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# African Mining, Gender, and Local Employment

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**Summary.** — The discovery of natural resources across the African continent brings hope for millions of poor people, but there are long-standing fears that the resources will be a curse rather than a blessing. One of the most frequently claimed effects is that gender inequality in economic opportunities may increase with mining. This paper is the first multi-country quantitative analysis of the local employment impacts for men and women of large-scale mining in the African continent. Using exact mine locations, we merge survey data for 800,000 individuals with data on all mine openings and closings across the continent, which enables a highly localized analysis of spillover effects. We employ a geographic difference-in-difference estimation exploiting the spatial and temporal variation in mining. We show that industrial mine opening is a mixed blessing for women. It triggers a local structural shift, whereby women shift from agricultural self-employment (25% decrease) to the service sector (50% increase), and are 16% more likely to earn cash. However, overall female employment decreases by 8% as agriculture is a larger sector than services. Male partners shift to skilled manual labor, and some find jobs in the mining sector. The effects of mine openings diminish with distance and are close to zero at 50 km from a mine. Mine closure causes the service and skilled sectors to contract. The results are robust to a wide battery of robustness checks, such as using different measures of distance and excluding migrants from the sample. This paper shows that large-scale mining can stimulate nonagricultural sectors in Africa, although it creates local boom-bust economies with transient and gender-specific employment effects.


*Key words* — natural resources, female employment, Africa

## 1. INTRODUCTION

Africa's opportunities are being transformed by new discoveries of natural resources and their rising prices (Collier, 2010), and the mining sector is the main recipient of foreign direct investment in Sub-Saharan Africa (World Bank, 2011). Whether the discovery of natural resources is a blessing or a curse to the economy and to a country's citizens is a contentious issue (see Frankel, 2010 or van der Ploeg, 2011 for overviews), and natural resource dependence is linked to various outcomes at the national level: institutions (e.g., Mehlum, Moene, & Torvik, 2006a, 2006b), corruption (e.g., Leite & Weidmann, 2002), civil war and conflict (e.g., Collier & Hoeffler, 2004; Collier & Hoeffler, 2005), rent appropriation by an elite (e.g., Auty, 2001, 2007), democracy (e.g., Barro, 2000; Jensen & Wantchekon, 2004), and female labor force participation (Ross, 2008, 2012).[1]

While the country-level economic and political effects of extractive industries are well explored, the research on their local economic effects is nascent. The present paper adds to recent literature on local effects of natural resources (e.g., Allcott & Keniston, 2014; Aragón & Rud, 2013; Berman, Couttenier, Rohner, & Thoenig, 2014; Caselli & Michaels, 2013; Chuhan-Pole, Dabalen, Kotsadam, Sanoh, & Tolonen, 2015; Kotsadam, Olsen, Knutsen, & Wig, 2015; Michaels, 2011; Wilson, 2012), by investigating the effects of large-scale industrial mining on local labor markets.[2] We use the best available survey data for Africa, Demographic and Health Surveys (DHS). The main focus is on women's labor market opportunities, and we contrast our findings with the effects for men. Access to employment improves women's lives and is listed among the top five priorities for promoting gender equality in the 2012 World Development Report (World Bank, 2012).

It is theoretically ambiguous whether industrial mining increases or decreases female employment. The African Mining Vision, formulated by the member states of the African Union, together with the African Development Bank and the United Nations, emphasizes that extractive industries may hurt women (UNECA, 2011). Similarly, Ross (2008, 2012) claims that exploitation of natural resources hurts women's employment via both demand and supply channels. In his model, female labor supply is reduced via a household income effect, spurred by higher male incomes and/or increased government transfers. The demand for female labor decreases as export-oriented and female-dominated manufacturing is crowded out by Dutch disease effects. He tests his theory using cross country regressions of female labor force participation on oil wealth and finds that oil rich countries have fewer women working, a finding he claims is also valid for mining. There is, however, little reason to expect these

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effects in Sub-Saharan Africa (SSA). First, the manufacturing sector in rural SSA is small (see Bigsten & Söderbom, 2006 or Isham, Woolcock, Pritchett, & Busby, 2005 for an overview). [3] Second, if women have the opportunity to shift to the service sector, the demand for female labor need not decrease. Women are overrepresented in sales and services in SSA, but underrepresented in production and manufacturing, as shown by data from ILO's Key Indicators of the Labour Market database (ILO, 2011).

The effects of natural resource extraction on the local economy are often described in terms of linkages and multipliers (e.g., Aragón & Rud, 2013; Eggert, 2002). Local multipliers describe the effect of an employment increase in one sector on employment in other sectors. Moretti (2010) shows that an increase in the production of tradable goods leads to increased local demand for non-tradables as the number of workers and their salaries increase. However, the multipliers for tradables depend on local changes in labor costs, since tradable goods have prices set nationally or internationally (Moretti, 2010; Moretti & Thulin, 2013).

The strand of literature on linkages and multipliers argue for positive local employment effects. If the multipliers are small, we will find economically and statistically insignificant effects. Such findings would support the traditional view of mines as having few or no linkages to the local community. This "enclave" theory was first hypothesized by Hirschman (1958) and became a stylized fact in the second part of the last century (UNECA, 2011, see also Ferguson, 2005). There is limited empirical evidence for this theory. Numerous case studies on artisanal and small-scale mining show that mining enables livelihood diversification (e.g., Fessehaie & Morris, 2013; Hirons, 2014; Hilson & Garforth, 2013; Okoh & Hilson, 2011; Spiegel, 2012). However, small-scale and large-scale mining differ in many respects: One important aspect is the labor to capital ratio, assumed high in small-scale mining and low in large-scale mining. Quantitative case studies of the large-scale sector find mixed results. The coal mining boom of the 70s in the US resulted in modest local employment spillovers but increasing wage rates (Black, McKinnish, & Sanders, 2005), and contemporary oil and gas booms in the US have increased district employment levels (Allcott & Keniston, 2014). A study of local welfare effects around the world's second largest gold mine in Peru found support for the enclave hypothesis in absence of policies for local procurement of goods (Aragón & Rud, 2013).

If the multiplier effects are stronger, we expect an increase in male and female labor force participation with female employment concentrated in services and sales and male employment concentrated in manual labor, reflecting the gender segregation in the Sub-Sahara African labor markets. Qualitative studies have found that women dominate the provision of goods and services around small-scale mines in Africa (Hinton, 2006; ILO, 1999), while they are not much engaged in the mining sector directly. [4] Spillover effects on the tradable sector are less likely to substantially affect the demand for female labor because women are not strongly represented in the tradable sector, including manufacturing and construction.

The effect on labor supply in agriculture is *a priori* ambiguous. A mine expansion can change local agriculture through a variety of channels: competition over land use, expropriation and changes in land prices (UNECA, 2011), pollution (Aragón & Rud, 2015), intra-household reallocation of labor including substitution effects, and demand changes for agricultural goods. The literature on small-scale mining often finds a shift from agriculture to mining (e.g., Lu & Lora-Wainwright, 2014), although some leave agriculture without finding new livelihood opportunities (Bebbington, Bebbington, Bury, Lingan, Muñoz, & Scurrah, 2008). Furthermore, the shift may not be sustainable in the long run as mines have limited life-spans (Cartier & Bürge, 2011; Jaskoski, 2014; Maconachie & Binns, 2007). We contribute by analyzing if these patterns hold for large-scale mining and through a gender lens. Moreover, we contribute by quantitatively assessing the long-run sustainability of the large-scale mining sector by separately analyzing mine closures. A limitation of the study is that it cannot compare the employment effects of small-scale versus the large-scale mining sector. Such a comparative analysis could inform national and international strategic policies on the total mineral sector. However, the study is policy relevant as it is, to our knowledge, the first quantitative assessment of the African large-scale mining sector's ability to generate local employment.

A novelty of the present paper is that it connects production data on 874 industrial mines starting in 1975 to DHS household survey data for women aged 15–49. The unique combination of datasets with more than 500,000 sampled women and almost 300,000 partners in 29 countries enables us to investigate local spillover effects on employment by a difference-in-difference method. By exploiting the spatial and temporal variation in the data, we compare people living close to a mine with those living further away, and individuals living close to a producing mine with those who live in the vicinity of a mine that is yet to open. We include sub-national region fixed effects and thereby control for time-invariant differences between countries and sub-national regions, such as time-stable mining strategies, institutions, trade patterns, openness, sectoral composition, level of economic development and gender norms. In addition, by including regional-specific time trends we make the identification strategy less reliant on assumption of similar trends across areas.

We show that industrial mine openings constitute a mixed blessing for women. They trigger a local structural shift, whereby women shift from agricultural work to the service sector, or out of the labor force. More women leave self-employment in agriculture (seven percentage points, or 25% decline) than enter into services (two percentage points, or 50% increase), but the service sector jobs are less seasonal and cash earnings opportunities increase with 7.4 percentage points (16%). A back-of-the-envelope calculation estimates that more than 90,000 women get service sector jobs as a result of industrial mining in their communities, and more than 280,000 women leave the labor force. Male partners shift to skilled manual labor, and some find jobs within mining. The effects of mine openings wear off with distance and are close to zero at 50 km from a mine. Mine closing causes the expanded sectors to contract. The results are robust to a wide battery of robustness checks, such as using different measures of distance and excluding migrants from the sample.

There are large and persistent differences in value added per worker in agriculture and non-agricultural sectors in developing countries (Gollin, Jedwab, & Vollrath, 2014). The difference indicates misallocation of workers, with too many workers in low yielding agriculture. In this paper, we show that mining has the power to locally stimulate non-agricultural sectors and provide cash earning opportunities. However, more people leave agriculture than access jobs in the growing sectors, and the jobs in the growing sectors are seemingly temporary. The findings indicate that large-scale mining is creating local boom-bust economies in Africa, with transient and gender-specific employment effects.

In the next section we present the data. In Section 3, we lay out the empirical strategy. In Section 4, we present the empirical results and in Section 5, we show robustness tests and heterogeneous effects, and in Section 6, we conclude.

## 2. DATA

We use a novel longitudinal data set on large-scale mines in Africa, from IntierraRMG. We link the resource data to survey data for women and their partners from the Demographic and Health Surveys (DHS), using spatial information. Point coordinates (GPS) for the surveyed DHS clusters, a cluster being one or several geographically close villages or a neighborhood in an urban area, allow us to match all individuals to one or several mineral mines.

From a mine center point, given by its GPS coordinates, we calculate distance spans within which we place every person. These are concentric circles with radii of 5, 10, 15, 20, 25 km and so on, up to 200 km and beyond 200 km.

We construct an indicator variable that answers the questions: Is there at least one active mine (defined as a mine with positive production volumes) within $x$ kilometers from the household? If not, is there at least one future mine (coded as inactive), or one past mine (coded as suspended) within $x$ kilometers? If still no, the person will be coded as living in a non-mining area. If she lives within a given distance from more than one mine, she will belong to the treated group if at least one mine was producing in the year she was sampled. We assume that individuals seek employment around any mine situated within $x$ kilometers from the home location and that benefits from an active mine dominate those from an inactive mine. A future mine is assumed to have less effect on the local economy, even if there may be economic activity associated with the pre-production stages. Thus, a person close to an active mine as well as an inactive mine will be assigned active = 1 and inactive = 0, since the categories are mutually exclusive. When we look at mine opening effects, all women close to suspended mines are excluded from the analysis.

Beyond the cut-off distance of $x$ kilometers, transportation costs are assumed to be higher than benefits accruing from employment opportunities. Behind this assumption lie two assumptions, i.e., the costs in terms of transportation and information increase with distance, and the footprint of a mine decreases with distance. The chosen baseline cut-off distance is 20 km, but the assumptions motivate us to try different distance cut-off points.

A woman lives on average 246 km away from a mine (variable *distance*) and 363 km away from an active mine (*distance to active*) as given by Table 1 8,195 women (1.6% of the sample) live within 20 km of at least one active mine, 2,334 (0.5%) live within 20 km of at least one inactive mine (but no active and no suspended mines), and 6,812 (1.3%) live close to a suspended mine.

### (a) *Resource data*

The Raw Materials Data (RMD) come from IntierraRMG (see IntierraRMG, 2013). The dataset contains information on past and current industrial mines or future industrial mines with potential for industrial-scale development, geocoded with point coordinates and yearly information on production levels. The panel dataset consists of 874 industrial mines across Africa. For these mines, we have production levels in 1975 and then for each consecutive year from 1984 to 2010.

Of the 874 mines in Africa, 275 are matched to a geographical cluster in the DHS data. All clusters are matched to mines, but not all mines are matched to clusters. This is because some mines are located in remote and sparsely populated areas or are densely clustered, or because we have no DHS sample for the country (e.g., South Africa). Considering only the mines that are closest to at least one cluster, 51 mines had opened by 1984, 109 mines opened during the following 26 years, and 90 mines closed during the same period (see Appendix Table A.3).

This is, to our knowledge, the only existing mine production panel dataset. The RMD focuses on mines of industrial size and production methods, often with foreign or government ownership. Most mines are owned by Canadian, Australian, or UK listed firms. Since the 1990s Africa has experienced a rise in large-scale, capital-intensive production, and today the continent is an important producer of gold, copper, diamond, bauxite, chromium, cobalt, manganese, and platinum (UNECA, 2011). The industrial mining industry is heavy in capital and firms are often large and multinational. There are several production stages: exploration, feasibility, construction, operation and closure. In contrast to the later stages, the exploration phase is often undertaken by smaller firms who obtain a three year exploration license. Large mining firms enter mostly in the post-exploration phase. In the feasibility phase, the company determines if the deposit is viable for commercial exploration. If it is deemed so, the company will apply for a mining license. The average length of such a license is 23 years in Africa, and can be renewed upon termination. The licenses are obtained from the government and the application process takes on average 2–3 years (Gajigo, Mutambatsere, & Ndiaye, 2012). The mine life, i.e., the length of the production phase, depends on the ore deposits and the world price, among other things. In our data set, the average life length of a mine is ten years. After production, there is a reclamation process (Gajigo *et al.*, 2012). Focusing on industrial-scale production, the mines in the dataset constitute a subset of existing mines and deposits in the region, excluding small-scale mines and informal or illegal mines. The external validity of the results from the main empirical strategy is therefore limited to large-scale mining.

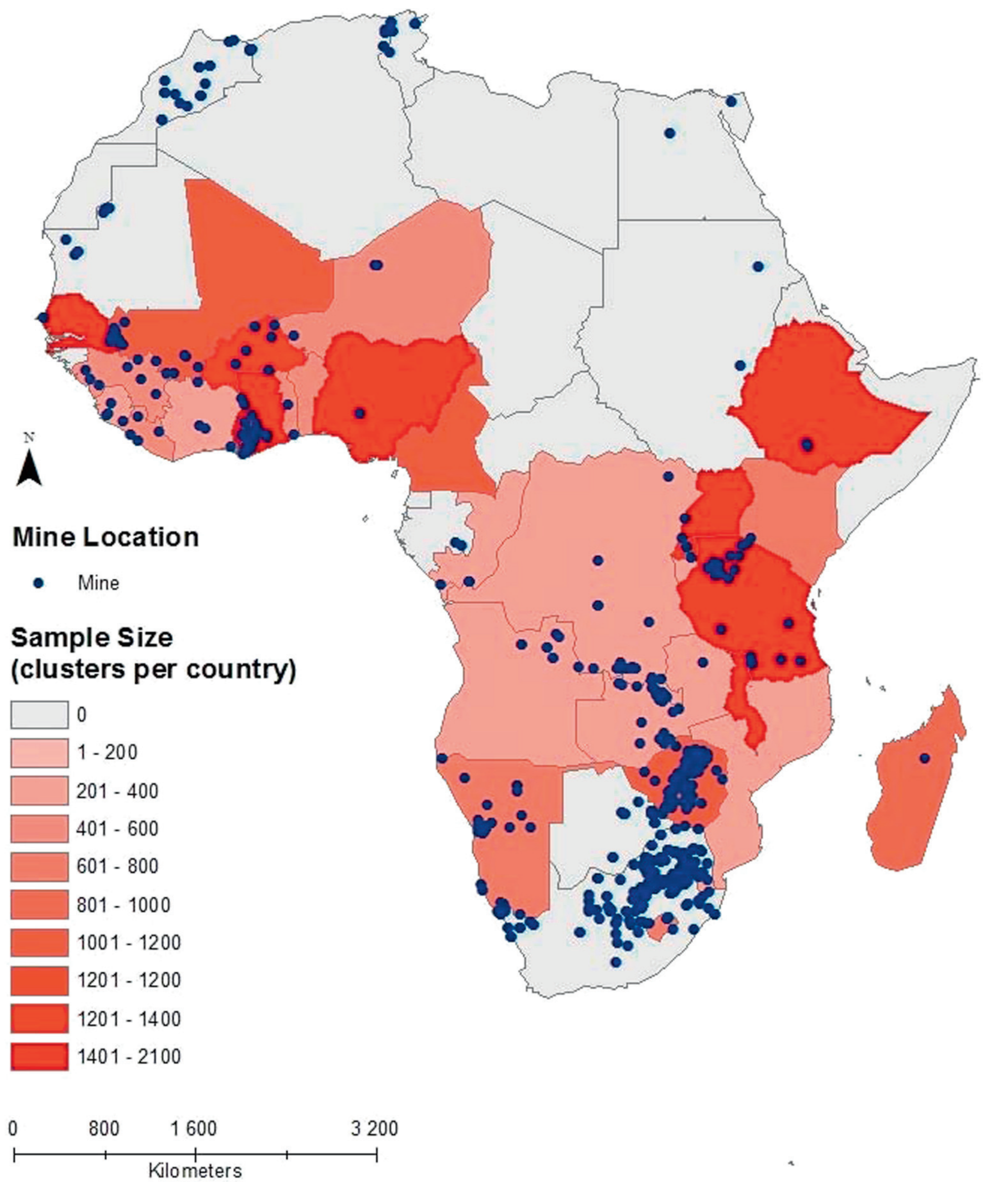
Industrial mining may exist alongside or replace small-scale and artisanal mining (ASM). While the production levels of ASM-type activities are small, they are an important source of livelihood in Africa. [5] Twenty-one countries in Africa are estimated to employ more than 100,000 people each in ASM, with Ghana and Tanzania above one million people each. Together, these two countries are estimated to have 13.4 million people dependent on ASM ("dependent" implying indirect employment and families of miners) (UNECA, 2011). The current definition of small-scale mining operations includes a cap of 50 employees and operations that are labor rather than capital intensive. Artisanal mining is characterized by traditional and often hand-held tools and may be of an informal and/or illegal nature. Similarly to large-scale mining, there are taboos regarding women's participation in underground work, yet women as well as children often engage in other ASM operations. In order to get a more complete picture of the effects of mining, we complement the main analysis using datasets from the U.S. Geological Survey (USGS) and the Center for the Study on Civil War (CSCW) on diamond mines. The USGS data cover a wider variety of mines and deposits beyond those of industrial size, but has the drawback of not including time-varying production levels. Similarly, the CSCW data include all diamond mines, but no production levels.

### (b) *DHS data*

We use micro data from the Demographic and Health Surveys (DHS). The DHS data are obtained from standardized surveys across years and countries. We combine the women's questionnaires from all 67 surveys in Sub-Saharan Africa that contain information on employment and GPS coordinates. The total dataset includes 525,180 women aged 15–49 from 29 countries. They were surveyed during 1990–2011 and live in 20,967 survey clusters in 297 sub-national regions. [6]

In Figure 1 we show the distribution of the mines and the DHS surveys used across Africa. The countries included are shown using lighter to darker red colors, where a darker color indicates more sampled clusters. The data cover large parts of Sub-Saharan Africa; Table A.1 in the Appendix shows the distribution of the sample by country. Table A.2 in the Appendix shows the distribution of the sample by years.

Definitions and summary statistics for our dependent and control variables are shown in Table 1, the occupational status (*working*) relates to whether the respondent had been working during the last 12 months: 66% of the women responded affirmatively. Women who are not working may be engaged in child care, household production, or backyard farming. The information on employment is disaggregated by sector of




*Notes:* Source: The map shows African large-scale mining sites in Africa 1975-2010.

Countries with geo-coordinated DHS data are colored red, indicating the number of surveyed clusters per country.

Figure 1. *Mines and DHS clusters by country. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)*

Table 1. *Descriptive statistics for women and partners*

| | | | |
|---|---|---|---|
| *Mine variables* | | | |
| distance | Distance to closest active or inactive mine (km) | 246.4 | 211.0 |
| distance to active | Distance to closest active mine (km) | 363.6 | 247.2 |
| active (20 km) | At least one active mine < 20 km | 0.016 | 0.125 |
| inactive (20 km) | At least 1 inactive mine < 20 km, no active/suspended | 0.005 | 0.067 |
| suspended (20 km) | At least one suspended mine < 20 km, no active | 0.013 | 0.113 |
| *Main dependent variables* | | | |
| working | 1 if respondent is currently working | 0.659 | 0.474 |
| services | 1 if respondent is working in the service sector | 0.036 | 0.187 |
| profess. | 1 if respondent is a professional | 0.027 | 0.161 |
| sales | 1 if respondent is working with sales | 0.168 | 0.374 |
| agric. (self) | 1 if respondent is self-employed in agriculture | 0.276 | 0.447 |
| agric. (emp) | 1 if respondent is employed in agriculture | 0.054 | 0.023 |
| domestic | 1 if respondent is employed as a domestic worker | 0.010 | 0.101 |
| clerical | 1 if respondent is employed as a clerk | 0.010 | 0.097 |
| skilled manual | 1 if respondent is employed in skilled manual labor | 0.046 | 0.209 |
| unskilled manual | 1 if respondent is employed in unskilled manual labor | 0.030 | 0.172 |
| *Other dependent variables* | | | |
| cash | 1 if respondent is paid in cash | 0.462 | 0.499 |
| cash & kind | 1 if respondent is paid both in cash and in kind | 0.167 | 0.373 |
| kind | 1 if respondent is paid in kind | 0.083 | 0.275 |
| not paid | 1 if respondent is not paid | 0.289 | 0.453 |
| seasonally | 1 if respondent is working seasonally | 0.320 | 0.467 |
| all year | 1 if respondent is working all year | 0.569 | 0.495 |
| occasionally | 1 if respondent is working occasionally | 0.111 | 0.314 |
| *Control variables* | | | |
| urban | 1 if respondent is living in an urban area | 0.327 | 0.469 |
| age | Age in years | 28.400 | 9.560 |
| schoolyears | Years of education | 4.200 | 4.344 |
| christian | 1 if respondent is Christian | 0.591 | 0.492 |
| muslim | 1 if respondent is Muslim | 0.338 | 0.473 |
| non mover | 1 if respondent always lived in the same place | 0.457 | 0.498 |
| *Partner information* | | | |
| partner | 1 if respondent has a partner | 0.671 | 0.470 |
| partner working | 1 if partner is currently working | 0.966 | 0.474 |
| partner services | 1 if partner is working in the service sector | 0.054 | 0.187 |
| partner profess. | 1 if partner is a professional | 0.073 | 0.161 |
| partner sales | 1 if partner is working in sales | 0.110 | 0.374 |
| partner agric. (self) | 1 if partner is self-employed in agriculture | 0.409 | 0.447 |
| partner agric. (emp) | 1 if partner is employed in agriculture | 0.113 | 0.226 |
| partner domestic | 1 if partner is employed as a domestic worker | 0.008 | 0.100 |
| partner clerical | 1 if partner is employed as a clerk | 0.020 | 0.097 |
| partner skilled manual | 1 if partner is employed in skilled manual labor | 0.137 | 0.209 |
| partner unskilled manual | 1 if partner is employed in unskilled manual labor | 0.044 | 0.172 |
| N | | 512,922 | |
| N with partners | | 277,722 | |

activity.[7] Note that a woman can only belong to one sector, which she states as her main occupation. The main focus of this paper is three occupational categories, given their relative importance. These are agriculture (total 33%), sales (16.8%) and services (3.6%). However, all categories are reported in Table 1 and the results for all categories are also presented for the baseline regressions. The surveys include demographic variables, place of residence, education, and religious affiliation. Regarding migration, women state in what year they moved to their current place of residence. However, no information is collected on previous place of residence or place of birth.[8] We also present labor market outcomes for the women's partners for all occupational categories. Partner's labor force participation is near universal at 96.6% and many (40.9%) are self-employed in agriculture. In addition, 11.3% are employed as agricultural workers and 13.7% are skilled manual workers.

## 3. EMPIRICAL STRATEGY

With several waves of survey data combined with detailed information on mines, the estimation relies on a spatial–temporal estimation strategy, using multiple definitions of the mine footprint area based on different proximity measures and alternative definitions of the control group.

Assuming that people are not restricted to only one mine but rather seek employment at or around any mine falling within a cut-off distance, our main identification strategy includes three groups with the baseline distance 20 km: (1) within 20 km from at least one active mine, (2) within 20 km from an inactive mine (defined as a mine that is not yet active), but not close to any active mines or suspended mines, and (3) more than 20 km from any mine. The baseline regressions are of the form:

$$Y_{ivt} = \beta_1 \cdot active + \beta_2 \cdot inactive + \alpha_r + g_t + \delta_{r*time} + \lambda X_i + \varepsilon_{ivt}$$

where the outcome $Y$, mainly the occupation,[9] of an individual $i$, cluster $v$, and for year $t$ is regressed on a dummy *(active)* for whether the person lives within 20 km of at least one active mine, a dummy *(inactive)* for whether the person lives close to a mine that has not started producing at the time of the survey, region and year fixed effects, region-specific linear time trends, and a vector $X$ of individual-level control variables. In all regressions, we control for living in an urban area, age, years of education, and indicators for religious beliefs.

Interpreting the coefficient only for *active* (20 km) would build on a premise that the production state (*active* or *inactive*) of the mine is not correlated with the population characteristics before production starts, i.e., that a mine does not open in a given location because of the availability or structure of the labor force in that geographical location. This is a potentially strong assumption that we do not wish to make because wage labor and population density may influence mining companies' investment decisions or could jointly vary with a third factor such as accessibility or infrastructure. Including the dummy variable for inactive mines allows us to compare areas before a mine has opened with areas after a mine has opened, and not only between areas close to and far away from mines. For all regressions, we therefore provide test results for the difference between *active* (20 km) and *inactive* (20 km). By doing this we get a difference-in-difference measure that controls for unobservable time-invariant characteristics that may influence selection into being a mining area. This is our main identification strategy.

Exploiting within-country variation may lead to more robust causal claims (e.g., Angrist & Kugler, 2008; Buhaug & Rød, 2006; Dube & Vargas, 2013; Maystadt et al., 2014 on conflicts; Kotsadam *et al.*, 2015 on corruption; Wilson, 2012 on sexual risk taking behavior in Zambia's copper belt; and Aragón & Rud, 2013 on the local economy in Peru). With region fixed effects, we expect that only time-variant differences within sub-national regions are a threat to this identification strategy. That is, we control for time-invariant components of regional mining strategies, institutions, level of economic development, sectoral composition, and norms regarding female work force participation. Nonetheless, the exact location of a mine within a country or region may still be influenced by factors other than abundance of resources. The placement of mineral deposits is random (Eggert, 2002), but the discovery of such deposits is not. In particular, the literature suggests that discovery depends on three other factors (Krugman, 1991; Isard, Azis, Drennan, Miller, Saltzman, & Thorbecke, 1998): (i) access to and relative price of inputs, (ii) transportation costs, and (iii) agglomeration costs. If selection into being a mining area, even within a country or region, is based on factors other than mineral endowments that are stable over time, we can control for such factors. We also control for region-specific time trends and thereby allow for different time trends across sub-national regions.

The interpretation of the coefficients from our estimation strategy relies on the population being the same before and after mine opening. We are using a repeated cross-sectional dataset, and we discuss in the robustness section how we deal with this issue by using the available information on migration. Additionally, we worry that the control group in the baseline definition is inherently too different from the population living in mining areas. Several measures are taken to ensure that the results are not driven by such dissimilarities, including using region fixed effects and geographically limiting the area from which the control group is drawn. Furthermore, the estimation strategy could capture other changes that happen parallel to and irrespective of the mine opening. Mine industrialization and employment changes could be driven by improvements in infrastructure. We use the best available data on road networks in Africa and explore whether the results are stable. As it is possible that mine openings cause roads to open, the results of this analysis must be viewed as any effect of the mine over and above that on roads directly. Different fixed effects, for the closest mines and for different types of minerals, are also included to verify the robustness of the results. We cluster the standard errors at the DHS cluster level, but we also present results where the standard errors are clustered at the regional level, at the level of the closest mine, and for multi-way clustering at both the DHS cluster and the closest mine.

## 4. RESULTS

We start by exploring the evolution of employment over time. Fig. 2 shows the trends in service-level employment for those within 20 km and those between 20 and 200 km from a mine. The $x$-axis shows the time in years in relation to when the mine opens and the $y$-axis shows the average levels of service employment in each year in relation to mine opening. The treatment group follows a similar trend as the control group in service sector employment until mine opening, but at a lower level. This supports the bearing assumption of parallel trends, necessary for a difference-in-difference specification. Service employment increases sharply once the mine opens.[10] The levels equalize somewhat at the 10th year, which, in part could be due to a geographic dispersion of the effects with time (the control group is limited to within 200 km). Such a dispersion effect would explain the increase in service employment in the control group. The decline in the treatment group close to the tenth year may be a result of mine closings since mine length in our sample is, on average 10 years. This hypothesis is supported by the right-side figure showing that service employment is higher close to mines that are going to close, but have not yet done so. This difference in service-level employment decreases as the date of closing appears and reverses once the mine closes. Similar trends are obtained if we have the residuals after controlled regressions instead of levels (figures are available upon request). Appendix Figures A.1 and A.2 show these trends for our four main outcomes of interest.

The main results following the empirical strategy previously outlined are reported in Table 2, with Panel A showing women's outcomes and Panel B the outcomes for these women's partners. The first variable, *active (20 km)*, captures the difference in outcomes between individuals living close to a producing mine and those living farther away. In Panel A, we see that the coefficient is positive and statistically significantly correlated with the woman working, working in the service sector, and working with unskilled manual labor (significant only at the 10% level). The second variable, *inactive (20 km)*,shows the difference between women living close to future mines and women living further away. We see that women in mining areas before the mine starts producing are more likely to work, especially as self-employed agricultural workers.

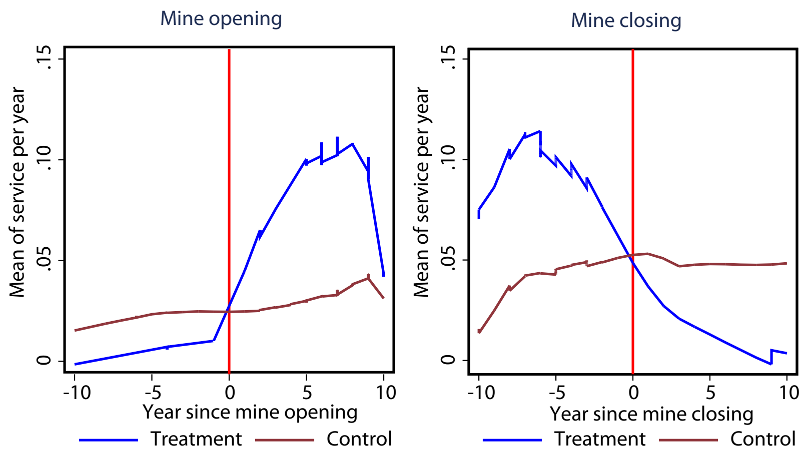



Figure 2. *Trends in service sector employment.*

Due to the possibility of non-random mine placement, we use a difference-in-difference strategy, whereby the effect of a mine opening can be read out as the difference between the coefficients for *active* (20 km) and *inactive* (20 km). Test results are presented for this difference ($\beta_1 - \beta_2 = 0$) henceforth. This difference shows that there is a decline of 5.4 percentage points in the probability that a woman is working when a mine opens in the area (which is calculated by the difference between *active* and *inactive*: $2.6 - 8.0 = 5.4$). Investigating the sectoral composition of the effect, it emerges that the decline in overall employment is driven by a decline in agricultural self-employment, an effect which is partly offset by an increase in service sector employment. The increase in the likelihood of working in the service sector is substantial at two percentage points. The sample mean of engaging in service sector jobs is 3.6%, so the increase in the likelihood is over 50%. Trying to quantify the effect of mine opening on female service sector employment, we make a back-of-the-envelope calculation and estimate that 94,402 women have benefited from service sector jobs generated by the industrial mining sector, while 283,206 women left the labor market.[11]

With respect to selection, it is also interesting to interpret the coefficient for *inactive* as the correlation between living in a mining area and our outcomes before the mines have any industrial-scale production. The statistically significant results for *inactive* show that there may be selection into being a mining area, which is not fully accounted for by including region fixed effects. We posit three possible reasons why the likelihood of women working is higher around inactive mines: (1) these are geographical areas with an agricultural focus, where women are more likely engaged in economic activities outside of the household; (2) the coefficient captures pre-opening effects (e.g., jobs generated in the prospecting and investment phase); and (3) the artisanal and small-scale mining activities that may employ women directly, in addition to indirectly generating employment. The first hypothesis is supported by the baseline results, where a large share of the population engages in subsistence farming. We explore the second hypothesis by looking at trends in employment (Figures 2 and A.1). According to the visual evidence, there is an increase in service sector employment and a decrease in agricultural employment during the pre-production phase, but the effects are small in magnitude and confined to the last years before mine opening. Regarding the third hypothesis, we explore direct employment in mining, and see that mining employment for women does not change with mine opening (see Table 4).[12]

For partners, there is a decreased probability of working, driven by a drop in agricultural employment. A substantial and positive effect of mine opening on men's employment in skilled manufacturing is identified.

(a) *Distance*

We choose a baseline distance of 20 km from the mine. Although this distance cut-off does not maximize the effect size, we find it reasonable for four reasons: (1) the geocoordinates in the DHS data are randomly displaced up to 5 km, and for 1% of the sample up to 10 km whereby small distance spans introduce more noise; (2) the geocoordinates in the mining data reflect the centroid of the mining area. With too small an area, we are likely to capture the actual mining site rather than the surrounding communities; (3) the sample size increases rapidly with distance, which increases the power of the results, all else equal; and (4) using distances longer than 20 km, we fail to capture the mine footprint. The choice is further motivated by empirical evidence on commuting distances in urban and rural Africa, showing that areas of 5, 10 or 15 km are likely integrated markets (see e.g., Amoh-Gymiah & Aidoo, 2013; Kung, Greco, Sobolevsky, & Ratti, 2013; Shafer, 2000). We discuss the choice of distance measures, and robustness to different models extensively in Section Appendix A.1 in the Appendix.

(b) *Mine closure*

We next examine the effects of a mine closing on employment. The results are shown in Table 3. The effects are not entirely symmetrical to the effects of mine openings. Initially, mine openings induced an increase in the likelihood of service sector employment for women, an effect that is offset by mine suspension. Agricultural self-employment increases, but the effect is not statistically significant, and the magnitude is much smaller than the decline induced by mine openings. These results indicate that the localized structural shifts spurred by mine openings are not reversible for women; i.e., women are inhibited from going back to agricultural production after a mine closing. In contrast, male partners increase agricultural

Table 2. *Mine opening and occupation for women (Panel A) and men (Panel B)*

| Variables | (1) Working | (2) Service | (3) Profess. | (4) Sales | (5) Agriculture self-employment | (6) Agriculture employment | (7) Domestic | (8) Clerical | (9) Skilled manual | (10) Unskilled manual |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Panel A: Woman* | | | | | |
| Active (20 km) | 0.026*** | 0.020*** | 0.000 | 0.000 | −0.010 | 0.001 | 0.002 | 0.003 | 0.005 | 0.005* |
| | (0.010) | (0.005) | (0.003) | (0.008) | (0.012) | (0.007) | (0.002) | (0.002) | (0.004) | (0.002) |
| Inactive (20 km) | 0.080*** | −0.000 | 0.005 | −0.014 | 0.060** | 0.005 | −0.003 | 0.009** | −0.005 | 0.023 |
| | (0.020) | (0.005) | (0.005) | (0.015) | (0.024) | (0.008) | (0.002) | (0.004) | (0.011) | (0.016) |
| Observations | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 | 512,922 |
| Sample mean | 0.659 | 0.036 | 0.027 | 0.168 | 0.276 | 0.054 | 0.010 | 0.010 | 0.046 | 0.030 |
| Active–inactive = 0 | 6.164 | 7.147 | 1.065 | 0.745 | 7.087 | 0.138 | 2.821 | 1.837 | 0.728 | 1.338 |
| *p* value (*F*-test) | 0.013 | 0.008 | 0.302 | 0.388 | 0.008 | 0.710 | 0.093 | 0.175 | 0.394 | 0.247 |
| | | | | | *Panel B: Husband or partner* | | | | | |
| Active (20 km) | 0.003 | 0.013** | 0.008 | 0.005 | −0.039** | −0.021 | −0.002 | −0.005* | 0.034*** | 0.011* |
| | (0.005) | (0.006) | (0.006) | (0.008) | (0.016) | (0.013) | (0.002) | (0.003) | (0.012) | (0.006) |
| Inactive (20 km) | 0.034*** | 0.002 | 0.020* | 0.008 | −0.013 | 0.015 | −0.001 | −0.003 | −0.002 | 0.007 |
| | (0.010) | (0.014) | (0.011) | (0.011) | (0.030) | (0.018) | (0.005) | (0.008) | (0.010) | (0.012) |
| Observations | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 | 277,722 |
| Sample mean | 0.966 | 0.054 | 0.073 | 0.110 | 0.409 | 0.113 | 0.008 | 0.020 | 0.137 | 0.044 |
| Active–inactive = 0 | 8.075 | 0.502 | 0.990 | 0.054 | 0.587 | 2.521 | 0.121 | 0.104 | 5.229 | 0.081 |
| *p* value (*F*-test) | 0.004 | 0.479 | 0.320 | 0.816 | 0.444 | 0.112 | 0.728 | 0.747 | 0.022 | 0.775 |

All regressions are OLS regressions. Occupational variables are indicator variables taking a value of 0 or 1. A person can only respond 1 to any of the categories. Occupations are not conditional on stating any occupation. Robust standard errors clustered at the DHS cluster-level in parentheses. All regressions control for year and region fixed effects, regional time trends, urban dummy, age, years of education, and religious beliefs. The coefficients of interest are active (20 km) and the difference between active (20 km) and inactive (20 km) capturing the shift that happens with mine opening. The *p*-values presented show if this difference is significantly different from zero. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3. *Mine suspension and occupation for women (Panel A) and men (Panel B).*

| Variables | (1) Working | (2) Service | (3) Profess. | (4) Sales | (5) Agriculture self-employment | (6) Agriculture employment | (7) Domestic | (8) Clerical | (9) Skilled manual | (10) Unskilled manual |
|---|---|---|---|---|---|---|---|---|---|---|
| *Panel A: Woman* | | | | | | | | | | |
| Suspended (20 km) | 0.026* | 0.002 | −0.004 | 0.007 | 0.016 | −0.003 | 0.004 | −0.001 | −0.001 | 0.007 |
| | (0.014) | (0.006) | (0.003) | (0.009) | (0.017) | (0.006) | (0.003) | (0.002) | (0.004) | (0.006) |
| Active (20 km) | 0.024** | 0.020*** | −0.000 | 0.001 | −0.011 | 0.001 | 0.002 | 0.003 | 0.005 | 0.004* |
| | (0.010) | (0.005) | (0.003) | (0.008) | (0.012) | (0.007) | (0.002) | (0.002) | (0.004) | (0.002) |
| Observations | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 | 519,734 |
| Sample mean | 0.659 | 0.036 | 0.027 | 0.168 | 0.276 | 0.054 | 0.010 | 0.010 | 0.046 | 0.030 |
| Suspended-active = 0 | 0.00945 | 5.358 | 0.714 | 0.290 | 1.813 | 0.186 | 0.365 | 1.907 | 1.219 | 0.141 |
| *p* value | 0.923 | 0.021 | 0.398 | 0.590 | 0.178 | 0.666 | 0.545 | 0.167 | 0.270 | 0.707 |
| *Panel B: Husband or partner* | | | | | | | | | | |
| Suspended (20 km) | 0.012** | −0.001 | −0.008 | 0.014 | 0.004 | −0.023** | 0.001 | 0.006 | −0.005 | 0.023** |
| | (0.006) | (0.005) | (0.006) | (0.011) | (0.018) | (0.011) | (0.004) | (0.005) | (0.010) | (0.011) |
| Active (20 km) | 0.001 | 0.003 | 0.007 | 0.007 | -0.059*** | 0.005 | −0.003* | −0.007** | 0.036*** | 0.013** |
| | (0.005) | (0.006) | (0.006) | (0.008) | (0.014) | (0.008) | (0.002) | (0.003) | (0.012) | (0.006) |
| Observations | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 | 281,021 |
| Sample mean | 0.966 | 0.054 | 0.073 | 0.110 | 0.409 | 0.113 | 0.008 | 0.020 | 0.137 | 0.044 |
| Suspended-active = 0 | 2.100 | 0.185 | 3.029 | 0.252 | 8.247 | 4.161 | 0.879 | 6.021 | 7.395 | 0.659 |
| *p* value (*F*-test) | 0.147 | 0.667 | 0.082 | 0.616 | 0.004 | 0.041 | 0.349 | 0.014 | 0.007 | 0.417 |

All regressions are OLS regressions. Occupational variables are indicator variables taking a value of 0 or 1. A person can only respond 1 to any of the categories. Occupations are not conditional on stating any occupation. Robust standard errors clustered at the DHS cluster level in parentheses. All regressions control for year and region fixed effects, regional time trends, urban dummy, age, years of education, and religious beliefs. The coefficients of interest are active (20 km) and the difference between active (20 km) and inactive (20 km) capturing the shift that happens with mine opening. The *p*-values presented show if this difference is significantly different from zero. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 4. *Direct employment in mining*

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | *RMG mine data* | | *USGS mine data* | | *Diamond mine data* | |
| Variables | Woman is miner | Husband is miner | Woman is miner | Husband is miner | Woman is miner | Husband is miner |
| Active (20 km) | 0.004* | 0.046*** | | | | |
| | (0.003) | (0.011) | | | | |
| Inactive (20 km) | 0.011 | 0.005 | | | | |
| | (0.009) | (0.021) | | | | |
| USGS mine (20 km) | | | 0.001 | 0.008*** | | |
| | | | (0.001) | (0.003) | | |
| diamond mine (20 km) | | | | | −0.000 | 0.037*** |
| | | | | | (0.002) | (0.012) |
| Observations | 259,114 | 149,692 | 264,695 | 152,228 | 264,695 | 152,228 |
| *R*-squared | 0.026 | 0.071 | 0.026 | 0.069 | 0.026 | 0.070 |
| *F* test: active–inactive = 0 | 0.406 | 2.913 | | | | |
| *p* value | 0.524 | 0.088 | | | | |

All regressions are OLS regressions. Robust standard errors clustered at the DHS cluster level in parentheses. All regressions control for year and region fixed effects, regional time trends, living in an urban area, age, years of education, and religious beliefs. Please see Table 3 for more information about coefficients of interest. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 5. *Payment and seasonality*

| Variables | (1) Cash | (2) Cash & Kind | (3) Kind | (4) Not Paid |
|---|---|---|---|---|
| *Panel A: Remuneration of work for women* | | | | |
| Active (20 km) | 0.014 | −0.029*** | 0.015* | −0.001 |
| | (0.015) | (0.011) | (0.008) | (0.012) |
| Inactive (20 km) | −0.060** | 0.017 | 0.056*** | −0.013 |
| | (0.030) | (0.019) | (0.018) | (0.030) |
| Observations | 255,889 | 255,889 | 255,889 | 255,889 |
| *F* test: active–inactive = 0 | 4.864 | 4.469 | 4.485 | 0.155 |
| *p* value | 0.027 | 0.035 | 0.034 | 0.694 |
| Variables | Seasonal | All year | Occasional | |
| *Panel B: Seasonality of work for women* | | | | |
| Active (20 km) | −0.075*** | 0.059*** | 0.016** | |
| | (0.015) | (0.013) | (0.008) | |
| Inactive (20 km) | −0.005 | 0.029 | −0.024* | |
| | (0.029) | (0.025) | (0.015) | |
| Observations | 303,291 | 303,291 | 303,291 | |
| *F* test: active–inactive = 0 | 4.713 | 1.138 | 6.084 | |
| *p* value | 0.030 | 0.286 | 0.014 | |
| Variables | Cash | Cash & Kind | Kind | Not Paid |
| *Panel C: Remuneration of work for men* | | | | |
| Active (20 km) | 0.073*** | −0.013 | −0.013 | −0.047*** |
| | (0.016) | (0.013) | (0.009) | (0.013) |
| Inactive (20 km) | −0.009 | −0.021 | 0.032 | −0.002 |
| | (0.037) | (0.030) | (0.034) | (0.035) |
| Observations | 128,135 | 128,135 | 128,135 | 128,135 |
| *F* test: active–inactive = 0 | 4.056 | 0.0715 | 1.693 | 1.399 |
| *p* value | 0.044 | 0.789 | 0.193 | 0.237 |
| Variables | Seasonal | All year | Occasional | |
| *Panel D: Seasonality of work for men* | | | | |
| Active (20 km) | −0.013 | 0.019 | −0.006 | |
| | (0.016) | (0.017) | (0.009) | |
| Inactive (20 km) | 0.004 | 0.051 | −0.055*** | |
| | (0.048) | (0.051) | (0.011) | |
| Observations | 108,764 | 108,764 | 108,764 | |
| *F* test: active–inactive = 0 | 0.102 | 0.374 | 11.81 | |
| *p* value | 0.750 | 0.541 | 0.001 | |

All regressions are OLS regressions. Robust standard errors clustered at the DHS cluster level in parentheses. All regressions control for year and region fixed effects, regional time trends, living in an urban area, age, years of education, and religious beliefs. Please see Table 3 for more information about coefficients of interest.$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 6. *Heterogeneous effects for women: service sector employment*

| Sample<br>Outcome | (1)<br>Baseline<br>Service | (2)<br>Never movers<br>Service | (3)<br>Marriedbefore mine<br>Service | (4)<br>Married to miner<br>Service | (5)<br>Women 15–20<br>Service | (6)<br>Intensity<br>Service |
|---|---|---|---|---|---|---|
| active (20 km) | 0.020*** | 0.026*** | 0.029*** | −0.029 | 0.007 | 0.015*** |
| | (0.005) | (0.008) | (0.009) | (0.020) | (0.007) | (0.005) |
| inactive (20 km) | −0.000 | 0.007 | −0.035*** | 0.080 | −0.006 | −0.000 |
| | (0.005) | (0.007) | (0.012) | (0.067) | (0.005) | (0.006) |
| intensity (20 km) | | | | | | 0.006*** |
| | | | | | | (0.001) |
| Observations | 512,922 | 194,103 | 291,395 | 4,628 | 138,606 | 518,368 |
| $R$-Squared | 0.036 | 0.091 | 0.094 | 0.133 | 0.070 | 0.092 |
| $F$ test: active–inactive = 0 | 7.147 | 3.164 | 20.25 | 2.425 | 2.085 | 11.83 |
| $p$ value | 0.008 | 0.075 | 0.000 | 0.120 | 0.149 | 0.001 |

All regressions are OLS regressions. Robust standard errors clustered at the DHS cluster level in parentheses. All regressions control for year and region fixed effects, regional time trends, living in an urban area, age, years of education, and religious beliefs. Intensity is a count variable for the number of active mines that are nearby. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

self-employment after mine closings, but experience a contraction in skilled manual and agricultural employment. There is a small increase in clerical jobs and a small decrease in professional work, but the magnitudes are negligible.

### (c) *Direct employment*

We further explore whether jobs are created in mining per se. A subset of the surveys include information on whether a woman or her partner work in mining. The categorization unfortunately differs between DHS survey rounds, and hence these variables can only be taken as indicators of engagement in mine activities.[13] We run regressions on whether a woman or her partner is engaged in mining using three different mine datasets (RMG, USGS or the CSCW diamond dataset). Table 4 shows that industrial-scale mining has no effect on employment in mining for women, as there is no statistically significant difference between active and inactive in Column 1. Neither do we find any statistically significant correlation for USGS mines, that may include small-scale mining sites. The USGS mine measure does not contain information on the type, timing, or significance of the mining activities. Anecdotal evidence suggests that it is common for women to engage in some type of artisanal and small-scale mining (ASM) activities, which this mine measure partly captures. Using the diamond dataset from CSCW, no correlation is found for women. In contrast, being within 20 km of a mine is significantly and positively associated with the woman's partner being engaged in mining for all three mine estimates, and there is an effect of mine industrialization in the RMG data. Mine openings increase the likelihood of the husband being a miner by 4.1 percentage points, which is a large increase relative to the sample mean of 2.6%.

Despite women seldom taking part in the large-scale mining, their labor market outcomes are substantially affected by industrial mining. The sectoral composition of the labor market effects for women is different from that of their partners. We continue by further assessing the robustness of the findings for women because we do not have all the necessary variables for the partners. However, we also conduct some extra analysis for a smaller sample of men for whom we have information on cash earnings and seasonality of work.

### (d) *Other measures of occupation*

To further assess the effects on employment changes, we investigate the effects of mining on remuneration and seasonality of work. We have data on how women are paid for work outside the household and whether they work all year, seasonally, or occasionally. The sample is smaller because the question is not asked in all DHS survey rounds. Being close to an inactive mine is associated with a higher probability of earning in-kind only and negatively correlated with earning cash (Panel A of Table 5), and women are less likely to work seasonally after mine opening, and more likely to work occasionally (Panel B). This is a finding in line with previous results, signaling that mining areas have a higher share of agricultural workers prior to production. The probability of earning cash increases by 7.4 percentage points $(0.014 - (-0.060))$ with mine opening and this effect is statistically significant. We also see a statistically significant reduced probability of being paid in-kind only or being paid both cash and in-kind. The effects indicate that the labor market opportunities for women change with mining. Mine opening induces a shift from more traditional sources of livelihoods, such as subsistence farming which is seasonal by nature and oftentimes paid in kind, to more cash-based, all year or occasional sectors such as services.

In more recent years, DHS has surveyed men based on the same questionnaire used for women's labor market outcomes. The male sample is, however, much smaller. This sample of 128,135 men (Table 5) indicate that men have higher cash earning opportunities (Panel C) and are less likely to work seasonally after mine openings (Panel D), in line with the results for women. The surveys of men produce very similar results to the partner regressions for the main occupational outcomes (results are available upon request).

### (e) *Migration*

Inward migration can be spurred by natural resource and mining booms and there is evidence of the creation of mining cities (Lange, 2006), urban–rural migration (Hilson, 2009) as well as work-migration (Corno & de Walque, 2012). Such migration patterns can cause a selection issue where women and their partners have moved to mining areas for work. While urbanization and inward migration are possible channels through which the multipliers work, we are also interested in knowing if the original population benefited from the expansion. By restricting the sample to women who have never moved, we try to show that our effects are not driven by women who have migrated inward. The results for services can be seen in Column 2 of Table 6 (and the results for all the main occupations are shown in Table A.11). The results resemble the baseline results both in terms of direction of effects and statistical significance.

We conduct several other robustness tests of our baseline results and these are extensively discussed in Appendix Section Appendix A.2. Most importantly, the results are qualitatively unchanged if we restrict the sample to only having control groups closer to the mines or if we control for distance to roads and add fixed effects for mineral and closest mine. The results are also robust to different clusterings.

## 5. HETEROGENEOUS IMPACTS

Mining can create non-agricultural job opportunities, allowing women to earn more cash and work outside the traditional and dominating agricultural sector. The uptake of jobs for women will likely depend on income and substitution effects. The income effect is linked to the supply side argument in Ross (2008, 2012), where women's employment is modeled to decrease as their husbands earn more money with the increase in extractive activities. If this channel is correctly hypothesized, the labor market effects will differ depending on a woman's marital status and spouse's occupation. In fact, we learn that married women in mining areas increase service sector employment more than married women further away (Table 6, Column 3) and the effect size is (non-significantly) larger than the baseline result (including all married and unmarried women, see Table 6, Column 1). [14] In contrast, the 4,628 women whose husbands are miners are no less likely to work in a service sector job (Column 4 of Table 6), potentially in line with the household income story. We cannot verify this claim, as we lack income data for the partners. Moreover, we find no significant change in service sector employment for women younger than 20 years old (Column 5).

Furthermore, we test if the effects are stronger if there are more active mines within 20 km. Introducing a count variable in Table 6, Column 6, we find that the probability that a woman is working in services increases with the number of active mines nearby. A woman near two active mines (the average number of mines nearby for women close to at least one mine is 2.19) is thus 2.7 percentage points more likely to work in services than a woman further away. In the Appendix we show these results for all our main variables of interest (Table A.9) as well as an analysis using changes in world prices (see Table A.17), showing that the effects are stronger in years when prices are higher.

We also test if it the case that the effect of mines differs between societies with high and low participation of women in the service sector. To this end we use data from the ILO on share of women in the service sector (ILO, 2011) and interact an indicator variable for being in a country with a high share of women working in services (above the median in the ILO data are defined as a high share). The results are shown in Table A.16 in the Appendix. We confirm that women are more likely to work in service sector jobs in these countries, but the interaction effect of being in a high female service country and in an active mining area does not increase the effect further. If anything, there seems to be less of an effect in countries with high participation of women in the service sector.

Employment opportunities matter for women. For welfare, it also matters what types of jobs are offered. We try to rule out the possibility that the increase in female employment in the service sector is driven by engagement in the sex industry. Using lifetime number of sexual partners, which should increase with sex trade activity, we find no indication of sex trade among women in active mining areas (Table A.14). In fact, there is a clear negative effect of mine openings on the number of sexual partners. Considering groups that may be at more risk, such as young women (aged under 25), women working in the service sector, and women without a partner, there is also a decrease in the number of sexual partners. Finally, we find no statistically significant difference in the likelihood of the woman never having sexual intercourse, and no change in the use of a condom in the last intercourse.

### (a) *Artisanal and small-scale mining*

To investigate the relationship between employment and a broader set of mines, we use the USGS and CSCW datasets. The results show that living within 20 km from an USGS mine is associated with roughly a one percentage point increase in the probability of working in sales or services and a 2.6 percentage point decrease in the probability of working in agriculture (see Panel A of Table A.18 in the Appendix). For diamond mines, we find that the probability of working in agriculture is 5.3 percentage points lower, the probability of working in sales is 2.8 percentage points higher, and the probability of working in services is 0.6 percentage points higher if the woman lives within 20 km of a diamond mine (Panel B of Table A.18 in the Appendix). The results using these other datasets are in line with the findings using the main dataset.

## 6. CONCLUSION

The discovery of natural resources across the African continent brings hope for millions of poor people, but there are also fears that the resources will be a curse rather than a blessing (Collier, 2010). In particular, one fear spelled out in The Africa Mining Vision is that gender inequality in economic opportunities may increase with mining (UNECA, 2011). Using detailed data on industrial mining in Sub-Saharan Africa, we explore whether mining generates local employment opportunities for women and men. Based on GPS coordinates, we merge individual-level data with mining data, which enables a highly localized analysis of spillover effects. We then employ a difference-in-difference estimation strategy to compare areas that are close to mines with areas farther away, before and after the production has started.

In total, our results suggest that industrial mine openings constitute a mixed blessing for women in Sub-Saharan Africa. On the one hand they cause a decline in agriculture, but on the other hand there is an increase in service sector jobs. The decline in agriculture is large and by far outweighs the increase in service sector jobs so in total female employment is reduced. The new jobs created are, however, likely to be better in the sense that remuneration is more likely to be in cash and since such employment is less seasonally dependent. Men access direct employment in mining or in skilled manual labor. Mine closings are more clearly negative for female employment as the new jobs seem to disappear while the opportunities to return to agriculture are hampered. As in both the literature on the local effects on small-scale mining (e.g., Bebbington *et al.*, 2008) and the literature on the macro-level effects of natural resources (e.g., Lu & Lora-Wainwright, 2014), we find that the benefits and costs of mining are unequally distributed. As the average life span of the mines is 10 years, our results suggest that focus should be put on enhancing the sustainability of mining communities by reducing the negative impacts of mine closings.

The results are robust to a wide battery of checks, such as using different distance cut-offs and different classifications of the control group, including different types of fixed effects and exclusion of migrants. The results are quantitatively important.

We calculate that more than 90,000 women may have gained a service sector job as a result of mine openings, but, in parallel, more than 280,000 women left the labor market.

We have not assessed the quality of the new work opportunities and whether women are facing decent and productive employment as a result of mining. Whether women are winners in the scramble for Africa's resources can only be concluded via a full welfare analysis. Such a welfare analysis must explore if women are voluntarily leaving the agricultural labor force in higher numbers than those accessing new employment in services. Moreover, future analysis must seek to assess how women are affected by potential environmental pollution and effects on household bargaining power.[15] Future analysis could also exploit heterogeneous effects across factors at the country level, such as for instance democracy or legal regimes surrounding mining.

## NOTES

1. Most of the literature on the resource curse, including Ross (2008, 2012), has focused on the national level. The national-level focus and cross country-based literature face severe endogeneity problems. Differences in resource abundance are endogenous to factors such as institutions, civil wars, and growth (Brunnschweiler & Bulte, 2008a, 2008b, 2009; Brückner & Ciccone, 2010; Maystadt, De Luca, Sekeris, & Ulimwengu, 2014). The efficiency of the economy in general (Norman, 2009), and the protection of property rights can influence the search for and exploitation of resources (Wright & Czelusta, 2003).

2. It should be noted that local employment effects may differ from national-level effects. National-level employment effects are beyond the scope of this study.

3. Fafchamps and Söderbom, 2006 use data from nine Sub-Saharan African countries and find that the proportion of female workers is only 12% in manufacturing firms. The manufacturing sector in SSA has also been found to be largely non-tradable, perhaps due to a long history of import restrictions on manufactured goods (Torvik, 2001), which would reduce potential Dutch disease effects.

4. One notable exception is artisanal and small-scale mining activities such as grinding, sieving etc.; i.e., activities confined to traditional mining activities. In both small- and large-scale mining, women rarely go underground into pits, for which there are often taboos and stigmas (ILO, 1999).

5. 3.0–3.7 million people in Africa were estimated to be engaged in small-scale or artisanal mining at the end of the last century, according to the ILO (1999). A more recent report from the UN and African Union estimates that 8.1 million people are engaged in ASM. See also Hilson (2011, 2012) and Hilson and Ackah-Baidoo (2011) for extensive discussions on the role of ASM in Africa.

6. The cluster sizes range from 1 to 108 women. The mean number of women in a cluster is 25 and the median is 24. In most cases, the regions correspond to the primary administrative division for each country. Where coding into the primary divisions is not possible in the DHS data, due to natural regions being used instead (e.g., North-East, North-West, etc.), we use the existing natural regions. We largely follow Kudamatsu, 2012 to make the coding consistent over the years. We complement the classification using Law (2012), which is available on www.statoids.com and which is the updated version of Law (1999). The regions are not of equal sizes; rather, they range from 30 to 22,966 sampled women. The average sample size of a region is 1,769 and the median is 1,201.

7. The DHS follows The International Standard Classification of Occupations (ISCO) in classifying occupations into sectors. Examples of service sector jobs in our dataset are restaurant workers, housekeepers, and travel attendants. Examples of skilled manual jobs in the data are bakers, electricians, plumbers, blacksmiths, and shoe makers.

8. Not all survey rounds include information on migration. In the sample, the year of the last move is available for 428,735 women.

9. Occupations are as a set of dummy variables indicating main occupation in the last year. More information about the occupational outcomes variables is provided in Table 1.

10. An increase in service sector employment is noted shortly before mine opening, which corresponds to the investment phase of the mine.

11. According to the World Bank Indicators for 2011, the Sub-Saharan African female population aged 15–65 is estimated to 236,241,202 people. In our sample, approximately 1.6% live within 20 km of an active mine. Our baseline estimates indicate that 2% of the women close to mines benefit from service sector employment, amounting to 73,727 women, and that 202,749 women left the labor market. Using a 25-km distance span from an active mine, we estimate that 94,402 women gained employment in the service sector, and 283,206 women left the labor market.

12. Direct employment in mining can also capture small-scale and artisanal mining employment.

13. Possible categories include: mine blasters and stone cutters; laborers in mining; miners and drillers; miners and shot firers; laborers in mining and construction; gold panners; extraction and building workers; mining and quarrying workers; and laborers in mining, construction, and manufacturing.

14. The results are for women who were married before the mine started producing. This is chosen to reduce the risk of selection bias, as women's marriage market choice may be influenced by the onset of mining. Mining communities are characterized by a high ratio of men to women and a transient labor force (see work by Campbell (1997) on gold mines in South Africa, and Moodie & Ndatshe (1994) for a historic analysis), aspects that can change the marriage market and relationship formation. However, we do not find any evidence that mining changes relationship formation (see Table A.15 in the Appendix).

15. To do a complete community welfare analysis, an even longer list of outcomes must be assessed. These include e.g., environmental effects such as deforestation, land degradation, pollution of air and water sources, as well as social issues such as displacement, inequality, and tension between miners and non-miners, intra household economic inequality, the spread of HIV/AIDS, and boom and bust economies (UNECA, 2011).

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## APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.worlddev.2016.01.007.