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WOMEN IN AFRICAN NATURAL RESOURCE BOOMS

Anja Tolonen

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Anja Tolonen is an assistant professor at Department of Economics at Barnard College, Columbia University. She defended her dissertation "Mining Booms in Africa and Local Welfare Effects: Labor markets, Female Empowerment, and Criminality" in May 2015 at University of Gothenburg. The dissertation can be found at http://hdl.handle.net/2077/38780. Her email is atolonen@barnard.edu.

Abstract: Promoting natural resource extraction as a strategy for economic development is controversial, although a common reality in many developing countries. The research summarized in this brief explores the local welfare effects of largescale mining in Sub-Saharan Africa. In particular, it explores changes in labor market participation for men and women, changes in gender norms and infant mortality. With mine opening, women living within 20 km of a mine switch from self-employment in agriculture to working in services or they leave the work force. Men switch from agriculture to skilled manual labor. Effects are stronger in years of high world prices. Mining creates local boom-bust economies in Africa, with permanent effects on women's labor market participation.

Note: The research discussed in this dissertation brief draws from three distinct papers and contains extracts from them. *African Mining, Gender and Local Employment* (joint with Andreas Kotsadam, forthcoming in World Development, July, 2016); *Local Industrial Shocks and Endogenous Gender Norms* (unpublished); and *Local Industrial Shocks and Infant Mortality* (unpublished).

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Introduction

Africa's natural resource wealth first drew the interest of colonial empires and then drove a thirst for independence that has been critical in shaping present day African development. Parts of the continent have benefited from this natural endowment—for example, megacities such as Johannesburg have grown on the sites of gold mines—while other parts of the continent have visibly gained little from their extracted resources. In the decades following independence, several countries failed to reap the benefits from their sub-soil wealth. Ghana, the profitable former Gold Coast Colony, saw gold production plummet at dawn of independence in 1957, and it remained low until the 1990s (Hilson, 2002). In Nigeria, oil revenues often failed to generate increases in economic wellbeing: the nation's oil rich regions experienced ecological disasters rather than human development (Watts, 2004). In stark contrast, Botwana's diamond riches led the country to double digit GDP growth rates from the 1970s and onwards. It has been argued that Botswana's institutions, including pre-colonial and early colonial institutions were pivotal in determining this success story (Hjort, 2010; Acemoglu, Johnson, and Robinson, 2003).

The last two decades have seen a new natural resource revolution take place in Africa. The continent's opportunities for high economic growth are being transformed by new discoveries of natural resources—oil, natural gas, and minerals—and rising commodity prices. The extractive sectors are the receiving the largest share of foreign direct investment and they contributed to two-thirds of total export growth between 2002 to 2012 (Chuhan-Pole et al., 2013). The inflow has been driven by a supercycle of mineral prices, growing demand from emerging markets such as China, and the never-ending need for energy sources. But what will this revival of the natural resource sector bring for African economic development?

Noted development scholar Paul Collier argues that Africa's natural resources can provide an exceptional opportunity for growth—if managed correctly (Collier, 2010). To ensure that the extractive industries bring wealth, governments need to focus on discovering, exploiting, taxing, and investing while maintaining strong political institutions (Collier and Laroche, 2015). However, few countries have followed this example to date. In contrast, the list of adverse effects is long. Dependency on natural resource exports makes countries vulnerable to world market price shocks. Price and production shocks can drive social and political instability. And as the extractive wealth is non-renewable, countries risk losing their most important income stream if no new discoveries are made.

The extractive sector's ability to generate sustainable economic development has long been disputed: is there a macro-economic natural resource curse (Sachs and Warner, 2001)? The resource curse predicts that natural resource extraction leads to over-specialization of the economy in this volatile and depletable sector. It also predicts that discoveries lead to political instability due to elite capture of rents (Leite and Weidmann, 2002) and conflict over resources[1]. Moreover, under conditions where there are gender segregated labor markets and Dutch disease effects, it has been hypothesized that the sector can result in a male-focused economy, with little demand for women's labor supply (Ross, 2008).

On the other hand, history shows that good governance of natural resource income can lead to sustained growth. Upon the discovery of diamonds in Botswana, the country quickly went from being one of the poorest countries in the world in the late 60s to having sustained double digit growth. The country had an average growth rate of 7% over 40 years (Hjort, 2010). Botswana as a case study proves that extractive industries can bring economic development also to poor countries.

[1]See van der Ploeg, 2011 for an overview.

However, cases like Botswana are the exception rather than the rule. There are numerous examples of countries in Africa failing to collect a significant share of the natural resource income. Zambia, a country heavily reliant on copper exports, received just 1.5% of the value of these copper exports through corporate tax (Standing and Hilson, 2013). The average royalty rate for gold mines in Africa was only 3% in 2010 (Gajigo et al., 2012). Ghana increased the rate to 5% in 2010, and more countries are likely to follow and renegotiate current rates[2], leading to increased hopes for sustained, inclusive growth.

The effects of extractive industries on local communities is less researched, but often assumed to be negative. Recent advances in data collection, such as geo-cordinated household surveys and the introduction of natural resource databases with geographic identifiers, have made this research agenda possible. In the seminal development economics book "Strategy of Economic Development" (1958), Albert O. Hirschman argued that the extractive industries are enclaves with few benefits for the local economy. However, 57 years later, we have identified that there are in fact spillovers and we have begun to learn about their economic importance and the welfare effects on local populations. Localized effects have been demonstrated in recent evidence from the U.S. (for natural gas, e.g. Allcott and Keniston, 2014, for coal e.g. Black et al., 2005), gold in Peru (Aragon and Rud, 2013), oil in Brazil (Caselli and Michaels, 2013), copper in Zambia (see Wilson 2012), and other resource abundant areas.

This dissertation attempts to understand the local welfare implications of one of the major extractive industries: the large scale mining industry. The research focuses on Africa which with a long tradition of large-scale mining and a diverse mining sector. Despite this, when I commenced this research in 2011, evidence from the economic

[2]One important framework for increased transparency within the sector has been defined in the Extractive Industries Transparency Initiative (EITI) which aims at negotiating fair deals and redistribution of funds. More info at https://eiti.org/eiti.

literature on the implications of large-scale mining on local African economies was scarce. The evidence of how the industry affects even was even more rare. One notable exception was Wilson's excellent study (Journal of Health Economics, 2012) that found that sexual risk taking behavior of young adults decreased in copper mining towns during the mining boom in the early 21^{st} century. The evidence has continued to grow, and there is now a body of research exploring the effects of large scale mining on local labor markets (Kotsadam and Tolonen, 2016 forthcoming in World Development), health (von der Goltz and Barnwal, 2014), the environment (Aragon and Rud, 2015), and social conflict (Berman et al., 2014) around the world.

The idea that large-scale mining operations have no effects on the livelihoods of local populations, including women, is quickly becoming less credible. Figure 1 shows the effect of large-scale mining on the local economies comparing the near vicinity of mines (the treatment group, defined as within 10km) with further away (the control group, defined as within 30-50km). As sometimes claimed by experts in the field, local economic effects are found during the investment phase (gray shaded area) which is two to three years before production start. By the time the mine opens (the red vertical line), the local economy has already seen a boost in night light intensity. The geographic extent is yet to be fully understood. It will likely depend on numerous factors, including population density, market integration, road networks, and commuting distances. In some cases, the effects may be limited to a 10 kilometer area around the mine, in others, they may reach beyond 20 kilometers from mine center point.

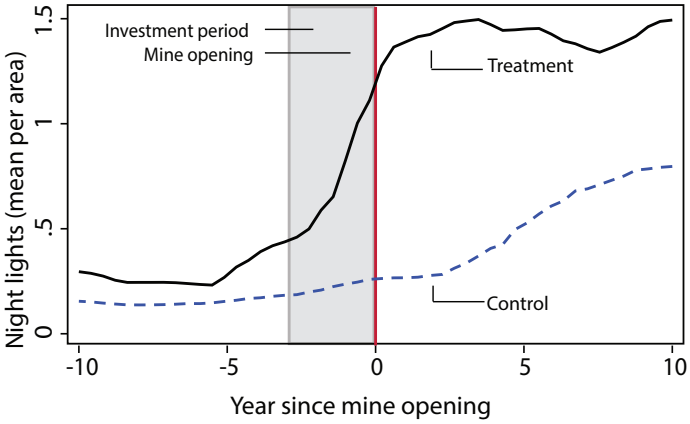

Figure 1: Night Lights Around Gold Mines

Notes: Non-parametric estimates of night lights within 10km and 30-50km from gold mines. Horizontal axis shows year since mine opening, and the red vertical line shows the mine opening year. The sample of gold mines comes from the paper Local Industrial Shocks and Infant Mortality.

The dissertation "Mining Booms in Africa and Local Welfare Effects: Labor markets, Female Empowerment, and Criminality", explores the effects of large scale mining in three related but independent chapters: labor market effects across the African continent, women's empowerment and infant health in gold mining communities in West and East Africa, and the last chapter analyzes the link between criminality and mining in South Africa. The dissertation brief will focus the gender effects of the industry. The chapter on the link between criminality and mining in South Africa will not be discussed.

Using large household survey data sets and official data, I employ quasi-experimental research designs and techniques of spatial econometrics to identify the causal effects of large scale mining on local welfare. The dissertation brief will focus on explaining the methods and the findings of these research papers, to help inform development policy

within the extractive industries.

The industrial mining data used in the research contains information on large-scale mining operations, but omits all artisanal and small-scale mining operations (ASM). ASM may be a confounding factor but as there are no suitable records of legal and illegal ASM activities it is not impossible separately analyze the two sectors. Artisanal and small-scale mining is part of the land use prior to the establishment of a large-scale mine in some but not all areas, and for some minerals but not others. The relationship between small and large-scale mining is not clear-cut. The establishment of a large-scale mine can crowd out small-scale activities, not affect the small-scale sector, or increase ASM activities if the latter uses the scrap material from the large-scale mine. It is unknown which one of these three scenarios is the most common. The effects of small and large-scale mining sectors may be very different. Women are strongly represented in some artisanal mining in Sub-Saharan Africa, for example in gold processing. Large-scale mining might thus be less inclusive than the artisanal sector. The health effects are different as the production methods vary between the two sectors. For example, small-scale gold mining is associated with mercury pollution — the mercury is used in the traditional amalgamation process to separate the gold from the ore — which can be a threat to fetal development and child health, whereas large-scale mining uses cyanide for the same process. The research papers further discuss how ASM may impact the interpretation of the results found.

Mining and Women's Employment

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. In addition, 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 effects in Sub-Saharan Africa. First, the manufacturing sector in rural SSA is small (see Bigsten and Söderbom 2006 or Isham et al. 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 the region, but underrepresented in production and manufacturing, as shown by data from ILO's Key Indicators of the Labour Market database (ILO 2011).

Data and Methods

In the paper African Mining, Gender and Local Employment (Kotsadam and Tolonen, 2016), we perform the first cross-national study testing these hypotheses with micro-data. We use the rapid expansion of large-scale mining in Sub-Saharan Africa to analyze local structural shifts and the role of gender in determining outcomes. We match 109 openings and 84 closings of industrial mines to survey data for 800,000

[3]Fafchamps and Söderbom (2006) use data from nine Sub-Saharan African countries and find that the proportion of female workers is only 12 percent in manufacturing firms. The manufacturing sector in Sub-Saharan Africa 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.

individuals and exploit the spatial-temporal variation. The mining production data is available for more than 800 industrial-scale mines, and the household surveys come from Demographic and Health Surveys (DHS). The combination of data gives us a unique datasets with more than half a million surveyed women, and their 300,000 partners living in 29 countries. The data set enables us to investigate local spillover effects on employment in a so called difference-in-difference method, which compares outcomes in a treatment and control group, before and after an event. The model flexibly controls time-invariant differences between countries and sub-national regions, such as mining strategies, institutions, level of economic development and gender norms, assuming that these do not change over time.

Figure 2 shows 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. Figure 3 shows the trends in service sector employment for women within 20 kilometers and those between 20 and 200 kilometers from a mine. The treatment group (defined as women living close to mines) follows a similar trend as the control group (defined as women further away) in service sector employment until mine opening, but at a lower level. Service employment increases sharply once the mine opens. 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.

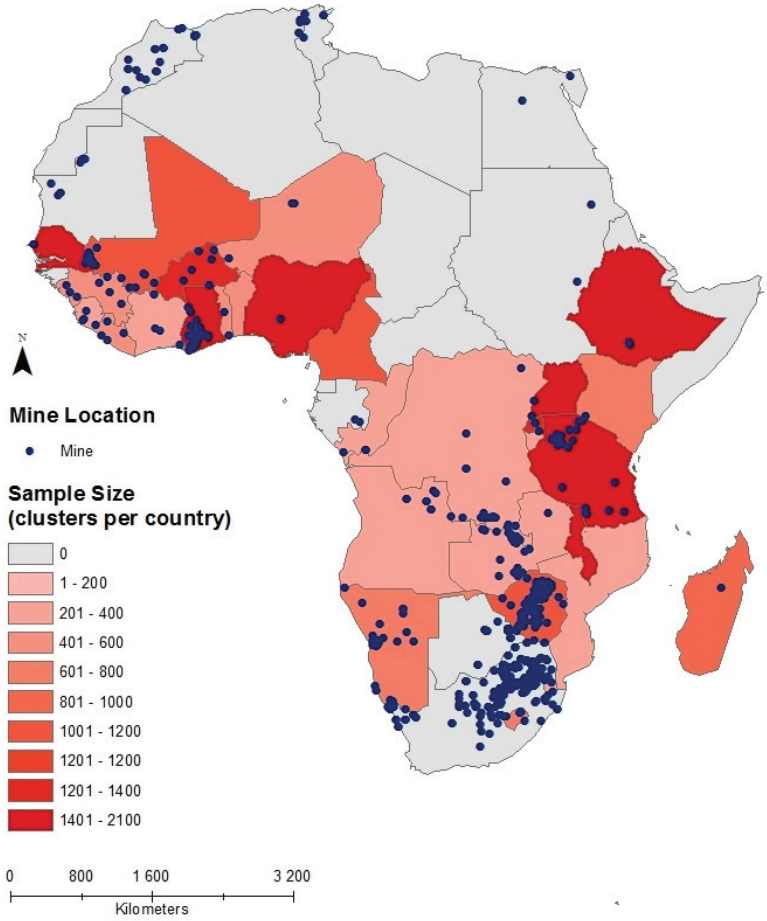

Figure 2: Mines and DHS Clusters by Country

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.

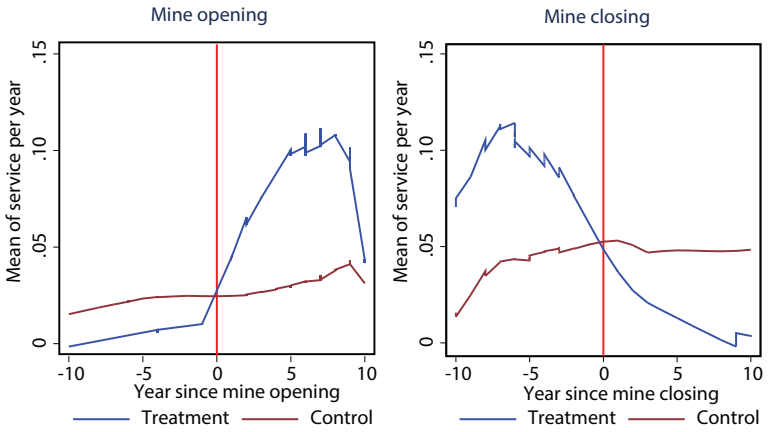

Figure 3: Trends in Service Sector Employment

Mixed blessing for women

The analysis shows that industrial mine openings are a mixed blessing for women. Mine openings trigger local structural shifts whereby women shift from agricultural work to the service sector, or out of the labor force. More women leave self-employment in agriculture (7 percentage points, or 25% decline) than enter into services (2 percentage points, or 50% increase). However, the service sector jobs are less seasonal and cash earnings opportunities increase with 7.4 percentage points (16%). Figure 4 shows the effects by distance. Women have higher chances of working in service sector jobs within 10 and 20km from a mine (Figure 4A), and seem to be shifting from agricultural employment (Figure 4B). 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. Analyzing these women's partners, we find that the labor market shifts are gender-specific. Male partners shift to skilled manual labor, and some find jobs within mining.

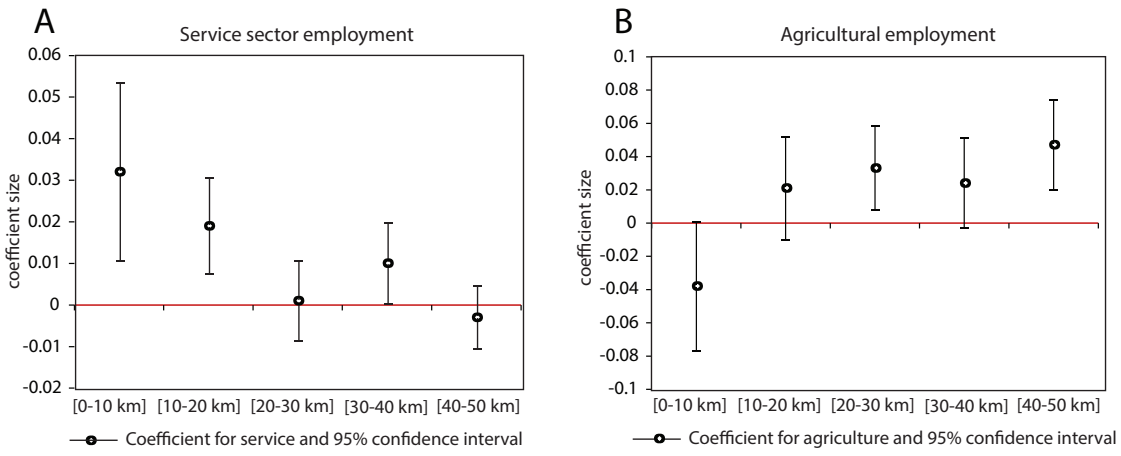

Figure 4: Spatial Autoregressive Model for Women's Service Sector and Agriculture Employment. Using Distance to Closest Active Mine

The effects of mine closings 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 the time of mine suspension. Women shift from the agricultural sector when the mines open. The results indicate that the localized structural shifts spurred by mine openings are not reversible for women: women are inhibited from going back to agricultural production after a mine closing. In contrast, male partners increase agricultural self-employment after mine closings, but experience a contraction in skilled manual and agricultural employment. The permanent decrease in women's labor market participation could be because men's labor opportunities are prioritized when jobs are scarce.

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. 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.

There are large and persistent differences in value added per worker in agriculture and non-agricultural sectors in developing countries (Gollin et al. 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 results indicate that large-scale mining is creating boom-bust economies with gender-specific effects.

Gold Mining and Endogenous Gender Norms

The finding that large-scale mining booms affect women's welfare raises further questions about how this might effect women's welfare. Does intra-household bargaining power change with the new employment? Does marriage market outcomes and fertility change? Do women become more empowered and are they less likely to accept domestic violence? These are the questions that I try to answer in the following chapter. The paper "Local Industrial Shocks and Endogenous Gender Norms" (Tolonen, 2016) explores how African gold mining shape gender norms.

Gender norms are important determinants for the success rate of development polices which has motivated gender targeted interventions, for example cash transfer

programs to mothers, microcredit loans to women, and vocational training programs for young girls. Recent evidence show that traditional gender practices such as the bride price tradition can be instrumental in increasing the uptake of schooling for girls (Ashraf et al., 2015). To some extent, current gender norms and beliefs can be traced back to historic adoption of an agricultural innovation—the plough—which affected the gender division of labor (Alesina, Giuliano and Nunn, 2011).

Gender norms may, however, change with economic development. In the cross-section, comparing most countries in the world, developed countries are more gender equal than developing countries (Jayachandran, 2015; Doepke, Tertilt and Voena, 2012). This correlation does not tell us the causal chains. It is hard to disentangle the cause and effect of gender norms in part because of nebulous definitions of gender norms and gender relations that span both the ideological and material (Agarwal, 1997), and because they reinforce each other (Duflo, 2012). In the research paper, I define gender norms broadly to include measures of attitudes, constraints, and intra-household bargaining power. To understand how economic development changes gender norms, I analyze the expansion of the large-scale gold mining industry as a quasi-experiment. Importantly, this industry is not dependent on women's labor supply which reduces the concern for reverse causality. Other industries that are more heavily relying on women's labor, such as the textile industry, would be less suitable to analyze as it would be hard to exclude that local changes in gender norms caused the expansion of the industry.

Large-Scale Gold Mining in Africa

The last decades saw a supercycle of commodity prices which led to a rapid increase in large-scale gold mining in African. This context gives us a "quasi-experiment" that allows us to isolate the causal effect of local industrialization on gender norms. As dis-

cussed previously, large-scale gold mining is a suitable industry to study this question. One reason is that investment decisions are independent of local population characteristics and determined by geological characteristics (Gajigo et al., 2012). A mineral deposit is the necessary condition for mining, and deposits are random geological occurrences (Eggert, 2002). Open pit gold mining is the dominant form of large-scale gold mining in the region and has a high capital to labor ratio. This means it is plausibly less reliant on the local labor market than many other industries - a fact that is sometimes considered a drawback of the industry as discussed in the introduction. While trying to understand the effect of industrial development on gender norms, this is a positive factor. The last advantage of studying an extractive industry is that it is dominated by large multinational firms (Gajigo et al., 2012), whose operations are to a high degree independent of the local economies in place before the mining. This reduces the fear of reverse causality, which in this case would be that changes in local gender norms spur the onset of large-scale mining.

To measure the effect of large-scale gold mining on gender norms I use individual level data on 50,000 women in the ages 15 to 49. They are surveyed between 1993 to 2012 in eight different countries (Burkina Faso, Cote d'Ivoire, Ethiopia, Ghana, Guinea, Mali, Senegal, Tanzania, illustrated in Figure 5). The data is repeated cross-section, so the same woman is not interviewed twice. The data include questions on justification of domestic violence, access to health care for self, and final say in household decisions. In addition, I explore effects on variables associated with female empowerment such as labor market outcomes (similar to Kotsadam and Tolonen, 2016), marriage formation, schooling and fertility. However, the distinction between gender norms and female empowerment is not clear-cut and I sometimes use them inter-changeably.

Gender Norms and Female Empowerment

I define gender norms broadly, encompassing three questions measuring gender relations: justification of wife beating, constraints to seek health care for oneself, and final say in household decisions. The domestic violence attitude questions are of the type: "In your opinion, is a husband justified in hitting or beating his wife in the following situations: *example*", and for access to healthcare: "Many different factors can prevent women from getting medical advice or treatment for themselves. When you are sick and want to get medical advice or treatment, is each of the following a big problem or not? *example*".

Gender relations is a term for the power dynamics between men and women, both in the ideological and material realms (Agarwal, 1997). The literature on gender relations is nebulous regarding the terminology and definitions: it refers to gender asymmetries, gender relations, gender roles, gender role attitudes, gender beliefs, gender differences, gender disparities, gender inequality, gender bargaining power, gender norms, gender identity norms, social norms and perceptions, as well as intra-household dynamics, intra-household bargaining power, household balance of power, female empowerment, and women's status (Agarwal, 1997; Albanesi and Olivetti, 2016; Alesina et al., 2011; Ashraf et al., 2010; Ashraf et al., 2014; Balk, 1997; Basu, 2006; Bertrand et al., 2015; Hiller, 2014; Farre and Vella, 2013; Komura, 2013), to name a few. Moreover, gender norms—such as those relating to fertility—have also been equalized with "culture" (Fernandez and Fogli, 2006), a concept notably hard to define (Fernandez and Fogli, 2009).

We have limited understanding on how gender norms form, are maintained, and under what conditions they change (Agarwal, 1997). There are two main limitations of this study. First, because I am studying an aggregate economic shock it is impossible to determine causality running between different indicators. That is, I am not be

able to say if increases in labor force participation changes justification of domestic violence, or if changes in justification of domestic violence spur increased female labor force participation. Second, the data focus on women and I have little information on how gender norms held by men change. I will not be able to answer the question if gender norms held by men cause or are caused by changes in gender norms held by women.

The paper adds to the literature on economic development and gender norms, which on the link between female work participation and female empowerment from a theoretical (Basu, 2006; Hiller, 2014), and empirical point of views. Empirical studies using household data have also studied the role of own earned income and intra-household bargaining power and female empowerment (see for example Baird et al., 2011; Bandiera et al., 2014; Heath and Mobarak, 2015). A second strand of literature explores how media changes gender norms in developing countries (Jensen and Oster, 2009; La Ferrara et al., 2012). Third, the paper adds to the literature on extractive industries and local welfare (Aragon and Rud, 2013; Aragon and Rud, 2015; Asher and Novosad, 2014; Berman et al., 2014; Chuhan-Pole et al., 2015; Corno and de Walque, 2012; Fafchamps et al., 2015; Loayza et al., 2013; Kotsadam and Tolonen, 2016; von der Goltz and Barnwal, 2014; Wilson, 2012), summarized in the review paper by Cust and Poelhekke (2015). This is the first paper within the aforementioned literature to explicitly explore how the extractive industries affect gender norms and female empowerment.

Methods and findings

The main empirical strategy is a difference-in-difference approach which means a comparison of the evolution across a treatment and a control group - where only the treatment experience a mine opening. I use spatial variation to define treatment and control

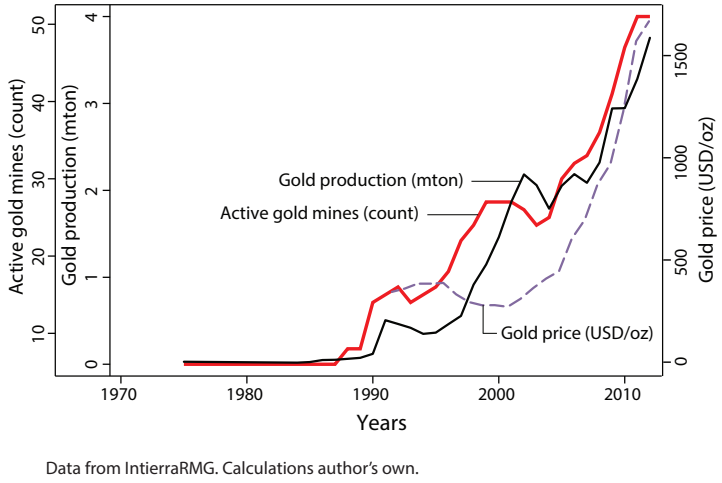

Figure 5: Illustration of the natural experiment

- where the control group is drawn far away from the gold mine, and temporal variation which is the mine opening year to define the pre-treatment and post-treatment status. The model will control for initial differences in development between the treatment and control villages. The model will flexibly control for country-wide shocks and district-wide characteristics. I also use the international gold price in an alternative model as a measure for mining intensity.

The results illustrate that gender norms change rapidly with local economic development. With the local boom in gold mining, the justification rate of domestic violence decreases by 19% from a high baseline with more than 40% of women justifying violence. After the expansion in large-scale gold mining, women have better self-stated access to healthcare. The latter is measured by a 23% decrease in barriers to access, including getting the permission to seek healthcare when needed. The magnitudes of these effects are large - all else equal, with a large-scale mine the justification of domestic violence decreases with the equivalent of receiving 5.8 extra years of schooling. The mean years of schooling in the sample is 2.95 years, and thus amounts to an effect equivalent to doubling of schooling among women. The change in barriers to access

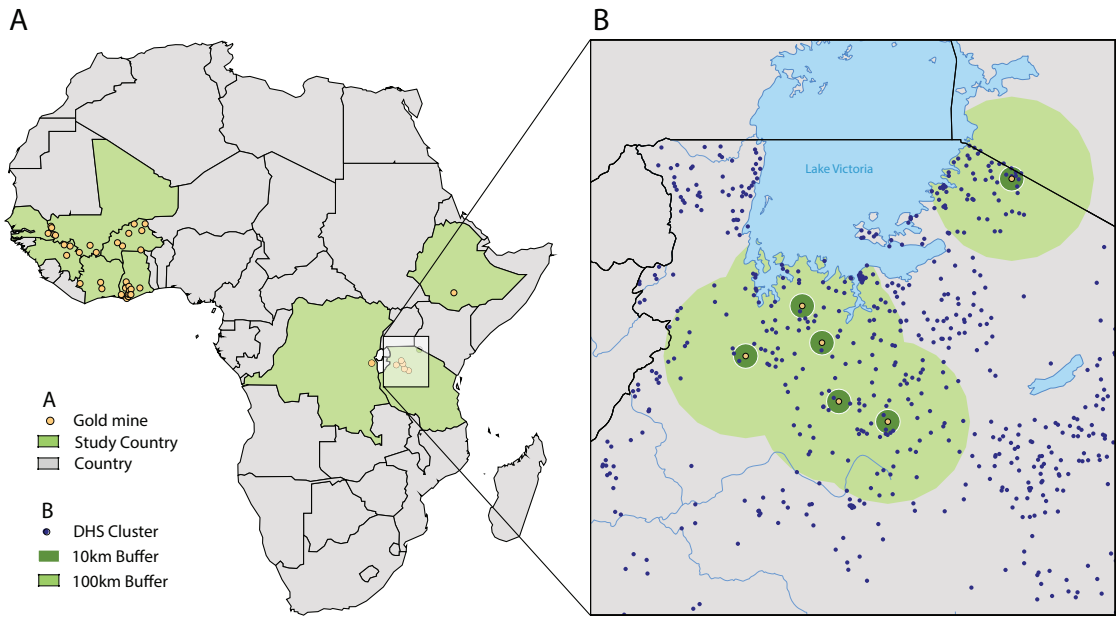

Figure 6: Map of Gold Mines and DHS Clusters in Northwestern Tanzania

healthcare for self is larger at 8.7 years of schooling. The largest changes in these attitudes are found among younger women, but also for this subgroup can I rule out that the effects are coming through increased schooling. The only change is schooling outcomes is that women are marginally more likely to marry men with more education.

An alternative explanation is that women's exposure to non-traditional gender norms increase. In fact, I find that women have better access to radios and more likely to listen to family planning radio shows. They are also more likely to read about family planning in the newspaper. Previous evidence from India and Brazil show that media access, such as cable TV connection (Jensen and Oster, 2009), and soap operas (La Ferrara, Chong and Duryea, 2012) change women's empowerment.

Contrary to the hypothesis that the male-dominated mining sector increases men's bargaining power within the household, I find no effects on decision-making power between spouses, nor changes in marriage formation, such as likelihood that the marriage

is polygamous, age at marriage, or age gap between partners. Selective migration of women with more gender equal norms cannot be ruled out, however, I confirm that women born in the communities are, alongside their migrant peers, less likely to justify domestic violence and more likely to work in the service sector. It is possible that inward migration of men and women with more pro-female norms increased local women's exposure to less traditional norms, resulting in norm shifts. Because the norms of migrant women and men cannot be observed prior to the migration decision, it is however not possible to test this hypothesis.

Gold Mining and Infant Mortality

In a third and similar paper "Local Industrial Shocks and Infant Mortality" (Tolonen, 2016b), I explore if the changes in local economic growth, women's employment and empowerment affect infant mortality rates. The data and methodology used are the same as in "Local Industrial Shocks and Endogenous Gender Norms" (Tolonen, 2016a), focusing on large-scale gold mine in sub-Saharan Africa.

Reducing infant mortality is part of the newly adopted Sustainable Development Goals. One in nine children in developing countries does not survive until its fifth birthday[4]. Sub-Saharan Africa is the region with the highest average rate of child mortality. It will be a challenge for several countries in the region to achieve the sustainable development goals for infant mortality—12 neonatal deaths and 25 deaths under the age of 5 per 1000 live births—by 2030. Especially countries in Central and West Africa are not on-track to meet the target (Wang et al., 2014).

Poverty and underdevelopment are causes for the high child mortality rates. Curable and preventable conditions—lower respiratory infections, diarrhea, malaria (Black

[4]Millennium Development Goals, Child Mortality, The World Bank, 2014. See http://www.worldbank.org/mdgs/child_mortality.html)

et al., 2003; Dupas, 2011), and malnutrition (Black et al., 2013)—are among the leading causes for the mortality rates. Maternal and early-life undernutrition alone are responsible for 45% of the global child mortality (Black et al., 2013). Environmental conditions including airborne and waterborne pollution are negatively affecting infant health in developing countries (Greenstone and Hanna, 2014; Jayachandran, 2009). It has been argued that the poor environmental quality in developing countries come from high marginal utility of income. When facing a budget constraint, poor households prefer consumption today over investing in environmental quality (Greenstone and Jack, 2015).

I explore if large-scale gold mining changes local infant mortality rates in Sub-Saharan Africa. The effect is a priori ambiguous: on the one hand it can increase infant mortality rates by polluting the environment (Aragon and Rud, 2015). On the other hand it can reduce it by bringing economic development (Aragon and Rud, 2013; Kotsadam and Tolonen, 2016). The effect of the health-wealth trade-off on infant mortality in the region is an open empirical question. While environmental pollution—large-scale gold mining is associated with arsenic, cyanide and other heavy metals—has negative health effects, it is possible that such negative effects are of second order importance in areas with high rates of child mortality due to poverty and malnutrition.

Data and Methods

The quasi-experiment at hand is the expansion in large-scale gold mining across nine African countries — Burkina Faso, Cote d'Ivoire, Democratic Republic of Congo, Ethiopia, Ghana, Guinea, Mali, Senegal, Tanzania, illustrated in Figure 5. This allows us to understand how infant mortality rates change with local industrial development. As discussed previously, the large-scale gold mines analyzed open up in poor, rural areas. This is illustrated by the higher mortality rate (with an average of 151 per 1000

live births) in the gold mining communities in the years before the mining starts.

I construct a dataset of 37,365 children born within 100 km of a mine by combining data on women's fertility records from Demographic and Health Survey (DHS) and large-scale gold mining data. Combining the two data sources using geographic information at the village/neighborhood and mine level, I construct several measures of proximity to mines. The papers define a control and treatment group similarly to the previous article discussed, using the spatial variation in distance to mine. However, the data is not at child level, rather than woman level. The outcomes for children in the treatment group, i.e. close to mines, are contrasted to those for children born further away. As in the earlier paper, the method flexibly controls for unobservable differences between countries and sub-national districts including culture, religion and ethnicity, as well as countrywide shocks and time trends within the subnational districts. Pre-mining trends are similar across the treatment and control groups, as illustrated by Figure 7, but there is a clear deviation from this trend around the time of the first year of gold production.

Large reductions in local infant mortality rates

As illustrated in Figure 7 there is a clear deviation from the trend around during the investment phase (shaded grey)—communities near large-scale gold mines see large reductions in infant mortality rates. Regression analysis confirms that infant mortality rates decrease with 50% within a few years from the start of the industrial gold mining. The effects are strongly localized - the change is experienced in communities within 10km from the mine center point. This is also the area with the starkest changes in local economic growth and job creation. Migration of households with better child health outcomes could be a mechanism explaining this effect. However, the results are fairly robust to the exclusion of children born to migrant women. Excluding all

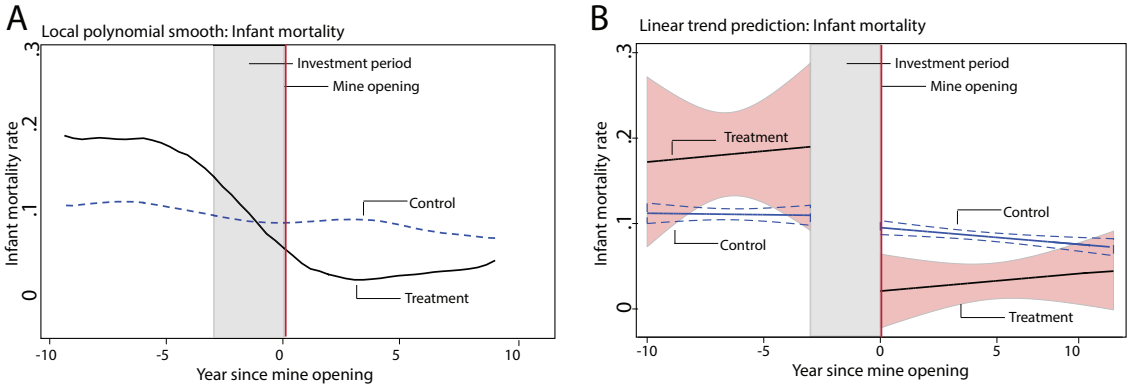

Figure 7: Local polynomial smooth estimation of infant mortality trends (A) and Linear trend analysis of infant mortality (B)

Notes: Years since mine opening is on the horizontal axis, ranging from ten years before mine opening to ten years after mine opening. The treatment group is drawn within 10 km from the closest mine, and the control group 30-50 km from the closest mine. Figure B provides 95% confidence intervals. In contrast to the main specification, there are no control variables, and only the opening year of the closest mine is considered.

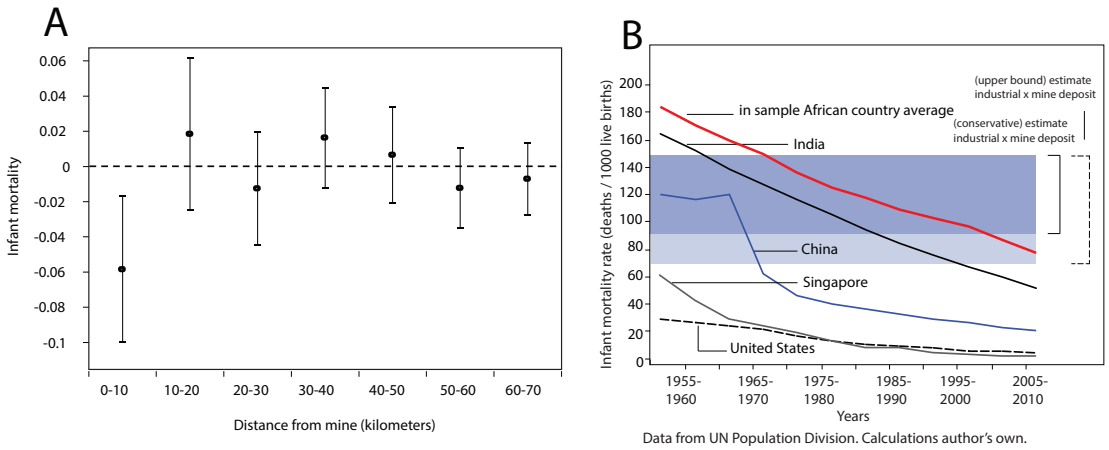

Figure 8: Spatial autoregressive model (A), Trends in infant mortality (B)

Notes: Figure A shows the results from a spatial autoregressive model with 10 km distance bins using the baseline set of control variables and 95% confidence intervals. The data in Figure B comes from UN Population Division and the calculations are the author's own. The data are provided with 5 years averages. The data in Figure B comes from DHS and shows the distribution of infant mortality by district within the sample

Table 1: Main Results

Dependent variable:	infant mortality first 12 months					total fertility	listen to radio family planning	service sector job
Sample:	children	children drop spillover	girls	boys	drop migrants	woman	woman	woman
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
industrial*mine deposit (at birth)	-0.055***	-0.079***	-0.095***	-0.063**	-0.073**			
	(0.019)	(0.026)	(0.036)	(0.032)	(0.034)			
industrial*mine deposit (at survey)						-0.217	0.147***	0.064**
						(0.141)	(0.046)	(0.024)
mine deposit (within 10 km)	0.034**	0.048**	0.064**	0.032	0.043	0.107	-0.070	-0.036
	(0.017)	(0.024)	(0.029)	(0.028)	(0.027)	(0.105)	(0.046)	(0.024)
Country-birth year FE	Yes	Yes	Yes	Yes	Yes	No	No	No
Country-survey year FE	No	No	No	No	No	Yes	Yes	Yes
District linear trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Drop 10-30 km away	No	Yes	Yes	Yes	Yes	No	No	No
Drop investment phase	No	Yes	Yes	Yes	Yes	No	No	No
Drop migrants within 2 yrs	No	No	No	No	Yes	No	No	No
Mean of outcome	0.097	0.102	0.098	0.105	0.113	3.260	0.470	0.233
Mean (treatment, pre-treatment)	0.151	0.151	0.150	0.154	0.151	3.905	0.354	0.120
Observations	37,365	29,221	14,863	14,358	20,623	57,581	46,028	55,944
R-squared	0.101	0.104	0.119	0.123	0.104	0.673	0.204	0.183

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ Clustered standard errors clustered at DHS cluster level. Linear probability models. All regressions in column 1 to 5 control for mother's age, age square, mother's education, urban, child's birth number, and fixed effects for district, birth month, and country-birth year. Outcome is infant mortality in the first 12 months since birth. All regressions columns 6-8 control for woman's age, education, urban, and fixed effects for district and country-survey year, as well as district linear time trend. Mine deposit captures if there is a gold deposit within 10 km from the household. Industrial captures if the gold deposit was actively extracted in the child's birth year, or in the survey year. The investment phase is defined as the two years preceding the opening year and is dropped in columns 2-5. In column 5 children born to mothers who migrated later than two years before the mine opening year are dropped. Mean (treatment, pre-treatment) is the sample mean for the treatment group before the mines were active.

children born to women who moved during of after the mine opening phase does not change the main result.

The measured effect of a new large-scale gold mine on local infant mortality is large, also compared with countrywide trends in infant mortality rates. The drop in the infant mortality rate occurring within one to two years from the first year of production is twice the size of the reduction in the infant mortality rate experienced by Singapore during its two decadal period of record economic growth. The effect is equivalent to the total reduction in infant mortality rates in the African survey countries since 1970 until today. The results illustrate that industrial development brings significant and rapid gains in infant survival rates in high mortality areas.

Conclusions

This dissertation brief has discussed findings from three research articles that explore how large-scale mining industries in Africa can change local welfare, with a special emphasis on the gender effects of the industry. First, we saw that mining affects communities both positively and negatively - it can spur much needed non-agricultural employment. But as total employment decreases, the industry may not be effective in stimulating enough local employment. This is especially true for women. In the long run, as the large-scale mines close down, there is further risk that employment decreases. The newly stimulated sectors contract again, but especially women are not going back to agriculture. The reason for these shifts and gender differential effects should be analyzed further.

In the two following articles, we saw that the expansion of large-scale gold mines generate local economic shocks that have the power to change gender norms and female empowerment. Moreover, they have have strong positive effects on infant survival. Both of these effects stand in contrast to most assumptions made about the industry's effects on women and children. The effects are however less surprising at closer scrutiny - the large-scale mining booms change women's employment, cash earnings and access to media, all known to influence women's empowerment. The infant mortality reductions occur from very high levels - the average infant mortality rate is 15% in the mining communities before the onset of mining - where the margin for health improvement from income are very large. It is not likely that these effects were to be replicated in a low mortality setting. In low mortality areas, for example in middle-income and high-income countries, it is possible that large-scale gold mining causes increases in infant mortality rates.

While these three research papers demonstrate outcomes spanning a range of in-

dicators important in determining social development, it is, however, too limited a set to provide a full cost-benefit analysis of large scale mining investment on welfare. Important indicators for local welfare are not analyzed—environmental degradation, the risks of accidents, health and safety for the miners, relocation, land rights, and measures of equity. A shortcoming of this dissertation is that it remains agnostic as to what best-practice is, and what is the fair level of local social development that ought to be expected from large scale mining investments. Moreover, future research must investigate how large scale and small scale mining can, and do, co-exist, and the long run effects of large scale mining activities. Despite these caveats, the methods and the results in this volume form an important basis for understanding the true social and environmental costs associated with resource extraction on local communities. As societies reliance on the wealth of the earth continues to grow, we must further out understanding of complex industry and understand how we can use these natural endowments for the benefit of all.

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