1%. Thus both the existence of mines as well as higher mineral prices appear to increase luminosity.

TABLE 2 Mineral resources and economic activity in mining regions.

	All mines (1)	≥ Major (2)	≥ Giant (3)	< Major (4)	< Moderate (5)	Prices (6)
Mine	0.858*** (0.116)	1.078*** (0.156)	1.371*** (0.280)	0.410*** (0.121)	0.178* (0.095)	
Mineral price						0.105*** (0.018)
Cell fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country–year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cells	9053	9053	9053	9053	9053	9053
N	199,138	199,138	199,138	199,138	199,138	199,138

Notes: This table collects difference-in-differences regressions that relate mineral resource activity (operating mines) to luminosity at the grid level for all of Africa (0.5 × 0.5 decimal degree cells). In this specification, we study whether mines increase luminosity in mining regions. The dependent variable is the log of mean light output in each cell. The independent variable in models (1)–(5) is a dummy variable that is 1 if a cell had an operating mine of a certain size as indicated in the column header. The independent variable in model (6) is the contemporaneous log price of the mineral that is extracted in a given cell. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

TABLE 3 Mineral resources and economic activity in mining regions—geographical spillovers.

	(1)	(2)	(3)	(4)	(5)
Mine	0.887*** (0.116)	0.893*** (0.116)	0.897*** (0.116)	0.901*** (0.116)	0.895*** (0.116)
10 km	0.303*** (0.084)	0.310*** (0.084)	0.314*** (0.084)	0.317*** (0.085)	0.312*** (0.085)
20–30 km		0.093** (0.041)	0.098** (0.041)	0.102** (0.042)	0.096** (0.043)
30–50 km			0.031 (0.037)	0.035 (0.038)	0.029 (0.039)
50–100 km				0.009 (0.021)	0.003 (0.023)
100–200 km					-0.011 (0.015)
Cell fixed effects	Yes	Yes	Yes	Yes	Yes
Country–year fixed effects	Yes	Yes	Yes	Yes	Yes
Cells	9056	9056	9056	9056	9056
N	199,230	199,230	199,230	199,230	199,230

Notes: This table collects difference-in-differences regressions that relate mineral resource activity (operating mines) to luminosity at the grid level for all of Africa (0.5×0.5 decimal degree cells). In this specification, we study whether mines increase luminosity in neighbouring cells. The dependent variable is the log of mean light output in each cell. The independent variables are dummies that are 1 if a cell had an operating mine within the indicated distance. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

Building on the specification in equation (1), we also explore how far the local economic effects of mines spread. More specifically, we adapt equation (1) by including dummies for cells within certain distance bands around mines.²³

The results are collected in Table 3. We find that after the opening of a mine, luminosity increases the most in the mining cells and declines successively in cells that are further away. Mines cease to have a noticeable effect on luminosity in cells that are about 30 km away from a mine.²⁴

5 | MINES AND ECONOMIC ACTIVITY IN NON-MINING REGIONS

How does mineral resource activity (anywhere in a given country) affect economic outcomes in non-mining regions? We study this question for three types of non-mining regions.

First, we focus on generic non-mining regions (which have no special connection to the government and its leader). While such regions might benefit from mineral resource activity elsewhere, such as through institutionalized inter-governmental transfer schemes, they could also be disadvantaged due to, for example, adverse macroeconomic developments or other more deliberate government actions.

Second, we study capital regions. It is plausible that policymakers use a share of the natural resource revenues to spend on amenities in the capital region as they or their ‘friends and family’ could benefit directly from such investments, or that resource discoveries cause urbanization (Huang *et al.* 2022).

Finally, we focus on leaders’ birth regions. Leaders’ birth regions might benefit for several reasons if the leader has access to additional resources, ranging from an innate, altruistic desire to benefit his or her birth place to more parochial and political considerations, such as fostering local political support (Huang *et al.* 2022).

5.1 | Mineral resources and luminosity in generic regions

5.1.1 | Estimation model

To study the effect of mines on generic non-mining regions, we implement a cross-country design with border regions. We focus on border regions, as standard cross-country designs (i.e. regressions with entire countries as units of observation) would likely produce biased estimates in our context due to unobserved heterogeneity. For example, countries facing economic difficulties might be more likely to search for and grant permissions to new mining operations (Maddala 1999).

The idea underlying the border design is that economic trajectories in border regions in neighbouring countries are relatively similar in the absence of country-specific economic shocks such as the opening of new mines. That is, the identifying assumption is that year-specific effects in border regions of different countries are similar. If this assumption holds, then a disproportionate increase in luminosity in the border regions of a country where a new mine starts up, compared to the border regions of neighbouring countries, can be ascribed to increased mineral resource activity.

We calculate average luminosity in cells that neighbour border cells but are located in foreign countries as described in [Online Appendix Subsection A.4.3](#). See also [Online Appendix Figure A.7](#) for the cells included in the border design sample.

Using the border-cell sample, we estimate the following model as our preferred specification:

$$y_{i,t} - \bar{y}_{i,t} = \alpha_i + \gamma_t + \beta \text{ Mines}_{c,t} + \varepsilon_{i,t}, \quad (2)$$

where $y_{i,t}$ is the log of the mean of luminosity in border cell i in year t , and $\bar{y}_{i,t}$ is the log of the mean luminosity averaged across border cells located in neighbouring countries within a 250 km distance. Here, α_i are cell fixed effects, γ_t are year fixed effects (which are not country-specific), and $\text{Mines}_{c,t}$ is the number of mines in the country where cell i is located in year t .

5.1.2 | Results

The results are collected in models (1a) and (1b) of Table 4. We continue to rely on heteroscedasticity- and cluster-robust standard errors (with cells as the unit of clustering) to evaluate significance.

We find that an additional mine anywhere in the country decreases luminosity in generic border regions relative to luminosity in border cells located in neighbouring countries. Specifically, the difference between both sets of cells declines by about 1%. Overall, these results suggest that non-mining regions are disadvantaged by additional mining operations elsewhere in the country. We explore in Section VII whether they are disadvantaged due to deliberate government actions or inadvertent country-level developments.

5.2 | Mineral resources and luminosity in capital regions

5.2.1 | Empirical model

Our preferred specification to study the effect of additional mineral resources on luminosity in capital regions is

$$y_{i,t} = \alpha_i + \sum_c \gamma_t \times c + \beta \text{ Mines}_{c,t} \times \text{Capital}_i + \varepsilon_{i,t}, \quad (3)$$

TABLE 4 Non-mining regions and mineral resources.

	Panel A: Generic regions		Panel B: Capital cities			Panel C: Leader regions		
	(1a)	(1b)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Mines	-0.011*** (0.003)		-0.014*** (0.002)			-0.013*** (0.002)		
Capital city	2.959*** (0.192)							
Capital \times Mines	0.008 (0.011)			0.062*** (0.012)	0.051*** (0.012)			
Leader						1.655*** (0.140)	0.068** (0.033)	0.052* (0.029)
Leader \times Mines						-0.005 (0.007)	0.001 (0.002)	0.001 (0.002)
Country fixed effects	Yes	—	Yes	—	—	Yes	—	—
Cell fixed effects	No	Yes	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	—	Yes	Yes	—
Country-year fixed effects	No	No	No	No	Yes	No	No	Yes
Countries	48	48	50	50	48	50	50	48
Cells	5041	5041	9058	9058	9056	9058	9058	9056
<i>N</i>	110,902	110,902	199,274	199,274	199,230	199,274	199,274	199,230

Notes: This table collects results for specifications following equation (2) (panel A), equation (3) (panel B) and equation (4) (panel C), which relate mineral resource activity (operating mines) to luminosity at the grid level across Africa (0.5×0.5 degree pixels). We study whether mines lead to an increase in luminosity in generic (border) regions, capital cities, and leader birth regions. The dependent variable in models (1a) and (1b) is the difference in log mean luminosity in cell i and log mean luminosity in neighbouring cells located in other countries. The dependent variable in models (2a)–(3c) is the log of mean light output in each cell. The variable of interest in models (1a) and (1b) is the number of mines in a country in year t . The variable of interest in models (2a)–(2c) is the interaction between a dummy indicating cells that cover capital regions and a count variable indicating the number of mines in a country in year t . The variable of interest in models (3a)–(3c) is the interaction between a dummy indicating cells that cover leaders' birth regions and a count variable indicating the number of mines in a country. Only mines with available data on startup and shutdown dates are included.

Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

where i indicates grid cells, and t indicates time periods. Here, $y_{i,t}$ is the log of the mean of luminosity in cell i in year t , α_i are cell fixed effects, $\gamma_t \times c$ are country-specific fixed effects, Capital_i is a dummy variable that is 1 for cells that cover capital cities, and $\text{Mines}_{c,t}$ is a count variable indicating the number of mines in country c in year t .

Note that the capital region dummy is perfectly collinear with the cell fixed effects (as capitals did not move during the sample period).²⁶ The number of mines in a country in year t is also perfectly collinear with the country-specific year fixed effects. However, the interaction between the number of mines variable and the capital region dummy variable is collinear with neither the cell fixed effects (since the number of mines varies over time) nor the country-specific year fixed effects (since capital regions constitute only a small fraction of the country). With this specification, we thus compare how luminosity evolves in capital regions when the number of mines increases relative to other regions in the country.

The identifying assumption for this specification is that the variation in the number of mines in a given year throughout the country is orthogonal to unobserved variables in capital regions. This appears to be a reasonable assumption as the startups or closures of mines across the country are plausibly unrelated to specific developments in capital regions (recall that we account for country-wide developments with the country–year fixed effects).

5.2.2 | Results

The results from estimating equation (3) are collected in models (2a)–(2c) of Table 4. To evaluate significance, we again rely on on heteroscedasticity- and cluster-robust standard errors (with cells as the unit of clustering).

Model (2a) of Table 4 reports results with only country and year fixed effects. Capital regions are on average more brightly lit than other regions, which is plausible given that they are typically (substantially) richer than the remainder of the country (African Development Bank 2015). The number of mines in the country is negatively correlated with luminosity. This may indicate that (additional) mines have adverse aggregate effects.

The variable of interest is the interaction between capital regions and the number of mines. In model (2a) of Table 4, this interaction is insignificant, which suggests that when the number of mines changes, luminosity in capitals does not evolve differently than in other regions. However, model (2a) is a basic specification that, in particular, does not account for cell-specific characteristics other than whether or not a cell is part of the capital city. For example, luminosity might increase more in less developed regions over time due to catch-up effects, rendering any effects of mine openings on capital cities' luminosity empirically undetectable without further adjustments to the specification.

Indeed, the results in model (2b) of Table 4 suggest that once we add cell fixed effects to account for time-constant differences between cells, the interaction between the capital cities and mines variable turns positive and significant. This suggest that capital regions benefit more from mine openings than other regions in the country. In model (2c), we replace the generic year fixed effects with country-specific year fixed effects. The results are virtually identical to those reported in model (2b).

Overall, the results imply that a share of mineral resource rents is shifted to the national capital. Capitals experience an increase in luminosity of about 5.1% when an additional mine opens, compared to other regions in the country. This effect may come about, on the one hand, because the national government uses additional resource revenues to provide various public goods in the capital. Alternatively, since the national elite resides in the capital, it may also be that the increase in luminosity is due to higher private incomes (and subsequent trickle-down effects). In this case, this increase in luminosity in the nation's capital may indicate that at least part of the resource rents is siphoned off and mostly benefits the ruling elite and individuals with relevant connections.

5.3 | Mineral resources and luminosity in leaders' birth regions

5.3.1 | Estimation model

Another region within a country that might experience a disproportionate increase in luminosity when aggregate mineral activity picks up is the birth region of the national leader. Previous evidence suggests that (national) leaders engage in regional favouritism and allocate disproportionate resources to their homelands when in power (Hodler and Raschky 2014; Asatryan *et al.* 2021, 2022). The motives for such behaviour could range from an innate, emotional attachment to their birth regions, to political calculus (e.g. birth regions might be the power base of a leader), or demands for public resources from regional elites of the birth region that the leader might be unable to resist (Baskaran and da Fonseca 2021).

Our preferred specification to study this question is

$$y_{i,t} = \alpha_i + \sum_c \gamma_t \times c + \delta \text{ Leader}_{i,t} + \beta \text{ Mines}_{c,t} \times \text{Leader}_i + \varepsilon_{i,t}, \quad (4)$$

where all indices and variables except the leader dummy are defined as in equation (3). Leader_{i,l} is a dummy that is 1 when a cell covers the birth region of the current national leader, and 0 otherwise. Note that unlike capital cities, leaders' birth regions can vary over time due to regime changes. As such, the dummy indicating leader's birth region is included in our preferred specification despite the cell fixed effects.

5.3.2 | Results

The results from estimating equation (4) are collected in models (3a)–(3c) of Table 4. As before, we rely on heteroscedasticity- and cluster-robust standard errors (with cells as the unit of clustering) to evaluate significance.

In model (3a) of Table 4, the dummy capturing leader's birth region is positive and highly significant. This indicates that leaders, on average, originate from richer parts of the country. As in the regressions above on capital cities, the aggregate number of mines is negatively correlated with luminosity, suggesting that mineral resources have detrimental aggregate effects. The interaction between leader's birth region and number of mines is insignificant.

The effect remains insignificant when we replace the country fixed effects with cell fixed effects (model (3b) of Table 4) and the generic year fixed effects with country-specific year fixed effects (model (3c)). Overall, leaders' birth regions do not benefit more from additional mines than other regions. One reason for this might be that leaders' birth regions might be prioritized even in the absence of additional mineral resource revenues. When additional resources become available due to the opening of mines, they can then be used for purposes other than birth town favouritism, for example, for public goods in capital cities, or siphoned off for private gains.²⁷

6 | HETEROGENEITY BY COUNTRY-LEVEL CHARACTERISTICS

There are two important potential sources of heterogeneity regarding the spatial effects of mineral resources.

The first is the type of political regime, notably whether a country is a democracy or an autocracy. It is conceivable that autocratic countries, in particular, fully extract the proceeds of mines out of the mining regions, leaving the mining regions with none of the benefits of higher mineral resource activity. Alternatively, autocratic countries might give a smaller weight to an equitable spatial distribution of mining proceeds, and instead allow mining regions to retain a larger fraction of the rents to minimize discontent in these regions.

With respect to non-mining regions, previous research suggests that (regional or ethnic) favouritism is more prevalent in non-democracies (Burgess *et al.* 2015). Capital regions may also benefit more in non-democratic settings if a lack of accountability and oversight enables national elites to capture more resource rents (Libman 2013).²⁸

The second important source of heterogeneity is the level of corruption in a given country. Similar to the potential heterogeneity with respect to the type of political regime, it is possible that mining regions benefit less in more corrupt countries from the extraction of their minerals. Favoured non-mining regions, in turn, could benefit more if expropriated mineral rents are shifted to these.

6.1 | Type of political regime

To study the heterogeneous effect of mines on mining regions, we interact the mining dummy in equation (1) with dummies for whether or not a country is a democracy. We define dummy variables for democracy and autocracy, respectively, depending on whether the Freedom House

index classifies a country as fully democratic or not in a given year (Freedom House 2019). Using these two dummies, we estimate separate coefficients for the intra-regional effect of mines in autocratic and democratic countries, respectively.

The results are collected in model (1) of Table 5. We find that the local effects of mining do not differ substantially between more and less democratic countries. In both types of regimes, mineral resource activity induces a local boom of similar size.

To explore the heterogeneous effect of mines on generic non-mining regions, we interact the number of mines variable in equation (2) with the dummy variables for whether a country is a democracy or an autocracy. The results are collected in model (2) of Table 5. We observe that the effect of mineral activity does not depend on the extent of democracy. Generic non-mining regions are equally worse off from mining activity elsewhere in both democracies and autocracies.

To study heterogeneous effects on capital cities, we interact the interaction between the capital cities' dummy and the number of mines variable in equation (3) further with the democracy and autocracy dummies. As per model (3) of Table 5, we find no difference in the effect of additional mining activity on capital regions between democracies and autocracies. In both political regimes, capital regions appear to benefit by similar amounts.

We adopt a similar approach for leaders' birth regions, and collect the results in model (4) of Table 5. For these regions, we observe heterogeneous effects. Specifically, we find that in autocracies, one additional mine increases luminosity in leaders' birth regions by about 0.7%. No

TABLE 5 Mineral resources and luminosity in non-mining regions—heterogeneous effects by regime type.

	Mining (1)	Border (2)	Capitals (3)	Leaders (4)
Mine × More democratic	0.715*** (0.130)			
Mine × Less democratic	0.911*** (0.125)			
Mines × More democratic		-0.010*** (0.003)		
Mines × Less democratic		-0.012*** (0.003)		
Capital × More democratic			0.052*** (0.013)	
Capital × Less democratic			0.051*** (0.013)	
Leader × More democratic				0.002 (0.002)
Leader × Less democratic				0.007*** (0.002)
Country fixed effects	—	—	—	—
Cell fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	—	—
Country–year fixed effects	Yes	No	Yes	Yes
Countries	46	46	46	46
Cells	8956	4968	8959	8959
N	182,368	101,684	182,460	182,460

Notes: This table reports an extension of the results in column (1) of Table 2 and columns (1b), (2c) and (3c) of Table 4. In these extensions, we explore heterogeneous effects according to the level of democracy in a country. We interact the respective variables of interest with dummies for whether a country in a given year is a full democracy or not, according to the Freedom House index. The dependent variable in columns (1), (3) and (4) is the log of mean light output in each cell. In column (2), the dependent variable is the difference between log mean luminosity in cell i and log mean luminosity in neighbouring cells located in other countries. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

similar effect exists for democracies. As discussed above, this result is consistent with previous findings on the importance of democracy for the prevalence of regional or ethnic favouritism.

6.2 | Level of corruption

To explore heterogeneous effects by the level of corruption on luminosity within mining regions, we interact the mining dummy in equation (1) with dummies for whether or not a country is (relatively) corrupt in a given year. We define a country as ‘more corrupt’ in a given year if its score for the ‘control of corruption’ index from the World Governance Indicators is below the median index value in a given year, and vice versa. Using these two dummies, we estimate separate coefficients for more and less corrupt countries.

The results are in model (1) of Table 6. We again find that the local effects of mines do not vary significantly between more and less corrupt countries.

To study whether the effects of mineral resources across the three types of non-mining regions differ by the level of corruption in a country, we again estimate separate interactions between the variables of interest and dummies for whether or not a country is more and less corrupt.

TABLE 6 Mineral resources and luminosity in non-mining regions—heterogeneous effects by level of corruption.

	Mining (1)	Border (2)	Capitals (3)	Leaders (4)
Mine × Less corruption	0.966*** (0.135)			
Mine × More corruption	0.739*** (0.147)			
Mines × Less corruption		0.002 (0.003)		
Mines × More corruption		−0.025*** (0.003)		
Capital × Less corruption			0.035*** (0.011)	
Capital × More corruption			0.056*** (0.016)	
Leader × Less corruption				0.001 (0.001)
Leader × More corruption				0.025*** (0.009)
Country fixed effects	—	—	—	—
Cell fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	—	Yes	—	—
Country–year fixed effects	Yes	No	Yes	Yes
Countries	46	46	46	46
Cells	8956	4968	8959	8959
N	125,091	69,759	125,156	125,156

Notes: This table reports an extension of the results in column (1) of Table 2 and columns (1b), (2c) and (3c) of Table 4. In these extensions, we explore heterogeneous effects according to the level of democracy in a country. We interact the respective variables of interest with dummies for whether a country in a given year has a high or low level of corruption according to the ‘control of corruption’ index from the World Governance Indicators. The dependent variable in columns (1), (3) and (4) is the log of mean light output in each cell. In column (2), the dependent variable is the difference between log mean luminosity in cell i and log mean luminosity in neighbouring cells located in other countries. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

The results are collected in models (2)–(4) of Table 6. We find that capital cities benefit in both corrupt and non-corrupt settings. However, leaders' birth regions experience an increase in luminosity only when the country is relatively corrupt. Similarly, generic regions witness a decline in luminosity only in corrupt countries. These results suggest that the level of corruption rather than the political regime determines how mineral revenues affect non-mining regions, in particular generic non-mining regions.

7 | MECHANISMS

In the estimates reported in Sections IV and V, we observe positive effects of mines on mining regions. These positive effects are visible up to 30 km away from the location of the mine. We also observe positive effects for capital regions. There are also positive effects on leaders' birth regions as long as a country is an autocracy. In contrast, we observe negative effects on generic regions.

The extensions that we have explored suggest the following mechanisms for these findings. First, that mines have spillovers for up to 30 km suggests a genuine expansion in economic activity. Second, that capital regions and—if a country is not a democracy—leader regions benefit from more mineral resource activity indicates that the government deliberately redistributes mineral resource revenues from the mining regions to regions that are politically important.

What is less clear is why luminosity declines in generic non-mining regions. We thus explore in the following the mechanisms behind our baseline findings further, focusing in particular on generic non-mining regions.

7.1 | Conflicts

One potentially important consequence of mines is an uptick in conflicts. In mining regions, conflicts could emerge for control of the mineral resources. However, non-mining regions could also witness more conflicts, for example, if mineral resources are used to fund conflicts elsewhere. Conflicts, in turn, might have negative consequences for economic development.

In Table 7, we explore the effect of mines on the incidence of conflicts. For this, in equation (1) we replace luminosity with the number of conflicts in cell i and year t . It appears that—in our

TABLE 7 Mineral resources and conflicts in mining regions.

	All mines (1)	\geq Major (2)	\geq Giant (3)	< Major (4)	< Moderate (5)	Prices (6)
Mine	−0.037 (0.038)	−0.074 (0.054)	−0.036*** (0.012)	0.036 (0.034)	0.107 (0.095)	
Mineral price						−0.003 (0.004)
Cell fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country–year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cells	9063	9063	9063	9063	9063	9063
N	199,360	199,360	199,360	199,360	199,360	199,360

Notes: This table collects difference-in-differences regressions that relate mineral resource activity (operating mines) to the number of conflicts at the grid level for all of Africa (0.5 × 0.5 decimal degree cells). In this specification, we study whether mines affect conflict incidents in mining regions. The dependent variable is the sum of conflict events in each cell. The independent variable in models (1)–(5) is a dummy variable that is 1 if a cell had an operating mine of a certain size as indicated in the column header. The independent variable in model (6) is the contemporaneous price of the mineral that is extracted in a given cell. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

* , ** , *** indicate significance levels at 10%, 5%, 1%, respectively.

TABLE 8 Mineral resources and conflicts in non-mining regions.

	Border (1)	Capitals (2)	Leaders (3)
Mines	0.020*** (0.005)		
Capital × Mines		0.011 (0.019)	
Leader × Mines			-0.004 (0.002)
Country fixed effects	—	—	—
Cell fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	—	—
Country–year fixed effects	No	Yes	Yes
Countries	48	48	48
Cells	5050	9066	9066
N	111,100	199,452	199,452

Notes: This table reports results that explore the effect of mineral resources on conflicts in non-mining regions. In column (1), the dependent variable is the difference between the sum of conflict events in cell i and the mean of the sum of conflict events in neighbouring cells located in other countries. The dependent variable in columns (2) and (3) is the sum of conflict events in each cell in a given year. We study whether mines lead to an increase in conflict events in generic regions (column (1)), in capital regions (column (2)), and in leaders' birth regions (column (3)). The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

* , ** , *** indicate significance levels at 10%, 5%, 1%, respectively.

sample—mines do not lead to more conflicts.²⁹ In fact, for giant mines, we even observe a small negative and statistically significant effect. Overall, the insignificant effect of mines on conflicts within mining regions is consistent with their positive effect on luminosity.

In Table 8, we explore the effect of mines on conflicts in non-mining regions. We find no effects in capital regions. However, it appears that conflicts decline in leaders' birth regions if mineral resource activity expands elsewhere in the country (while the estimate is insignificant, it has a relatively large p -value). At the same time, the number of conflicts increases in generic regions across the country. Both findings can be interpreted in conjunction with the results found for luminosity. That is, the increase in luminosity in leaders' birth regions in non-democratic countries (model (4) in Table 5) could be explained by a decline in conflicts, for example due to leaders using mineral resource rents to pacify competing local groups.

Similarly, the decline in luminosity in generic non-mining regions (models (1a) and (1b) of Table 4) could be explained in part by an increase in conflicts, possibly because leaders make use of the resource revenue to fund conflicts elsewhere. Of course, another possible interpretation of this finding is that it is the deterioration of economic conditions in non-mining regions (e.g. due to macroeconomic adjustments) that is responsible for the increase in conflicts. This question is an exciting area for future research. In any case, there appears to be a clear link between country-wide aggregate mineral resources, conflicts, and economic developments in non-mining regions.

7.2 | Ethnic redistribution

To further understand to what extent the spatial patterns that we observe are due to intentional decisions of policymakers—notably inter-regional redistribution of mining revenues—we explore how luminosity responds to mineral resource activity based on the spatial distribution of

ethnic groups. Specifically, we study whether regions inhabited by ethnic groups that are politically powerful—that is, that are in positions of power at the national level—respond differently to mineral resources than regions inhabited by ethnic groups that are politically weak (i.e. discriminated against).

We classify the grid cells in each year as ‘strong’ if they are inhabited by at least one group whose ‘power status’ is coded by Vogt *et al.* (2015) as ‘Monopoly’ or ‘Dominant’. Similarly, we classify all cells inhabited by at least one group coded as ‘Discriminated’ as weak. We classify all other grid cells as neutral. Cells can be both weak and strong if they are inhabited by two or more groups with opposite ‘power status’. Cells can also change their classification over time (see Figure 3 for a visual representation of cells’ power status).

We then explore whether mines lead to a larger increase in luminosity if the region surrounding a mine is inhabited by an ethnic group that is politically strong, and vice versa. Such a pattern would indicate that the national government deliberately redistributes more resources away from mineral resource regions if they are inhabited by ethnicities that are discriminated against. The corresponding empirical model that we use to explore this question is an extension of equation (1). Specifically, we add an interaction of the mines dummy with a dummy for whether or not a cell is inhabited by a politically strong or weak ethnic group, respectively.

We collect the results in Table 9. They suggest that the effect of mines is substantially smaller, in fact almost zero, when the mining region is inhabited by a politically weak ethnic group. This finding indicates that national governments intentionally redistribute resources spatially, in particular that they redistribute more resources away from mining regions when they are inhabited by politically weak ethnicities.

In Table 10, we explore how generic non-mining regions respond to mineral resources in view of their ethnic markup. We focus on generic non-mining regions as capital regions and leaders’ birth regions are arguably politically well represented in all circumstances. Specifically, in equation (2) we interact the number of mines variable with dummies for whether or not a cell was inhabited by a politically weak or strong ethnicity, respectively.

Table 10 suggests that generic regions inhabited by politically weak groups experience a large decline in luminosity when mineral resource activity expands. In contrast, no such decline is observable in regions that are inhabited by politically strong groups. These results reaffirm that, at least in part, the spatial implications of mineral resource activity emerge due to deliberate redistribution by the national government.

7.3 | Country-level institutional quality

An alternative channel through which mineral resources might negatively affect economic outcomes in generic non-mining regions is a general decline in institutional quality. If mineral resources result in corruption and political instability, then it is plausible that this will negatively affect economic development across the country, and in particular in generic non-mining regions. This channel would thus imply that luminosity declines in generic non-mining regions also due to inadvertent country-level adjustments, in addition to those direct government actions as discussed above.

To explore this channel, we relate the number of mines in a country to country-level institutional quality using standard cross-country regressions. More specifically, we use four proxies for institutional quality: whether or not a country is democratic, whether it has high levels of corruption, whether it has high levels of government effectiveness, and whether it has high levels of political stability.

The results are collected in Table 11. Overall, we find no strong associations between mines and institutional quality. As such, the reason why mines diminish economic activity in generic non-mining regions does not appear to be a decline in aggregate institutional quality.

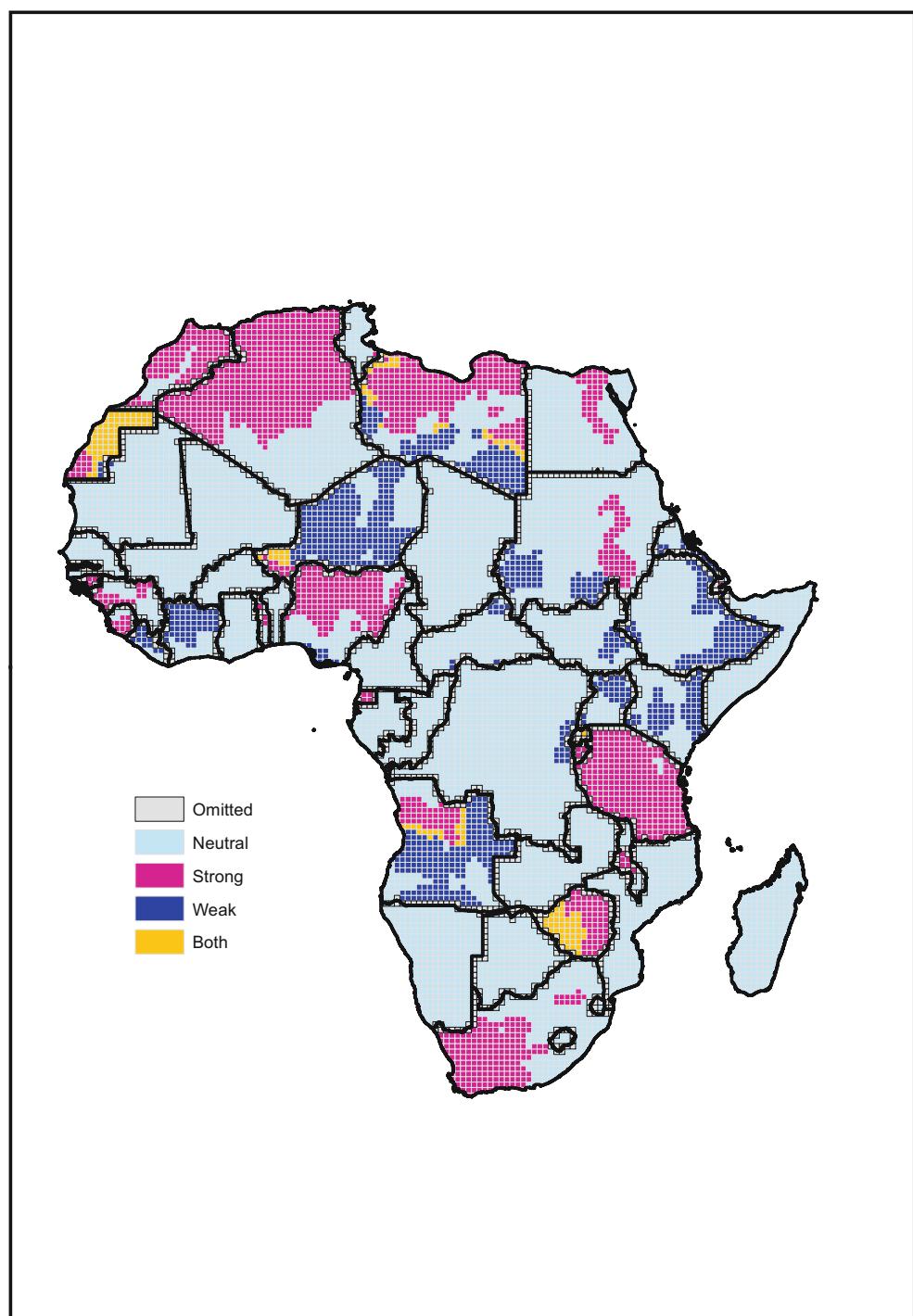


FIGURE 3 Grid of Africa matched to political power of ethnic groups. *Notes:* This figure shows a grid over Africa. It indicates all cells that were inhabited by at least one ethnic group that was politically powerful (i.e. that was classified as having a 'monopoly' on power or as politically 'dominant' in the ethnic power dataset by Vogt *et al.* 2015) for at least one year during the sample period. It also indicates all cells that were politically weak (i.e. that were inhabited by at least one ethnic group classified as 'discriminated' for at least one year during the sample period). Some cells have both politically strong and politically weak ethnic groups. All other cells are indicated as neutral.

TABLE 9 Mines and luminosity in mining regions inhabited by politically strong and weak ethnicities.

	(1)	(2)	(3)
Mine	0.821*** (0.125)	0.846*** (0.125)	0.842*** (0.125)
Strong	-0.045 (0.036)		-0.047 (0.036)
Strong × Mine	-0.078 (0.120)		0.030 (0.128)
Weak		0.126*** (0.028)	0.126*** (0.028)
Weak × Mine		-0.611*** (0.218)	-0.625*** (0.229)
Cell fixed effects	Yes	Yes	Yes
Country–year fixed effects	Yes	Yes	Yes
Cells	7281	7281	7281
N	158,547	158,547	158,547

Notes: This table collects difference-in-differences regressions that relate mineral resource activity (operating mines) to luminosity at the grid level for all of Africa (0.5×0.5 decimal degree cells). In this specification, we study whether mines increase luminosity in mining regions less if they are inhabited by politically weak regions, and vice versa. The dependent variable is the log of mean light output in each cell. The independent variables are a dummy variable that is 1 if a cell had an operating mine, and an interaction variable that is 1 if a cell is inhabited by a contemporaneously politically weak or strong ethnicity, respectively. The sample includes operating mines with available information on startup and shutdown dates in the MinEx data. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

TABLE 10 Generic non-mining regions and mineral resources inhabited by politically strong and weak ethnicities.

	(1)	(2)
Strong	-0.416*** (0.101)	0.023 (0.031)
Weak	0.067 (0.098)	0.056** (0.028)
Mines × Strong	0.004 (0.004)	-0.000 (0.001)
Mines × Weak	-0.138*** (0.030)	-0.024*** (0.006)
Country fixed effects	Yes	—
Cell fixed effects	No	Yes
Year fixed effects	Yes	Yes
Country–year fixed effects	No	No
Countries	44	44
Cells	4077	4077
N	88,427	88,427

Notes: This table collects results for specifications following equation (2) that relate mineral resource activity (operating mines) to luminosity at the grid level across Africa (0.5×0.5 degree pixels). We study whether the aggregate number of mines affects luminosity in generic non-mining regions. We additionally distinguish between border regions inhabited by 'politically strong' and 'politically weak' ethnicities. The dependent variable is the difference between the log of mean light output in each border cell and the average of the log mean light output in neighbouring cells in foreign countries. The independent variable is a count variable indicating the number of mines in a given country in year t . Only mines with available data on startup and shutdown dates are included. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the cell.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

TABLE 11 Mines and country-level institutional quality.

	Democracy	Corruption	Government effectiveness	Political stability
	(1)	(2)	(3)	(4)
Mines	−0.006 (0.010)	0.018 (0.018)	0.016* (0.009)	−0.034 (0.028)
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Countries	47	47	47	47
N	993	680	680	680

Notes: This table collects results for specifications that relate measures for institutional quality to country-level mineral resource activity. The dependent variable in model (1) is a dummy for whether or not a country is a full democracy according to the Freedom House index. The dependent variable in model (2) is the control of corruption score from the Worldwide Governance Indicators. The dependent variable in model (3) is the government effectiveness score from the Worldwide Governance Indicators. The dependent variable in model (4) is the political stability and absence of violence/terrorism score from the Worldwide Governance Indicators. Higher scores correspond to better outcomes in the Worldwide Governance Indicators. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the country.

* , ** , *** indicate significance levels at 10%, 5%, 1%, respectively.

7.4 | Terms of trade adjustments

Another channel through which mineral resources could cause economic harm to non-mining regions is terms of trade adjustments. Regions that specialize in sectors other than mining might be harmed if the exchange rate appreciates when mineral resource exports increase. For example, exports of manufacturing or agricultural products might decline, in turn hurting regions that specialize in these sectors. Similarly, regions with a large hospitality industry that caters to foreign tourists might witness lower demand. These effects would be in line with the Dutch Disease literature.³⁰

To study this channel, we make use of census data from IPUMS. The IPUMS census data indicate the locations of respondents up to the second tier (GEOLEV2) of government (e.g. districts). Using all available census waves and countries within Africa, we calculate the share of respondents in each tier 2 region employed in (i) mining, (ii) manufacturing, (iii) agriculture, and (iv) the hospitality industry (hotel and restaurants) over the sample period (i.e. we take the over-time average for regions that have data in multiple census waves). We then estimate interaction models of the form

$$y_{i,t} = \alpha_i + \sum_c \gamma_t \times c + \beta \text{ Mines}_{c,t} \times \text{Sector share}_i + \varepsilon_{i,t}, \quad (5)$$

where i indicates different tier-2 regions, α_i region fixed effects, γ_t year fixed effects and c country dummies (i.e. we include country-specific year fixed effects), and Mines is the number of mines in a country. Sector share is the share of respondents in each region that works in each of the four sectors discussed above.

The interaction between the number of operating mines in the country and the sector share is the variable of interest and captures whether regions that specialize in either of the four sectors are better or worse off if mineral resource activity expands in the country. [Online Appendix Figure A.4](#) shows the industry shares across regions with available data. The data are available for 20 countries. Note that the variable capturing the share of each sector is perfectly collinear with the region fixed effects.

We collect the results from estimating equation (5) in Table 12. As expected, we observe that an uptick in mining activity increases light output in regions where a larger share of the respondents is employed in the mining sector (model (1)). The interaction effect between the number

TABLE 12 Spatial effect of mines by sectoral specialization.

	Mining (1)	Manufacturing (2)	Agriculture (3)	Hospitality (4)
Mines × Mining share	2.350*** (0.690)			
Mines × Manufacturing share		-0.665* (0.341)		
Mines × Agriculture share			-0.062 (0.040)	
Mines × Hospitality share				-1.318 (1.320)
Country fixed effects	—	—	—	—
Cell fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	—	—	—	—
Country–year fixed effects	Yes	Yes	Yes	Yes
Countries	20	20	20	20
Cells	1734	1734	1734	1734
<i>N</i>	38,148	38,148	38,148	38,148

Notes: This table collects difference-in-differences regressions that relate mineral resource activity (operating mines) to luminosity at the tier 2 regional level (GEOLEV2) for all of Africa. In these specifications, we study whether mines lead to an increase in luminosity in regions with a larger (1) mining sector, (2) manufacturing sector, (3) agricultural sector, and (4) hospitality sector. The dependent variable is the log of mean light output in each cell. The variable of interest is the interaction between the over-time average of the share of census respondents employed in each sector and a count variable indicating the number of mines in a country in year t . Only mines with available data on startup and shutdown dates are included. Heteroscedasticity- and cluster-robust standard errors are in parentheses. The unit of clustering is the region.

*, **, *** indicate significance levels at 10%, 5%, 1%, respectively.

of mines and the share of respondents working in the mining sector is positive and significant. In contrast, the interaction between the number of mines and the share of respondents working in manufacturing is negative and significant at the 10% level (model (2)), indicating that additional mineral resource activity harms regions specializing in manufacturing. We also observe negative (albeit insignificant) coefficients for regions specializing in agriculture (model (3)) and the hospitality industries (model (4)).

Overall, these estimates indicate that an expansion in mineral resource activity has negative effects on regions that specialize in sectors other than mining. As discussed, one obvious reason for this is terms of trade adjustments that harm non-mining regions.

8 | CONCLUSION

We study how mineral resources affect economic conditions in both mining and non-mining regions across the African continent by combining cross-country data and subnational variation. Using nighttime luminosity as a proxy for the local economy, we find that mines expand economic activity in mining regions. The economic implications of mineral resources on non-mining regions, on the other hand, are heterogeneous: (i) generic non-mining regions are in general disadvantaged; (ii) capital regions benefit from mineral resource activity anywhere in the country; and (iii) leaders' birth regions benefit in autocratic regimes.

This second set of results suggests that mineral resources have important economic implications beyond the mining regions. While the improvement in economic conditions in capitals

and leaders' birth regions indicates that the government engages in regional favouritism and redistributes mining revenues to politically important regions, the explanation for the decline in economic activity in generic non-mining regions is less obvious. Exploring mechanisms for this result, we found that conflicts increase in generic non-mining regions when mineral resource activity expands, a finding consistent with the interpretation that national governments partially use mining revenues to fund conflicts elsewhere in the country. We also find evidence for terms of trade adjustments that disadvantage regions specializing in sectors other than mining. As such, the decline in economic activity within generic non-mining regions can be explained by both deliberate government policies as well as inadvertent macroeconomic adjustments due to increased mineral exports.

Overall, these findings advance our understanding of how mineral resources affect the spatial distribution of economic activity. They underscore, in particular, that mineral resources affect not only mining regions, but, through various channels, non-mining regions as well. As the effects of mineral resources on non-mining regions have been neglected in the literature, one important conclusion from this paper is that such broader spatial effects should be taken into account in future research on the economic implications of mineral resources.

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ENDNOTES

¹ This literature follows a long strand of research using cross-country data (Sachs and Warner 1995; van der Ploeg, 2011).

² For example, the resource sector may crowd out other sectors that could be more viable in the longer term (Cust and Viale 2016). Mineral resource wealth might also depress regional incomes over a longer horizon if children and young adults drop out of education (human capital accumulation) to work in the mineral resource sector (Ahlerup *et al.* 2019).

³ Marginally related papers are by Huang *et al.* (2022), who study how regional redistribution of resource rents influences urbanization and structural transformation across regions, and Hodler *et al.* (2023), who study how the interplay between the location of mines and the spatial distribution of ethnic groups influences the likelihood of conflicts. While related, these two papers do not explore the entire spectrum of spatial economic implications of mineral resources.

⁴ See Aragón *et al.* (2015) for a more extensive discussion of possible macroeconomic channels.

⁵ Thereby, we also implicitly contribute to the broader literature on fiscal federalism (Wildasin 1997; Baskaran 2012).

⁶ According to Laporte and Quatrefares (2015), whether governments (and other domestic stakeholders) receive their 'fair' share of resource rents is up for debate. In any case, how resource rents should be shared between governments and private investors is a question that is separate from how rents should be shared between different tiers of government and across the various regions within the country. Basic economic theory suggests that pure rents can be fully captured by the government (e.g. by a lump-sum tax), but in practice this is not feasible due to, for example, international production capacity constraints.

⁷ Of course, the true reason why revenues are assigned in this way may be not the normative prescriptions of this literature but political expediency.

⁸ Control over natural resources is typically allocated to the local government tier only if their economic importance is small (Brosio and Singh 2014). With the recent wave of decentralization, ownership of resources has been partially transferred to subnational governments, but national governments generally continue to be the main claimants (Brosio and Singh 2014). See [Online Appendix Table A.20](#) for details regarding the constitutional arrangements with respect to the ownership of mineral resources across several African countries.

⁹ Depending on the country in question, regional and local governments may be allowed to tax resource rents to a degree using such taxes.

¹⁰ Indeed, Fjeldstad *et al.* (2014) point out that local governments in Africa, with the possible exception of South Africa, rely heavily on central government transfers to fund their expenses. One notable example is Botswana, where rural councils receive 92% and urban areas receive 62% of their revenues from the central government.

¹¹ In the regressions, sample sizes are typically slightly smaller, primarily due to missing data on luminosity.

¹² The thresholds for precious metals are Minor ≥ 0.03 Moz Au (millions of ounces of gold) equivalents, Moderate ≥ 0.32 Moz Au equivalents, Major ≥ 2.24 Moz Au equivalents, Giant ≥ 11.18 Moz Au equivalents, Supergiant ≥ 80.00 Moz Au equivalents. For other minerals, the thresholds are Minor ≥ 0.03 Mt Cu (millions of megatonnes of copper) equivalents, Moderate ≥ 0.32 Mt Cu equivalents, Major ≥ 2.45 Mt Cu equivalents, Giant ≥ 18.97 Mt Cu equivalents, Supergiant ≥ 35.00 Mt Cu equivalents.

¹³ In particular, the version of the MinEx database available to us provides information on mineral resource activity up to 2015 and includes various details on mines, in particular their startup and shutdown dates. See [Online Appendix Section A.1](#) for more details on the MinEx data.

¹⁴ The number of mines that contribute to the regressions is slightly lower, i.e. 284 mines, because some mines were closed exactly in 1992 or opened up and closed in the same year.

¹⁵ [Online Appendix Table A.13](#) provides summary statistics of the luminosity data and all further data used below.

¹⁶ Another more specific concern with using luminosity as a proxy for local economic development in mining regions is that mineral activity itself can emanate light at night. For example, producers could install floodlights to enable production at night or to reduce road hazards in mining regions. Mines could also be illuminated at night to prevent illegal mining activity by artisanal miners. Technically, the effect of mines that we estimate below represents a composite effect of such direct effects of mining activity on luminosity and the broader welfare effects. However, such alternative reasons for light at night in mining regions are unlikely to influence our estimates substantially. The largest mine by area in the world (Hull Rust open pit mine in the USA) has area 8.1 km^2 , which is significantly smaller than the grid cells. In addition, we also find below that mineral resource activity increases lights in cells that neighbour mining cells but have no mines themselves.

¹⁷ We draw a buffer around the geographic coordinates to capture capitals that are close to the sea. Without a buffer-based approach, the longitude and latitude coordinates might be projected slightly outside of the range of the African land cells by our GIS software due to projection inaccuracies. Note that capitals falling entirely into cells at the border to another country are dropped as well when we remove border pixels in our baseline specification.

¹⁸ See <https://www.worldpop.org> (accessed 9 June 2024).

¹⁹ We add 0.01 to each grid's value of mean luminosity to avoid missing values once we take the log.

²⁰ We drop cells where more than one mineral is extracted in these specifications. For minerals for which we have no prices, the interaction variable is set to 0.

²¹ For the baseline estimates, we replicate the estimations with Conley standard errors as well as different units of clustering in [Online Appendix Table A.17](#).

²² Among the 519 deposits, MinEx classifies 246 as major, giant or supergiant. Among these 246 deposits that were of at least major size, we lack information on startup or shutdown dates for only 47 mines, leaving us with a sample of 199 at least major mines (coverage 81%). As such, another advantage of studying the economic implications of major mines is the better sample coverage.

²³ However, one concern with these specifications is that it becomes increasingly unclear whether regions within the distance bands should be considered as treatment or control units. Non-mining cells that are close to mines likely constitute appropriate counterfactuals for mining cells, thus their inclusion in the control groups strengthens identification. On the other hand, such cells are also those that are subject to spillovers.

²⁴ We report a replication of the baseline specifications after dropping the mining cells in [Online Appendix Table A.16](#). In addition, we report a number of further robustness tests and extensions in the [Online Appendix](#): in [Subsection A.4.1](#), we study the effect of mine discoveries rather than openings; in [Subsection A.4.2](#), we report results from event studies with mine openings and discoveries; in [Subsection A.4.3](#), we focus on mines located in border regions to refine our identification strategy; in [Subsection A.4.4](#), we explore the effect of different types of minerals on local economic development; in [Subsection A.4.5](#), we study the implications of the Extractive Industries Transparency Initiative (EITI). The results reported in these subsections are in line with the baseline results.

²⁵ As in equation (1), we add 0.01 to each grid cell's value of mean luminosity to avoid missing values once we take the log.

²⁶ We omit the capital of South Sudan, Juba, as this country has officially existed only since 2011.

²⁷ We report a number of robustness tests and extensions on the results reported in this section in the [Online Appendix](#). First, we report results with Conley standard errors as well as different units of clustering for the baseline specifications in [Table A.18](#). Second, we study in [Subsection A.5.1](#) whether the effects that we identify are stronger (or weaker) for mines that MinEx classifies as at least 'major'. Third, we explore the effect of different types of mines in [Subsection A.5.2](#). Fourth, we study whether the EITI has potentially affected non-mining regions in [Subsection A.5.3](#). Overall, the results reported in the [Online Appendix](#) are in line with the baseline findings reported in this section.

²⁸ Libman (2013), for example, shows that the effect of natural resources on regional economic performance depends on the level of *subnational* democracy using variation in the level of subnational democracy across the Russian Federation.

²⁹ Note that Arezki *et al.* (2015) report similar results.

³⁰ The recent empirical evidence on the Dutch Disease in general, and specifically in Africa, is mixed. Harding and Venables (2016) find that natural resource revenues generally decrease exports by the non-resource sectors. Asiamah *et al.* (2022) find similar evidence specifically for sub-Saharan Africa. Cust *et al.* (2022) show that Dutch Disease effects are relevant in Africa and that one important channel for its emergence is the public sector. On the other hand,

Pegg (2010) argues that while Botswana exhibits many symptoms consistent with the Dutch Disease, the prime reasons for these symptoms are not those that are discussed in the Dutch Disease literature.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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