How much do artisanal miners earn? An inquiry among Congolese gold miners

How much do artisanal miners earn?
An inquiry among Congolese gold miners.

This draft: September, 2020. Author copy

Sara Geenen

IOB – Institute of Development Policy (University of Antwerp).
Lange Sint-Annastraat 7, 2000 Antwerpen, Belgium
e-mail: sara.geenen@uantwerp.be

Nik Stoop

IOB – Institute of Development Policy (University of Antwerp), LICOS (University of Leuven).
Lange Sint-Annastraat 7, 2000 Antwerpen, Belgium
e-mail: nik.stoop@uantwerp.be
Corresponding author

Marijke Verpoorten

IOB – Institute of Development Policy (University of Antwerp), LICOS (University of Leuven).
Lange Sint-Annastraat 7, 2000 Antwerpen, Belgium
e-mail: marijke.verpoorten@uantwerp.be

Acknowledgements

The research was funded by FWO – Research Foundation Flanders (Research grant 1517614N, PhD scholarship 11Q2816N and EOS Project 30784531), and by CEGEMI – Centre d'Expertise en Gestion Minière at the Université catholique de Bukavu. Permission to conduct the research was granted by the University of Antwerp's Ethics Committee for the Social Sciences and Humanities (file nr. SHW_15_06), by the Congolese Ministry of Mines, by SAESSCAM (the Congolese public Service for Assistance to Artisanal and Small-Scale mining) and by the local authorities in Kamituga. This research would not have been possible without the artisanal miners of Kamituga who offered their time to be interviewed; the enumerators (Alex Nyakabasa, Célestin Mukotanyi Munyali, Fortunat, Bamporiki Bisanga, Gabriel Mugisho Dunia, Isidore Barhanywerha Baderhakuguma, John Kadjunga, Jules Nyunda Nkuru, Olivier Rubambura Kabuye, Pascal

Barhanywanywa, Serge Nyembo Charles and Teiggy Birhula Mongane) who worked in sometimes challenging circumstances; the local guides in Kamituga (Belgique Babingwa, Jean Bisimwa, Leonard Kabungulu, Oswald Bilinganene, Paul Aishi Wabutongo and Waluna Itongwa); and Janvier Kilosho who contributed to supervising the data collection. We offer them our sincere gratitude. We further owe thanks to employees of Banro, SAESSCAM, IPIS (International Peace Information Service) and INSO (International NGO Safety Organization) for their assistance and for sharing valuable information and data with us. We received much appreciated comments from Bossissi Nkuba and Ben Radley. All errors and opinions expressed remain ours.

Abstract

Artisanal and small-scale mining (ASM) is acknowledged to provide incomes to tens of millions of individuals around the world, yet systematic data on miners' earnings are lacking. We developed a sampling method and survey tools suited for systematic data collection and applied it to a stratified random sample of 453 miners in the largest mining town in Congo's South Kivu province. Our research design allows us to study how much artisanal gold miners earn, and what determines their earnings. In doing so, we assess the financial attractiveness of artisanal mining, and uncover whether earnings from artisanal mining are merit-based, i.e. determined by experience, expertise and risk-taking behavior, or identity-based. This allows us to test the claim that artisanal mining has a social-levelling effect.

1. Introduction

Artisanal and Small-scale Mining (ASM) provides an income to tens of millions of individuals around the world (Delve 2020). In Sub-Sahara Africa it ranks among the most important non-farm rural income activities (Banchirigah and Hilson, 2010). Its contribution to the economic and social lives of people remains however poorly quantified because of several reasons. First of all, being largely informal and often illegal, the activity is barely captured in national accounts (Mwaipopo et al., 2004; World Bank, 2019). Second, the high variability in earnings combined with miners' reluctance to declare them, and the poor accessibility of several ASM sites present major challenges for carrying out micro-level surveys (World Bank, 2019).

Prominent scholars on artisanal mining have argued that this data gap keeps the sector invisible, thereby contributing to its marginalization by policymakers (Hilson, 2019, 2005; Hilson and McQuilken, 2014; Labonne, 2014; World Bank, 2019). Systematic and accurate data on ASM can help inform governments about the true development and poverty alleviating potential of ASM (Hilson and Maconachie, 2019). It can further inform relocation, reorientation and compensation programs. The need for such programs has increased since the early 2000s due to increased investments of large-scale mining companies in areas occupied by artisanal miners; but they have lacked effectiveness, in part due to poor baseline information (Carson et al., 2005; Hilson, 2005; Perks, 2011).

A recently launched initiative, *Delve*, seeks to build a global data platform on ASM, ultimately aiming at the recognition of ASM as an important contributor to global development and better policy making (Delve 2020). This initiative, taken by the World Bank and the nonprofit organization Pact, has among others resulted in more accessible and up-to-date information on the number of artisanal miners, as well as an open-access survey tool to stimulate the collection of standardized information on ASM populations (Delve 2020).[1] The latter does not, however, contain questions that probe into miners' income.

Our contribution is twofold. First, we make a methodological contribution to the measurement of ASM incomes. We aim at a best estimate of miners' earnings, asking four different questions and triangulating answers across these questions. We further use a 'ladder of life' approach to compare miners' earnings with earnings from the main alternative economic activity: agriculture. To

[1] https://delvedatabase.org/resources/tool-asm-standardized-survey-questionnaire.

promote systematic data collection on ASM, we carefully present our sampling and measurement method, and make our survey-tool and data publicly available.[2] Second, we contribute to the debate on the development potential of ASM. By studying how much miners earn, we assess the financial attractiveness of artisanal mining. The individual-level survey data further allow us to identify the determinants of miners' income (identity-based or merit-based) and test a claim that has been made in the ASM literature, namely that ASM - with its low barriers to entry and relatively egalitarian norms - has social levelling potential and provides an opportunity for upward mobility in a rural social landscape that is otherwise largely characterized by social immobility (Bryceson and Fisher, 2014; Bryceson and Geenen, 2016; Engwicht, 2018; Stoop and Verpoorten, 2020; Van Acker, 2005).

We conduct our study in the Democratic Republic of Congo (DRC), home to an estimated two million ASM workers[3], thereby occupying the third place worldwide in terms of the absolute number of people working in ASM (Delve 2020). Eastern DRC (North and South Kivu province, former Orientale and former Katanga) in particular hosts at least 382,000 artisanal miners across 2,700 sites, 66% of which are digging for gold (Matthysen et al., 2019). The region is also characterized by poor road infrastructure, persistent insecurity, and a deficient administration, thus providing us with a 'hard case' for systematic data collection. Our study focuses on Kamituga, the largest gold mining town in South Kivu province, where about 15,000 artisanal miners were operating at the time of our survey in 2015.

In the next section, we review studies that have provided estimates on artisanal miners' income and its determinants. Section 3 describes our case selection rationale and research methods. Section 4 presents descriptive statistics, followed by a multivariate analysis of earnings' determinants in Section 5. Section 6 discusses our main findings, while Section 7 presents a brief conclusion.

2. Quantifying artisanal mining

According to the Delve data platform, 40.2 million people were working in ASM anno 2017, among which 30% women (Delve 2020).[4] Sub-Sahara Africa counted almost 12 million ASM

[2] The survey instrument and data can be consulted on www.nikstoop.com.
[3] Most publications remain vague about whether they include only pit workers (miners directly involved in mineral extraction) or also site workers (workers involved in processing, transport, etc.). In this article, 'miners' refer to pit workers only.
[4] The DELVE platform refers to the following secondary sources: Buxton (2013); Dorner et al. (2012); IGF (2018); ILO (1999) and United Nations (1993).

workers, among which two million are based in DRC (Delve 2020). Multiplier effects are poorly quantified, but are thought to range from three to seven jobs for every person engaged in ASM (Phillips et al., 2001; World Bank, 2019). In contrast, large-scale mining in developing countries only provides about two million jobs (Tibbett, 2009). Furthermore, despite the existence of some multiplier effects through indirect and induced jobs (World Gold Council, 2015), large-scale mining struggles to establish linkages with the local economy (Bazillier and Girard, 2020; Cassimon et al., 2016), and has lower poverty-reducing effects compared to agriculture, transport services and agro-processing (Christiaensen and Martin, 2018). Gold is estimated to account for about half of all ASM operations worldwide, and while providing only 12% to 20% of the total global gold production, artisanal and small-scale gold mining (ASGM) is estimated to create up to 90% of total employment in gold mining (IGF, 2018; Levin, 2014; Seccatore et al., 2014; Verbrugge and Geenen 2020).

Given the wealth of academic ASM research that has emerged over the past decade, the lack of systematic quantitative data on earnings is astonishing. Even recent studies that set out to assess ASM's impact on livelihoods (Barreto et al., 2018) or that make a case for ASM's contribution to the Sustainable Development Goals through employment and wealth creation (Hilson and Maconachie, 2019), remain vague on earnings. The few available academic estimates on gold earnings come from Tanzania, Burkina Faso, Ghana and the DRC.

For Tanzania, Bryceson and Jønsson (2010) put forward an estimate of about $150 monthly income, on average, for a sample of 108 small-scale miners, but with very wide variation (going from close to $0 to over $500). For one mining site in Burkina Faso, Luning (2008, p. 194) estimates daily earnings between $7.50 and $9.50, but she does not specify her methodology to arrive at these numbers. Based on in-depth interviews with 52 artisanal gold miners in southwestern Ghana, Bansah (2019) estimates monthly earnings around $250, ranging between $163 and $1,220. Also in Ghana, Owusu et al. (2019) put monthly earnings between $205 and $1028, while Bansah et al. (2016) present some more diversified data of earnings for different categories of ASM workers. However, neither of the latter papers provides detailed information on what underlies these estimates.

Turning to eastern DRC, a survey in Orientale Province, carried out by Channel Research and Pact and cited in Perks (2011, p. 1122) puts average monthly earnings for gold miners between $80 and

$150. Based on a (non-representative) survey among 258 gold pit managers in South Kivu[5], Geenen (2014: 174) estimates that pit workers earn between $36 and $118 per month during preparatory periods, and between $128 and $195 during periods of high production, while pit managers earn between $1,180 and $6,226 per month during periods of high production. Radley (2020, 2019, pp. 92–93), based on 2016-2017 financial logbooks collected from pit managers in one gold mine in South Kivu, arrives at an estimated average of $163 per month for pit workers, and $1,674 for pit managers. Research by IPIS (2014) indicates that gold miners earn on average between US$ 70 and 105 per month. Just recently, IPIS with Levin Sources and Fairphone published the results of their study on tin miners' earnings in North and South Kivu (de Brier et al., 2020). Relying on a combination of mine-level data collected over the period 2009-2018, and a non-representative survey with 93 individuals (washers and diggers) carried out in two cassiterite mines in November 2019, they find that tin miners earn on average between $71 and $86 per month. According to the authors, these earnings do not allow a miners' household to cover a basic needs expenditure basket, but are higher than those of the general population in the country (de Brier et al., 2020, p. 48).

Even when ASM earnings are not specified, many studies mention that the latter compare favorably with income from other economic activities, farming in particular (Banchirigah, 2008; Banchirigah and Hilson, 2010; Barreto et al., 2018; Carson et al., 2005; Cartier and Bürge, 2011; Hilson, 2011; Perks, 2011; Tschakert, 2009). Fisher et al. (2009), studying gold and diamond mining in the Mwanza region of Tanzania, report that people working in mining are less likely to be poor than people with other occupations. Phillips et al. (2001) mention that in Tanzania "the basic income in mining towns (reservation wage) was about six times what rural men could earn doing farm labor".[6] Similarly, Radley (2019, p. 92) states that in South Kivu ASGM earnings are higher than farmers' ($1 per day) and teachers' ($30 to $50 per month).

In sum, some scattered data on artisanal miners' earnings are available, but these have largely been based on qualitative research or non-representative quantitative surveys. Admittedly, rigorously estimating ASGM earnings involves major challenges. First, several authors mention reluctance on the part of miners to report earnings (Bryceson and Jønsson, 2010; Geenen, 2014; IPIS, 2014; Stoop and Verpoorten, 2020). Because of the generalized informality of ASGM activities, miners

[5] The survey was carried out in 2011 in four mines (47 respondents in Kamituga, 127 in Lugushwa, 18 in Mukungwe and 66 in Luhwindja).

[6] The method used to arrive at this conclusion is not specified in Phillips et al. (2001). But, if one assumes a daily wage of $1 for agricultural labor, and 25 working days per month, this would amount to $150 per month.

may tend to underreport their earnings. This invokes a need to come up with creative methods, such as asking for reservation wages (see below), expenditures (Bryceson and Jønsson, 2010) or using financial logbooks (see Radley, 2019). Second, miners' earnings vary over time, depending on endogenous factors such as the availability of labor, technology and financial resources as well as the life cycle of the mine, or exogenous factors such as weather conditions and world mineral prices. Third, earnings vary across different categories of mining work, ranging from relatively low-skilled to high-skilled, specialized labor. Finally, miners are remunerated with a fluctuating combination of payments in kind and in cash. Hence, any estimate should be duly contextualized; and a large number of estimates, under varying circumstances, are needed to provide meaningful insight into miners' earnings.

3. Methods

In this section, we present our rationale for selecting Kamituga as a case study and give relevant background information. We also describe our field work methods, from the sampling to the survey design and implementation. Finally, we explain how we measure artisanal miners' earnings and its determinants.

3.1. Case study

Kamituga is located in the center of South-Kivu province, in the territory of Mwenga (see Figure 1). According to estimates carried out in 2013, gold production in Kamituga amounts to 618 - 840 kilograms per year, or 12% to 17% of the provincial total of 4,800 kilograms (Geenen, 2014, p. 58). Besides its importance in terms of gold production, three practical reasons guided our choice: accessibility, safety and familiarity. First, located at 180 km of the provincial capital Bukavu, the site is relatively well accessible by Route National 2. Second, even though more than seventy armed groups were active in eastern DRC in 2014-5 (Stearns and Vogel, 2015), travelling to Kamituga was relatively safe at the time of the field work. Third, we could build on the extensive local network of the first author, who had been working with artisanal miners in the area for over five years. Combined with further repeated visits, this allowed us to create the necessary trust and network to draw a stratified random sample of miners and conduct a structured survey.

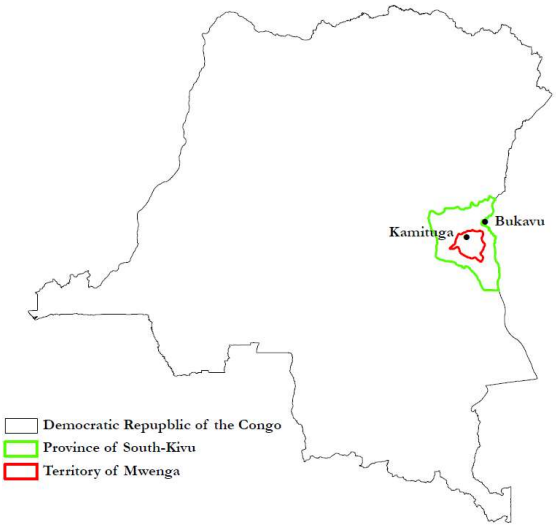

Figure 1. Location of Kamituga in the DRC

Kamituga's history as a gold mining town has been described by various scholars (Geenen, 2015, 2014; Kyanga Wasso, 2013; Vlassenroot and Raeymaekers, 2004). It has been characterized by industrial (between the 1930s and 1996) as well as artisanal (since the 1960s) gold production. During the two Congo wars (1996-1997 and 1998-2003) Kamituga saw its population more than double, as rural in-migrants came to look for economic opportunities and relative security. In 2015, the town counted up to 15,000 artisanal miners[7] and around 130,000 inhabitants[8].

After the wars ended, the Congolese government sought to increase its inflow of foreign exchange, among others by introducing a new, fiscally attractive, mining code. Combined with favorable mineral prices on the world market, the new code attracted large-scale mining investment (Stoop et al., 2019). The three mining permits on which Kamituga town and its surrounding mining sites are located, were acquired by Banro, a Canada-based multinational (Geenen, 2015). Being in the exploration phase (since 2011), the company tolerated artisanal miners within its concession at the time of our survey, provided they respected a number of restrictions, for example not using oxygen

[7] Although it is hard to accurately estimate the total number of artisanal miners, the available estimates seem to corroborate each other. Geenen (2013: p.6) estimates the number of artisanal miners between 10,000 and 15,000. During our fieldwork in 2015, the representatives of several local mining committees communicated that a census undertaken in 2013 counted 13,600 artisanal miners. We counted 15,250 artisanal miners on the combined membership lists of the two largest local committees of artisanal miners (COKA and CRC). Finally, when combining the IPIS (2020) estimates, collected in the period 2013-2015, for the number of artisanal miners for all mining sites located on the concessions of Banro Kamituga Mining, we count 14,695 artisanal miners.

[8] Geenen (2014: p.100) estimates the number of inhabitants at 100,000 based on 2012 data. According to the local administrator of Kamituga, the last population census conducted before our survey estimated the number of inhabitants at 187.000 (Personal interview, 2015). This census covered the entire health zone of Kamituga, including neighboring villages. For the city of Kamituga, the number of inhabitants was probably around 130,000 in 2015.

machines, water pumps, or any other tools that lift productivity above the 'artisanal' level (Kilosho Buraye et al., 2017; Mulonda et al., 2019).

In sum, Kamituga is a long-standing mining town with a large recent population growth and a tense cohabitation of artisanal and industrial mining. What are the implications for miners' earnings? First, the spatial restrictions imposed by Banro at the time of our research depressed miners' earnings (see also Kilosho Buraye et al., 2017; Stoop and Verpoorten, n.d.). Technological innovations such as the introduction of ball mills and better performing water pumps increased ASM productivity, but were repressed by Banro (Mulonda et al., 2019). Second, earnings in a mature mining site are likely to be lower, on average, compared to earnings in a freshly discovered 'rush site' where there is a higher probability of large windfall gains (Jønsson and Bryceson, 2009). In terms of socioeconomic mobility, the implications of Kamituga's history might be twofold. On the one hand, a large population with a considerable proportion of recent migrants can give individuals the anonymity to transcend clan and ethnic boundaries (Bryceson and Fisher, 2014). On the other hand, due to its long history as a sedentary mining town – in the ethnic homeland of the Balega (or Barega)[9] – ethnic ties and descent may still play a role, for instance when it comes to accessing high-yielding mining pits, or to a particular division of labor.[10]

3.2. Sampling

In order to study miners' earnings, we aimed to reach a representative sample of miners. Ideally, the basis for drawing such a sample is a reliable and up-to-date list of all miners. Such list was however not available, and conducting a full census of artisanal miners was not feasible because of time and budget constraints. Instead, we established complete lists of miners for a limited number of purposefully selected mining zones. To do so, we took advantage of the hierarchical structure of the Kamituga mining site. The site is divided in different zones headed by 'zone managers' (*chefs de colline*), which consist of several mining pits supervised by 'pit managers' (*Présidents Directeur Général* or simply *PDG)*, who have a number of miners working with them.

[9] 84% of miners in our sample belong to the Balega group (cf. below). The Balega are an ethnic group with little social stratification; traditionally they were governed by a series of norms that were preserved by a 'secret society', the Bwami (Biebuyck, 1973). The institution of the 'King' or 'Mwami' is not indigenous to the Lega, but was – in the framework of indirect rule – introduced by the Belgian colonial power (Ndaywel è Nziema et al., 1998, p. 360).

[10] In Kamituga, Bashi migrants coming from the wider Bukavu region, are commonly found in trading activities (Geenen, 2014, p. 243).

We first made a list of all active mining zones (about 40)[11], from which nine were selected using the principle of maximum variance, i.e. seeking variation in terms of geographical location, size, distance from the center of Kamituga, and the presence of Banro. We asked zone managers of selected zones to provide us with a list of all pit managers, who then provided us with a list of all miners working with them. The complete list for the nine selected zones consisted of 1,254 artisanal miners, working in 72 different pits. In each zone, we randomly selected half of the pits. For each selected pit, we randomly selected ten miners to be included in the survey. The pit managers of selected pits were also included.[12] Our final sample comprises 453 artisanal miners working in 42 pits. Figure 2 visualizes the sampling procedure.

It should be noted that our sample is limited to miners who work in the mining pits and is therefore exclusively male. The sampling did not target so-called site workers, such as ore washers, carriers, and ore crushers, among which one commonly also finds women and whose earnings are generally lower (Radley, 2019, p. 82; Geenen, 2015). In this sense the survey is still limited in capturing the diversity of labor roles in the mine.

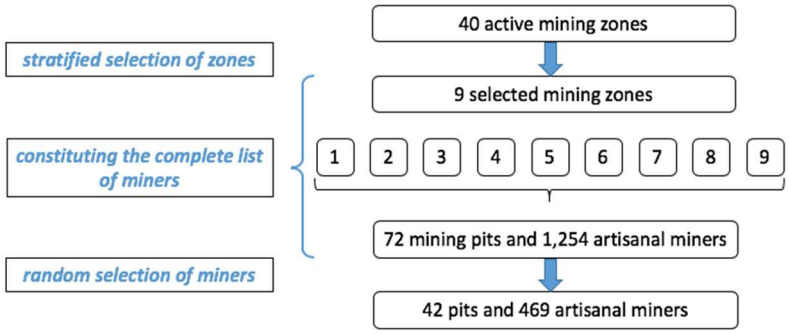

Figure 2. Selection of mining zones, pits and miners

[11] We established the list of mining zones in collaboration with the two main local committees of artisanal miners, COKA (Comité des Orpailleurs de Kamituga) and CRC (Comité de Renaissance de Calvaire).

[12] The average pit on the list counts 17 miners. For selected pits with more than 30 miners, we randomly selected 15 instead of ten miners. When a pit with less than ten miners was selected, we randomly selected an additional pit in the same mining zone. Although our sampling was intended to capture only pit workers, 16 of our respondents turned out to be site workers (ore washers, crushers or carriers). In the remainder of the paper they are excluded, bringing the total sample size down from 469 to 453.

3.3. Survey questions on ASM earnings

To capture miners' earnings, we included four different survey questions. First, we asked miners to report how much they earned *in the week before they were surveyed*. Second, we asked miners to estimate their earnings in *an average week of active production*. Third, we conducted a thought experiment: we asked miners at what wage they would be willing to switch from artisanal mining to an alternative activity, the so-called *reservation wage* (Varian, 1992). Specifically, we asked miners if they would be willing to quit ASM and take up an alternative activity, while varying the daily wage associated with the alternative activity from $1 to $5, $10, $15, and $20. Fourth, we asked miners to *compare their material well-being to that of farmers*, which is the predominant activity in the region. To facilitate the comparison, we presented the respondents with a 'ladder of life'. The ladder visualizes nine standards of living, ranging from the poorest in Kamituga (level 1) to the richest (level 9) (see Figure 3). Respondents were asked to indicate the minimum and maximum standard of living they associated with the economic activities of pit manager, miner and farmer, as well as the level at which the majority of people engaged in that activity are located. Respondents were also asked to indicate their own ranking on the ladder.

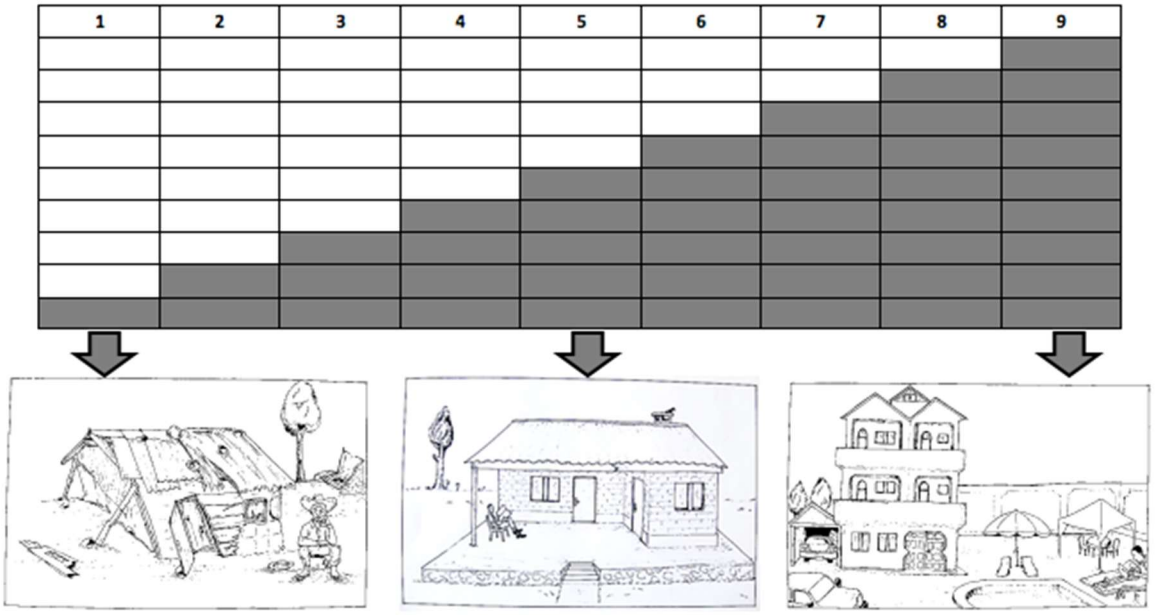

Figure 3. Ladder of life
Notes: The drawings were created by local artist Francesco Nyamo.

4. Who are the miners and how much do they earn?

In this section, we (1) present individual characteristics of our respondents that may influence their earnings, (2) present estimates of their mining earnings, and (3) compare their perceived material well-being to that of farmers.

4.1. Individual characteristics

There are eight types of pit workers in our sample, which can roughly be divided in four categories (see Panel A of Table 1). The pit manager is the one who starts the operation and manages the team. Pit managers generally make large investments during the preparatory period (buying fuel, timber, tools and food), often relying on pre-financing by gold traders or financiers (Geenen, 2011). As soon as the pit enters the production phase, part of the production (usually one third) is used to recover these investments. There are 42 pit managers in our sample (9.3%).[13] Next in the hierarchical structure of a mining pit is the *conducteur* (12.8%), who oversees the extraction process, and the *capita* (4.2%), who supervises the team on a daily basis. In what follows, we will call them the 'right hands' of the pit manager. Third, special expertise is provided by the *boiseur* (6.4%); the

[13] For every selected pit, we interviewed the pit manager, while we only interviewed a random selection of the miners working with him. Pit managers are thus overrepresented in our sample.

foreur (21.4%); the *machiniste* (1.3%) and the *prospecteur* (0.2%). The *boiseur* is in charge of building timber constructions to stabilize the pit; the *foreur* digs the tunnels; the *machiniste* repairs and maintains the water and oxygen pumps; while the *prospecteur* finds and selects the richest gold veins to be exploited. In what follows, we will call them the 'experts'. The remaining artisanal miners, called *pelleteurs* (44.4%), are in charge of evacuating rock and sand from the pit.

We asked each miner to rank these different mining functions from riskiest to least risky. Pit managers clearly stand out as incurring the most financial risk – being ranked first by 99% of respondents. Physical risk is concentrated at the lower end of the pit hierarchy, among experts and *pelleteurs*. The *foreur* – who is in charge of excavation – stands out, being ranked first by 37% of respondents. Next are the *machiniste*, *boiseur* and *pelleteur*, who are ranked as incurring the most physical risk by 22%, 19% and 19% of respondents, respectively.

Panel B of Table 1 summarizes some individual characteristics of the miners in our sample. Our respondents are on average 33 years old, with ages ranging from 16 to 65 years. A miner in our sample has on average 12 years of experience in ASM, indicating a long-term engagement with the activity. Both age and working experience clearly increase as miners progress in the hierarchy of the mining pit. Pit managers have significantly more working experience (with an average of 21 years), while those at the bottom of the hierarchy – *pelleteurs* – have around nine years of experience. Just over half of the miners (53%) was born in Kamituga[14] and 84% identify themselves as belonging to the Lega ethnic group.[15] While these characteristics are distributed quite evenly across mining functions, right hands and experts are slightly more likely to belong to the Lega ethnicity and to be born in Kamituga compared to *pelleteurs*.[16] When looking at the activities of artisanal miners' parents, we find that 36% of their fathers was also engaged in artisanal mining. In terms of schooling, 18% of the miners did not finish primary school while for another 16% primary school is the highest educational level attained. More than half of miners (55%) quit school somewhere during secondary school. Of the 11% that finished secondary school, 2% went on to pursue higher education.

Table 1. Demographic and mining information

[14] Nearly all miners (97%) and their parents (96%) were born in the province of South Kivu. Moreover, the large majority of miners (84%) and their parents (82%) were born in the territory of Mwenga.
[15] 7.3% are Shi and 2.4% are Nyindu, while 6.4% come from diverse other ethnicities (i.e. Aushi, Bangubangu, Bembe, Fuliru, Havu, Lendu, Lokole, Luba, Mungala, Tembo and Tetela).
[16] Results from a t-test indicate that this difference in means is significant at the 5% significance level.

Panel A: mining functions

	obs.	% in sample	highest financial risk	highest physical risk
Pit manager	42	9.27	99.36	0.51
Right hand				
Conducteur	58	12.80	0.21	1.80
Capita	19	4.19	0.00	0.77
Expert				
Boiseur	29	6.40	0.00	19.02
Foreur	97	21.41	0.00	37.02
Machiniste	6	1.32	0.00	22.37
Prospecteur	1	0.22	0.00	0.00
Pelleteur	201	44.37	0.43	18.51
Total	453	100	100	100

Panel B: summary statistics by mining function

	obs.	mean age	mean years of mining experience	% born in Kamituga	% Lega	% father was a miner
Pit manager	42	44.07	21.24	52.38	76.19	35.71
Right hand	77	35.64	13.36	54.55	88.31	41.56
Expert	133	34.04	11.88	60.15	88.72	36.09
Pelleteur	201	29.48	8.95	47.26	81.59	34.83
Total	453	33.22	11.70	52.76	84.33	36.42

Panel C: highest level of schooling

	obs.	%	cum %
No schooling	10	2.21	2.21
Stopped during primary school	72	15.89	18.10
Finished primary school	71	15.67	33.77
Stopped during secondary: years 1-3	177	39.07	72.84
Stopped during secondary: years 4-5	72	15.89	88.73
Finished secondary	40	8.83	97.56
Higher education	11	2.43	99.99
Total	453	100	

Notes: In Panel A, financial and physical risk indicate the percentage of respondents that listed a particular mining function as the most risky one.

4.2. Miners' earnings

Based on the answers to the question on earnings in the *week prior to the survey*, we calculate average earnings for preparatory and production periods.[17] Panel A of Table 2 gives an overview. At the time of our survey, 57% of miners worked in a pit that was in the preparatory phase, while 43% worked in a pit that was in the production phase. We find that pit managers in our sample earn on average $55 per week in preparatory periods and $185 during the production phase. These earnings should not be considered a pure profit. As mentioned above, pit managers generally make large investments during the preparatory period which they need to recover once the pit starts producing gold.

Table 2. Miner's earnings and income position, by mining function

Panel A: Estimated revenues for the week preceding the survey (in $US)

	preparatory period		production phase	
	Obs.	Mean	Obs.	Mean
Pit Manager	21	55	21	185
Right hand	39	43	38	103
Expert	74	29	59	45
Pelleteur	124	14	77	34

Panel B: Estimated revenues for an average week in the production phase (in $US)

	Obs.	Mean	St.dev.	Min.	Max.
Pit Manager	42	191	195	15	717
Right hand	77	92	88	7	500
Expert	133	52	51	7	167
Pelleteur	201	24	26	1	167

Panel C: Reservation wage (in %): "Would you be willing to quit ASM for an alternative activity that earns a certain $10 per day?"

	No	Very unlikely	Unlikely	Likely	Very likely	Total
Pit Manager	42.9	7.1	23.8	7.1	19.1	100
Right hand	16.9	10.4	19.5	7.8	45.5	100
Expert	14.3	10.5	18.1	12.8	44.4	100
Pelleteur	10.0	4.5	11.4	7.0	67.2	100
Total	15.5	7.5	15.9	8.8	52.3	100

Panel D: Position on the ladder of life (1-9)

	Obs.	Mean	St.dev.	Min.	Max.
Pit Manager	42	4.8	1.6	2	9
Right hand	77	4.0	1.0	2	7
Expert	133	3.4	1.0	2	6
Pelleteur	201	2.9	1.2	1	7

Notes: This Table is based on information from the 453 pit workers in our sample, which includes: 42 pit managers; 77 right hands; 133 experts and 201 *pelleteurs*.

[17] The production phase of a mining pit is preceded by a preparatory period, also called '*période de souffrance*' because little is being earned. This period may last from a couple of months up to several years.

The right hands of the pit manager – the *conducteur* and *capita* – on average earned $43 per week in preparatory periods and $103 during the production phase. The experts – *boiseur*, *foreur*, *machiniste* and *prospecteur* – earned $29 in the preparatory period, and $45 during the production phase. The other artisanal miners, *pelleteurs*, earn the least: $14 per week in preparatory periods and $34 during the production phase.

Second, we asked respondents to estimate their earnings during *an average week of active production*. The findings are in line with the above reported revenues for miners who were in the production phase. On average, earnings roughly double across each of our four broad categories: pit managers report earnings of $191; their right hands earn around $92; the experts earn around $52; while *pelleteurs* earn around $24 per week (see Panel B of Table 2).[18] The averages hide a large variation though, even within the subgroups of miners. Figure 4 illustrates this, providing the distribution of mining revenue for pit managers; their right hands; the experts and the other miners.

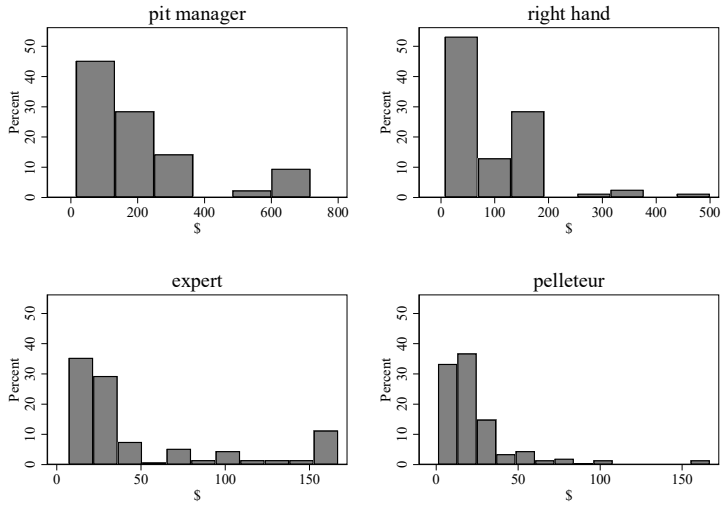

Figure 4. Distribution of mining revenue during 'average week in active production'

[18] During the production phase, a pit's output is usually shared according to a 'two-meter principle'. Although this principle may differ from pit to pit, in general the rocks extracted from the first two meters of the tunnel are reserved for the pit manager, the next two meters are shared by the right hands, while the following two meters are shared among the other miners - after which the cycle restarts. The speed at which the two meters are dug may vary from a couple of days to a week and depends on many factors including the hardness of the rock, the depth of the tunnel and the presence of water in the pit. We asked miners to estimate the average earnings from their two meters of production. To account for the fact that every actor only earns a revenue about one third of the time, we divided these earnings by three to get to a rough estimate for an average week's earnings during the production period (these are reported in Panel B of Table 2).

To approximate miners' reservation wage – the minimum wage necessary to make them switch to an alternative activity, we asked if they would be willing to quit ASM to take up another activity, while varying the daily wage associated with the activity from $1, to $5, $10, $15 and $20. Again, we find large variation along miners' functions within the mining pit. Figure 5 shows the answer distribution across the different daily wages. To keep the Figure clear, it only distinguishes between pit managers and other pit workers. While virtually no one would be willing to quit ASM for an activity that earns $1 a day, about 25% of pit workers would very likely switch to an activity that earns $5 a day. When further increasing the daily wages to $10 and $15, the majority of pit workers would very likely make the switch (56% and 76% respectively). Pit managers clearly have a higher reservation wage: those willing to quit ASM remain a minority at $5 (12%), $10 (19%) and $15 (40%). At a daily wage of $20, the majority of both pit workers (88%) and pit managers (71%) would very likely quit ASM. Yet, for almost one third of pit managers (29%) this reservation wage still is too low.

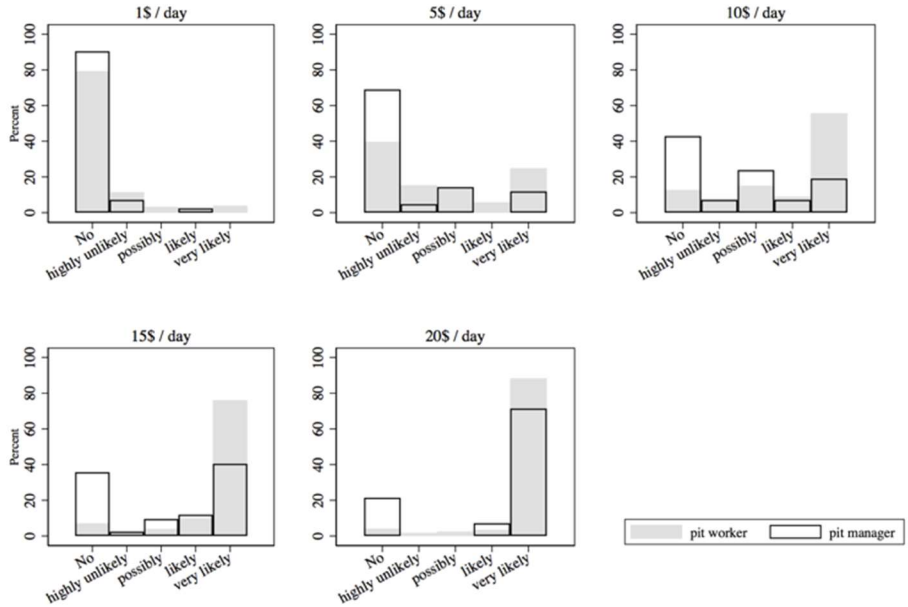

Figure 5. Distribution of reservation wage

Panel C of Table 2 presents the answer distribution for all mining functions, when the daily wage of the alternative activity is set at $10. On average, just over half of our respondents (52%) would be willing to quit ASM for such an activity. Yet, we can clearly see this wage is more appealing to *pelleteurs* (67% would very likely quit ASM) than to experts (44%); right hands (46%); and especially

pit managers – of whom only 19% would very likely quit ASM for another activity that yields a certain $10 a day.

4.3. Comparing the standard of living for miners and farmers

Respondents were asked to indicate on a nine-step ladder of life (cf. Figure 3) the minimum and maximum standard of living they associate with the economic activities of a pit manager, pit worker and farmer, as well as the level at which the majority of people engaged in those activities are located. Figure 6 clearly indicates that pit managers are considered to have the highest standard of living (4.9), on average, while farmers have the lowest (2.7) and pit workers are located somewhere in between (3.2). Less than 10% of our respondents perceive farmers to be situated on a higher step of material wealth than pit workers. At their maximum earning potential, pit managers are on average believed to be able to reach level 7.7 on the ladder of life. By contrast, the average upper limit for pit workers and farmers is situated at level 5.4 and 4.4 respectively.

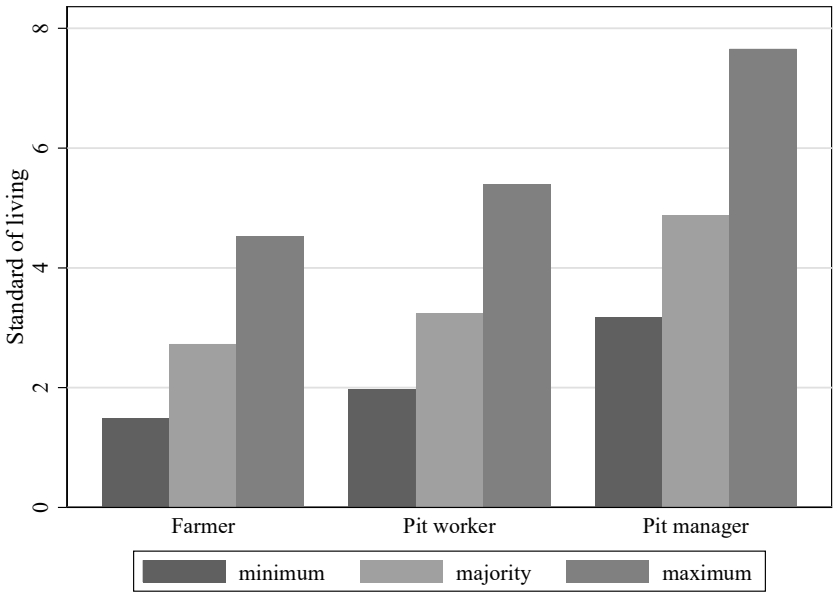

Figure 6. Ladder of life: Standard of living of farmers, pit workers and pit managers

When asked about their own position on the ladder, we again note the hierarchy in responses across mining functions: 4.8 for pit managers; 4.0 for the right hands; 3.4 for the experts; and 2.9 for *pelleteurs* (see Panel D of Table 2). Note that with 2.9, *pelleteurs* are still just above the level attributed to most farmers (2.7).

Finally, it is interesting to note that we find relatively little evidence of income diversification at the household level. For the majority of our respondents (61%), mining is the only source of household income. Households that do diversify their income sources earn an income from small commercial activities (24% - mostly operating small shops); agriculture (12%) or various services (6% - taxi moto, barber, tailor, etc.). This can be explained by the specific position of Kamituga as a long-standing mining town.

5. What determines miners' earnings?

Miners' earnings may be determined by many different factors. In this section we divide these factors in three categories (Table 3). First are what we label 'merit-based factors', including the years of mining experience; a miner's function in the pit and the associated risk-taking; and the years of schooling. Although they are partly shaped by identity-based factors (for instance access to schooling may increase with the wealth of one's parents, or access to a well-paid job in the mine may be easier when born in town), they further depend on individual capacity and perseverance. In other words, these are factors that can be influenced by an individual miner.

Table 3. Determinants of ASM earnings

Individual factors		Context
Merit-based	*Identity*	
Mining experience	Age	Mining zone
Mining function	Lega ethnicity	Mining pit
Risk taking	Born in Kamituga	
Level of schooling	Father was miner	

Second are identity factors related to ethnicity, age or descent; thus out of the control of the individual. To capture the influence of these factors, we rely on variables that measure ethnicity, age, place of birth and fathers' involvement in the mining sector. Summary statistics for these individual determinants of ASM earnings are presented in Table 1 above.

Third are factors related to the circumstances in which miners operate: i.e. factors related to the mining zone and mining pit. For instance, earnings may vary due to variations in the availability

and quality of gold veins; access to electricity used to power water- and oxygen pumps; accessibility of the area; hardness of the rock, etc.[19]

In what follows, we analyze (1) how each determinant is correlated with ASM earnings in a bi-variate analysis (for instance: do miners with more years of experience earn more?), (2) to what extent these determinants influence ASM earnings when accounting for the influence of the other determinants in a multi-variate regression analysis (for instance: does experience still play a role ceteris paribus, e.g. when comparing two otherwise similar *foreurs*?).

5.1. How do merit-based and identity factors correlate with earnings?

We have already found that earnings vary substantially between mining functions (panel B of Table 2). During an average week of active production pit managers earn on average $191 per week; right hands $92; experts $52 and *pelleteurs* $24.[20] Table 4 now also compares mean ASM earnings across other individual determinants. Starting with merit-based factors, we compare ASM earnings across quintiles of mining experience. Going from the first to the fifth quintile, miners on average have 3, 6, 10, 15 and 26 years of experience in the mining sector. While miners in the first three quintiles earn roughly the same ($39, $40 and $44 per week), those in the highest two quintiles earn about double ($82 and $91 per week) – a difference that is significant at the 1%-significance level.

We then turn to risk-taking. From Table 1, we know that physical risk is concentrated among experts and *pelleteurs*. *Foreurs* take the biggest risks, followed by *machinistes*, *boiseurs* and *pelleteurs*, while *prospecteurs* are not considered to take much risk. Looking at the mean ASM earnings for these actors, we don't find evidence for a risk premium: while *foreurs* earn more than *machinistes* and *pelleteurs*, their earnings are not significantly distinguishable from those of *boiseurs* or *prospecteurs*.[21] Taking financial risks is however strongly correlated with ASM earnings: with $191 per week pit managers earn significantly more than the other pit workers who earn $46 per week on average. Finally, there is no clear relationship between miner's level of schooling and ASM earnings.

[19] De Brier et al (2020) find that seasonality, level of mechanization, accessibility of the mine and phone coverage significantly influence earnings, with the presence of cooperatives and inclusion in a traceability system having an inconclusive effect.

[20] An ANOVA test shows that these mean earnings are all statistically different from one another at the 1% significance level.

[21] Note however that our sample contains very few *machinistes* (6) and only one *prospecteur*.

Table 4. Mean weekly ASM earnings by individual determinants

Merit-based factors	obs.	mean weekly earnings	
Mining experience (quintiles)			
less than 5 years (mean=3)	103	$39	
5-7 years (mean=6)	89	$40	
8-11 years (mean=10)	92	$44	
12-19 years (mean=15)	96	$82	***
20-46 years (mean=26)	89	$91	***
Runs high physical risk (*sample = experts & pelleteurs*)			
Foreur	97	$54	
Machiniste	6	$25	**
Boiseur	29	$49	
Pelleteur	201	$24	***
Prospecteur	1	$33	
Runs high financial risk			
No	411	$46	
Yes *(pit managers)*	42	$191	***
Level of schooling			
no schooling	11	$26	
stopped during primary school	76	$50	
finished primary school	72	$80	*
stopped during secondary: years 1-3	182	$56	
stopped during secondary: years 4-5	74	$58	
finished secondary	42	$53	
higher education	12	$110	**

Identity-based factors	obs.	mean weekly earnings	
Age (quintiles)			
16-24 years (mean=21)	100	$33	
25-29 years (mean=27)	92	$42	
30-35 years (mean=32)	108	$60	***
36-42 years (mean=39)	79	$71	***
43-65 years (mean=49)	90	$95	***
Born in Kamituga			
No	214	$50	
Yes	239	$67	**
Lega ethnicity			
No	71	$58	
Yes	382	$64	
Father was a miner			
No	288	$59	
Yes	165	$60	

Notes: This Table is based on information from the 453 pit workers in our sample. Stars indicate the statistical significance-level of the difference in means with respect to first category of each variable, obtained after an ANOVA test. *** p<0.01, ** p<0.05, * p<0.1

Next, we turn to identity-based factors. Age quintiles tell a similar story as working experience. Going from the first to the fifth age quintile, miners are on average 21, 27, 32, 39 and 49 years old. Overall, ASM earnings increase with age. While there is no significant difference in earnings between miners in the first two quintiles ($33 and $42 per week), those in the third and fourth age quintile earn almost double ($60 and $71 per week), while those in the fifth quintile earn the most ($95 per week). Place of birth also matters: miners born in Kamituga earn significantly more than other miners ($67 vs $50 – a difference that is significant at the 5% significance level). Ethnic identity does not seem to play a role. Miners belonging to the Lega ethnic group earn on average $64, which is statistically not distinguishable from the $58 earned by miners from other ethnicities. Having a father who worked in ASM has no significant impact on earnings either.

5.2. How do merit-based and identity factors influence earnings, ceteris paribus?

We now turn to a multi-variate regression analysis. This allows us to analyze how ASM earnings vary with each of these determinants, while simultaneously controlling for the influence of the other determinants. It allows us, for instance, to check whether being born in Kamituga still matters for earnings when we are comparing pit managers. Importantly, a regression analysis also allows us to control for contextual factors related to specific mining zones or pits. For instance, when a pit is located in a zone with higher mineralization, earnings may be higher; when it is located in a zone that has difficult road access or has problems of mounting ground water, earnings may be lower. By introducing mining zone fixed effects or pit fixed effects[22] we control for such factors and can study how the individual determinants influence within-zone or within-pit variation in earnings. We estimate the following equation:

$$EARNINGS_{iz} = \alpha_0 + M'_{iz}\,\mathrm{A} + I'_{iz}\,B + C'_{iz}\,\Gamma + \varepsilon_z \qquad (1)$$

where i indexes the 453 miners and z the 9 mining zones. The outcome variable, denoted by $EARNINGS_{iz}$, are the estimated average earnings in a week of active production. Since ASM earnings are strongly skewed to the right, we use a logarithmic transformation.[23] M'_{iz} and I'_{iz} are vectors containing the explanatory variables related to merit-based and identity factors as listed in

[22] For instance, in the case of mining zones, this implies the inclusion of eight dummy variables, taking the value 'one' for one of the nine zones, and zero for all other zones. The dummy for one of the zones is omitted as the reference category.

[23] Figure A1 in Appendix 1 illustrates that ASM earnings are skewed to the right, with most observations having relatively low earnings and few observations having much larger earnings. The Figure further shows that a logarithmic transformation helps to approach a normal distribution, one of the assumptions of a linear regression model.

Table 3.[24] Contextual factors are captured by C'_{iz}, using either mining zone fixed effects or pit fixed effects. Standard errors (ε_z) are clustered at the level of the mining zones (or -pit) to account for within-zone (or -pit) correlation of residuals. The equation is estimated using a linear regression model (OLS).

We run eight different regression specifications. Detailed information and full regression output is presented in Appendix 2. Figure 7 summarizes the main findings of a linear regression model with pit-level fixed effects. It presents the percent change in ASM earnings associated with a one-unit increase in each of the explanatory variables. Horizontal lines represent 90% confidence intervals. Panels A and B focus on merit-based determinants, Panel C focuses on identity-based determinants, while Panel D controls for both types of determinants. *Pelleteurs* are the reference category to which earnings of the other mining functions are compared. The level of schooling was included in every regression specification but omitted from the Figure.

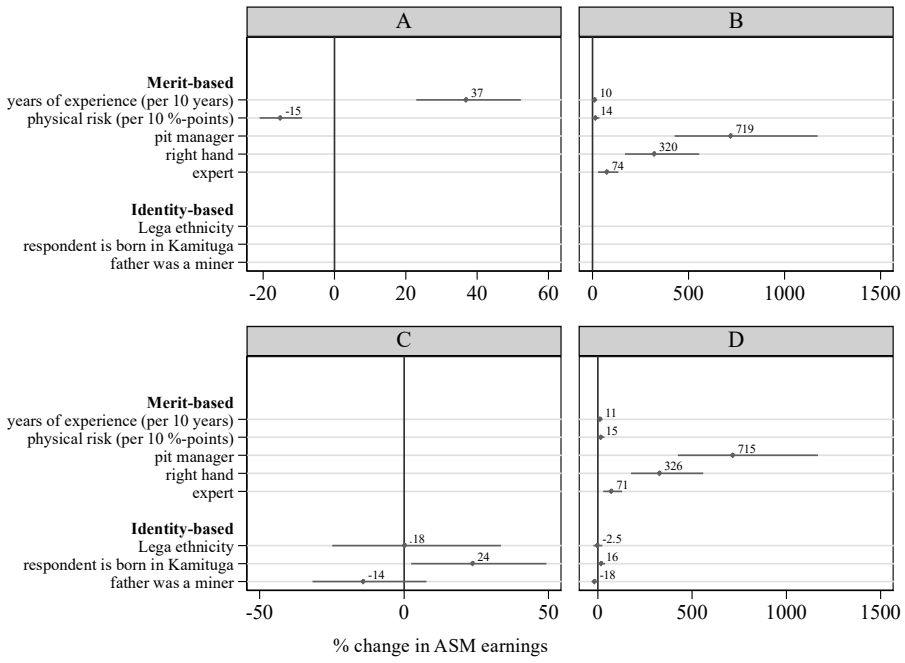

Figure 7. Determinants of ASM earnings

Starting with the merit-based factors, we find that experience matters. Panel A of Figure 7 tells us that ASM earnings increase with 37% for each additional ten years of experience in the mining sector, a finding that is significant at the 1%-significance level. It further shows that miners who

[24] We exclude two variables from the regression: 1) financial risk-taking, as this is highly correlated with the indicator variable for pit managers and 2) age, as this is highly correlated with years of experience in the mining sector.

take physical risk generally earn less. Indeed, as we saw before, the dangerous tasks are concentrated at the low end of the pit hierarchy, among *experts* and *pelleteurs*. When comparing miners with a similar function in the same pit, however, experience and taking physical risk are no longer significantly related to ASM earnings (Panel B).

Panel B further shows that a miner's function in the pit is a very important determinant of ASM earnings. Compared to *pelleteurs* working in the same pit, pit managers earn 719% more; his right hands earn 320% more and experts earn 74% more. These findings are all highly significant, at the 1%-level. Moreover, controlling for mining function strongly increases the variation in ASM earnings that we can explain with our model, moving from 24% in Panel A to 43% in Panel B.

We then move to Panel C, looking only at identity-based factors. Once included in the ASM labor force, a miners' ethnicity or having a father who was also a miner do not affect ASM earnings. We do find that miners who were born in Kamituga earn about 24% more, although this finding is only significant at the 10%-significance level. When we control for both merit- and individual-based determinants in Panel D, descent no longer significantly influences ASM earnings. Comparing Panels B and D, we further see that the estimated coefficients on the merit-based determinants remain relatively unchanged when additionally controlling for the identity-based determinants. This suggests that identity-based factors have little mediating impact on the relationship between merit-based factors and ASM earnings. Finally, it is interesting to note that the inclusion of identity-based determinants adds very little explanatory power, as the variation in ASM earnings we can explain with our model basically remains unchanged between Panels B and D – moving from 43% to 44%.[25]

Combined, these findings suggest that ASM earnings are primarily determined by the function a miner has in a pit. Above we have defined this function as being mostly merit-based, although we acknowledged that identity-based factors may play a role as well (for instance, miners born in Kamituga may have a higher chance of being 'promoted' to right hands). To examine to what extent this is the case, we now look at the determinants of climbing up the hierarchical mining ladder. Specifically, we run a regression where the outcome variable is an indicator that equals zero for *pelleteurs* (44% of our sample) and one for all miners who are higher up the ladder (the remaining 56%). As explanatory variables we include the merit- and identity-based factors that are not

[25] As measured by the R^2 value reported in Columns 6 and 8 of Table A1 in the Appendix.

specifically linked to a mining function.[26] By including pit-level fixed effects, we focus on the within-pit variation in climbing up the hierarchical ladder. Figure 8 presents, for a one-unit increase in each of the explanatory variables, the % point change in the probability of being higher up the mining ladder than a *pelleteur*. Horizontal lines represent 90% confidence intervals.

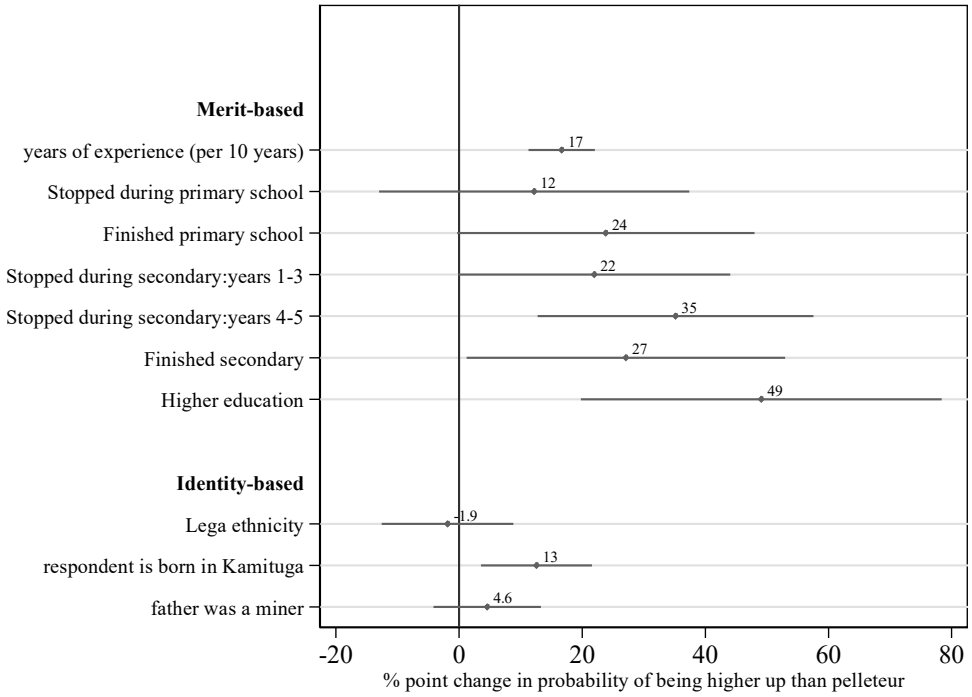

Figure 8. Determinants of climbing up the hierarchical mining ladder

Starting with merit-based factors, we find that experience is important: with every additional ten years of mining experience, the probability of not being a *pelleteur* increases with 17 percentage points. Education also matters: the higher a miner's level of schooling, the more likely it is that he is higher up the ladder. For instance, compared to miners without schooling, the probability of not being a pelleteur is 24 percentage points higher for miners who finished primary school; 35 percentage points higher for those who were close to finishing secondary school; and 49 percentage points higher for miners who went to university. Moving to identity-based factors, we find that ethnicity or having a father who was a miner do not significantly influence miners' position on the ladder. Descent does play a role, as miners who are born in Kamituga are about 13 percentage points more likely not to be a *pelleteur*. Yet, again we find that adding the identity-based factors adds little explanatory power to the model.[27]

[26] We include the same explanatory variables as above, while excluding the proxy for physical risk and the mining function dummies.

[27] The R^2 increases with 2%, from 25% to 27%.

6. Discussion

In this paper we provide unique evidence on ASM miners' earnings and their determinants. Miners are categorized according to the types of work they do, in pit managers, their right hands, experts and other miners. We estimate that earnings roughly double across these four categories: pit managers earn on average $191 per week, their right hands $92, experts $52 and *pelleteurs* $24. On the ladder of life, miners place themselves above farmers. In terms of policy, these findings send a powerful message that miners should not be considered as a homogeneous category when designing interventions.

Our analysis of earnings determinants reveals that earnings are primarily determined by the function occupied in the mine. Other merit-based factors such as the years of experience in the sector, and whether one occupies a position that involves financial risk, are important as well. First, miners need experience in order to climb up the hierarchy of the mining pit. With experience, miners develop their skills and may acquire technical expertise helping them to become experts or pit manager's right hands (Bryceson and Geenen, 2016; Geenen, 2015). Second, those who bear high financial risks – pit managers – earn significantly more than their colleagues in the same pits. According to the survey carried out by Geenen (2014, p. 169) pit managers had spent $1,411 on fuel, timber, tools and food for the workers in the month preceding the survey, which represented somewhat less than a third of the total turnover. Preparatory works may take several months up to several years, after which such costs need to be recovered. Of course, the mere willingness to take these risks does not suffice. Pit managers need to have access to significant financial capital, which they might have gained through previous capital accumulation (or because they come from wealthier families), or which they seek by making agreements with local gold traders (Geenen, 2015).

Among the identity-based factors, age and ethnicity do not play a role in determining ASM earnings in our research site. Years of schooling neither turns up significantly, although more educated miners are more likely to climb up the hierarchical ladder (but this need not be the effect of schooling; it can be driven by innate ability). A significant factor is the place of birth, with miners who are born in Kamituga earning significantly more than others. This effect disappears when comparing miners in the same function, in the same pit, indicating that miners born in Kamituga are more likely to climb up the hierarchical ladder. This 'sons of soil' effect seems unrelated to their ethnic background, but may be explained by extended family (inter-ethnic marriages are

common) and friendship relations. For instance, a close relationship with a pit manager will help a miner to more quickly advance in his career. Miners who are born in Kamituga have been exposed to mining since their childhood, which may positively influence their skills, but also their knowledge of prevailing norms that regulate work and life inside and outside the pits.

These results help to test the claim that ASM has a social-levelling effect. We cannot test to what extent *entry* into the ASM labor force is determined by individual characteristics. Once a miner has started his 'career' in ASM however, we find that years of mining experience, risk-taking and place of birth significantly influence earnings, but not ethnicity. The strongest determinants are thus merit-based factors, and among the identity-based factors, only place of birth is significant. This indicates that despite the possibilities for upward social mobility, being an in-migrant does constrain one's opportunities to move to more rewarding positions, or to more rewarding pits.

While this study provides some unique systematic data on ASM earnings, several limitations remain. First the survey has targeted pit workers and not site workers, among which we find categories such as *twangeurs* (those crushing the rocks), transporters, *loutriers* (those operating the processing spaces) and *mamans bizalu* (women processing waste). Second, in order to better assess the value of earnings, we should have information on operation costs (for the pit managers), on non-wage benefits (such as food and drinks), as well as on the cost of living in the mines (which is generally higher as compared to non-mining sites) (de Brier et al., 2020; Geenen, 2015; Labonne, 2014). Finally, our study is limited to a single mining site in South Kivu, and to one type of mining (underground gold mining). To improve data collection and acquire a richer understanding of earnings in ASM, our survey instrument can be adopted in other contexts, for other types of minerals and mining (alluvial, open-pit, by dredging, etc.) or extended to include other ASM workers.

7. Conclusion

With this article, we first of all make a methodological contribution. Although in recent decades a wealth of ASM research has given us rich insights in the ways in which ASM miners organize their work, quantitative data on ASM earnings are still lacking. Systematic and differentiated data on ASM earnings are crucial if we want to fully understand the socio-economic significance of mostly informal ASM activities, and inform policymakers to design better targeted and more inclusive policy interventions. In this article we carefully present our sampling and measurement method, and we make our survey-tool and data publicly available in order to promote their uptake in other

contexts. Second, we make a contribution to the literature on ASM and development, analyzing which factors determine miners' earnings. We find that the most important determinant of miners' earnings is one's function in the pit, which is – to a large extent – determined by years of mining experience and the level of education, although being a son of the soil also helps. Overall, merit-based factors appear to be stronger determinants of miners' earnings than identity-based factors, indicating that ASM provides possibilities for upward social mobility. This study thus confirms and complements a number of findings in the ASM literature, while providing much needed systematic data.

8. References

Banchirigah, S.M., 2008. Challenges with Eradicating Illegal Mining in Ghana: A Perspective from the Grassroots. Resour. Policy 33, 29–38.

Banchirigah, S.M., Hilson, G., 2010. De-agrarianization, re-agrarianization and local economic development: Re-orientating livelihoods in African artisanal mining communities. Policy Sci. 43, 157–180.

Bansah, K.J., 2019. From diurnal to nocturnal: Surviving in a chaotic artisanal and small-scale mining sector. Resour. Policy 64, 101475.

Bansah, K.J., Yalley, A.B., Dumakor-Dupey, N., 2016. The hazardous nature of small scale underground mining in Ghana. J. Sustain. Min. 15, 8–25.

Barreto, M.L., Schein, P., Hinton, J., Hruschka, F., 2018. The Impact of Small-Scale Mining Operations on Economies and Livelihoods in Low- to Middle-Income Countries. UK Department for International Development, London.

Bazillier, R., Girard, V., 2020. The gold digger and the machine. Evidence on the distributive effect of the artisanal and industrial gold rushes in Burkina Faso. J. Dev. Econ. 143, 102411.

Biebuyck, D.P., 1973. Lega Culture: Art, Initiation, and Moral Philosophy Among a Central African People. University of California Press, Berkeley.

Bryceson, D.F., Fisher, E., 2014. Mineralising Africa and Artisanal Mining's Democratising Influence, in: Bryceson, D.F., Fisher, E., Jønsson, J.B., Mwaipopo, R. (Eds.), Mining and Social Transformation in Africa: Mineralizing and Democratizing Trends in Artisanal Production. Routledge, London ; New York ; New York, NY.

Bryceson, D.F., Geenen, S., 2016. Artisanal frontier mining of gold in Africa: Labour transformation in Tanzania and the Democratic Republic of Congo. Afr. Aff. 115, 296–317.

Bryceson, D.F., Jønsson, J.B., 2010. Gold Digging Careers in Rural East Africa: Small-Scale Miners' Livelihood Choices. World Dev. 38, 379–392.

Buxton, A., 2013. Responding to the Challenge of Artisanal and Small-Scale Mining: How Can Knowledge Networks Help? IIED, London.

Carson, M., Cottrell, S., Dickman, J., 2005. Managing Mineral Resources Through Public-Private Partnerships: Mitigating Conflict in Ghanaian Gold Mining. Princeton, NJ: Woodrow Wilson School of Public and International Affairs.

Cartier, L.E., Bürge, M., 2011. Agriculture and Artisanal Gold Mining in Sierra Leone: Alternatives or Complements? J. Int. Dev. 23, 1080–1099.

Cassimon, D., Verbeke, K., Verpoorten, M., 2016. FDI from a 'financing for development' perspective. Opportunities for Africa's Great Lakes Region. Reflets Perspect. Vie Économique Tome LV, 29–46.

Christiaensen, L., Martin, W., 2018. Agriculture, structural transformation and poverty reduction: Eight new insights. World Dev. 109, 413–416.

de Brier, G., Jorns, A., Geray, M., Jaillon, A., 2020. The Miner's Revenue and Basic Needs Study. IPIS, Antwerp.

Delve, 2020. DELVE - A Global Platform for Artisanal and Small Scale Mining Data. URL https://delvedatabase.org (accessed 1.6.20).
Dorner, U., Franken, G., Liedtke, M., Sievers, H., 2012. Artisanal and Small-Scale Mining (ASM) (POLINARES Working Paper No. 9). European Commission.
Engwicht, N., 2018. "It can lift someone from poverty": Imagined futures in the Sierra Leonean diamond market. Extr. Ind. Soc. 5, 260–266.
Fisher, E., Mwaipopo, R., Mutagwaba, W., Nyange, D., Yaron, G., 2009. "The ladder that sends us to wealth": Artisanal mining and poverty reduction in Tanzania. Resour. Policy 34, 32–38.
Geenen, S., 2015. African Artisanal Mining from the Inside Out: Access, norms and power in Congo's gold sector. Routledge.
Geenen, S., 2014. "Qui Cherche, Trouve" the Political Economy of Access to Gold Mining and Trade in South Kivu, DRC.
Geenen, S., 2013. Dispossession, Displacement and Resistance: Artisanal Miners in a Gold Concession in South-Kivu, Democratic Republic of Congo. Resour. Policy.
Geenen, S., 2011. Relations and regulations in local gold trade networks in South Kivu, Democratic Republic of Congo. J. East. Afr. Stud. 5, 427–446.
Hilson, G., 2019. Why is there a large-scale mining 'bias' in sub-Saharan Africa? Land Use Policy 81, 852–861.
Hilson, G., 2011. Artisanal Mining, Smallholder Farming and Livelihood Diversification in Rural Sub-Saharan Africa: An Introduction. J. Int. Dev. 23, 1031–1041.
Hilson, G., 2005. Strengthening artisanal mining research and policy through baseline census activities. Nat. Resour. Forum 29, 144–153.
Hilson, G., Maconachie, R., 2019. Artisanal and small-scale mining and the Sustainable Development Goals: Opportunities and new directions for sub-Saharan Africa. Geoforum.
Hilson, G., McQuilken, J., 2014. Four decades of support for artisanal and small-scale mining in sub-Saharan Africa: A critical review. Extr. Ind. Soc. 1, 104–118.
IGF, 2018. Global Trends in Artisanal and Small-Scale Mining (asm): A Review of Key Numbers and Issues. Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development.
ILO, 1999. Social and Labour Issues in Small-Scale Mines. International Labour Organization, Geneva.
IPIS, 2020. Database: Artisanal mining site visits in Eastern DRC. Int. Peace Inf. Serv. URL https://ipisresearch.be/home/conflict-mapping/maps/open-data/
IPIS, 2014. Analysis of the Interactive Map of Artisanal Mining Areas in Eastern DR Congo: May 2014 Update. International Peace Information Service, Antwerp.
Jønsson, J.B., Bryceson, D.F., 2009. Rushing for Gold: Mobility and Small-Scale Mining in East Africa. Dev. Change 40, 249–279.
Kilosho Buraye, J., Stoop, N., Verpoorten, M., 2017. Defusing the social minefield of gold sites in Kamituga, South Kivu. From legal pluralism to the re-making of institutions? Resour. Policy 53, 356–368.
Kyanga Wasso, A., 2013. Sominki En Liquidation: Aide-Memoire Sur L'evolution De La Societe À Kamituga. Sominki, Bukavu.
Labonne, B., 2014. Who is afraid of artisanal and small-scale mining (ASM)? Extr. Ind. Soc. 1, 121–123.
Levin, 2014. Global Trends in Artisanal and Small-Scale Mining: What Do These Mean for Mongolia? Levin Sources.
Luning, S., 2008. Gold Mining in Sanmantega, in: Abbink, J., Dokkum, A. van (Eds.), Dilemmas of Development: Conflicts of Interest and Their Resolutions in Modernizing Africa. African Studies Centre, Leiden.
Matthysen, K., Spittaels, S., Schouten, P., 2019. Mapping artisanal mining areas and mineral supply chains in eastern DR Congo. IPIS.
Mulonda, S.B., Radley, B., Geenen, S., 2019. Arrêtez les concasseurs! Transformation, quasi-dépossession et répression autour de la production d'or à Kamituga, in: Conjonctures de l'Afrique Centrale 2019., Cahiers Africains. L'Harmattan, Paris, pp. 158–186.
Mwaipopo, R., Mutagwaba, W., Nyange, D., Fisher, E., 2004. Increasing the Contribution of Artisanal and Small-Scale Mining to Poverty Reduction in Tanzania (Technical Report). DFID, London.
Ndaywel è Nziema, I., Obenga, T., Salmon, P., 1998. Histoire générale du Congo : de l'héritage ancien à la République Démocratique. Duculot, Paris.

Owusu, O., Bansah, K.J., Mensah, A.K., 2019. "Small in size, but big in impact": Socio-environmental reforms for sustainable artisanal and small-scale mining. J. Sustain. Min. 18, 38–44.
Perks, R., 2011. 'can I Go?'—Exiting the Artisanal Mining Sector in the Democratic Republic of Congo. J. Int. Dev. 23, 1115–1127.
Phillips, L.C., Semboja, D.H., Shukla, G.P., 2001. Tanzania's Precious Minerals Boom: Issues In Mining and Marketing (Discussion Paper No. 68). African Economic Policy.
Radley, B., 2020. A Distributional Analysis of Artisanal and Industrial Wage Levels and Expenditure in the Congolese Mining Sector. J. Dev. Stud. 0, 1–16.
Radley, B., 2019. Mining Industrialisation in the African Periphery: Disruption and Dependency in South Kivu, DRC. CERES, Research School for Resource Studies for Development.
Seccatore, J., Veiga, M., Origliasso, C., Marin, T., De Tomi, G., 2014. An estimation of the artisanal small-scale production of gold in the world. Sci. Total Environ. 496, 662–667.
Stearns, J., Vogel, C., 2015. The Landscape of Armed Groups in the Eastern Congo. Congo Res. Group Cent. Int. Coop.
Stoop, N., Verpoorten, M., 2020. Risk, Envy and Magic in the Artisanal Mining Sector of South Kivu, Democratic Republic of Congo. Dev. Change 51, 1199–1224.
Stoop, N., Verpoorten, M., n.d. Would you fight? We asked aggrieved artisanal miners in Eastern Congo.
Stoop, N., Verpoorten, M., van der Windt, P., 2019. Artisanal or industrial conflict minerals? Evidence from Eastern Congo. World Dev. 122, 660–674.
Tibbett, S., 2009. A Golden Opportunity. Recasting the Debate on the Economic and Development Benefits of Small-Scale and Artisanal Gold Minng. CRED Foundation.
Tschakert, P., 2009. Recognizing and nurturing artisanal mining as a viable livelihood. Resour. Policy 34, 24–31.
United Nations, 1993. Guidelines for the Development of Small and Medium-Scale Mining: Selected Papers Presented at the Un Interregional Seminar Held in Harare, Zimbabwe, 15-19 February 1993. United Nations.
Van Acker, F., 2005. Where did all the land go? Enclosure & social struggle in Kivu (D.R.Congo). Rev. Afr. Polit. Econ. 32, 79–98.
Varian, H.R., 1992. Microeconomic Analysis, Third Edition, 3rd edition. ed. W. W. Norton & Company, New York.
Vlassenroot, K., Raeymaekers, T., 2004. Conflict and Social Transformation in Eastern DR Congo. Academia Press Scientific Publishers, Gent [Belgium].
World Bank, 2019. State of the Artisanal and Small-Scale Mining Sector 2019. Washington, D.C.
World Gold Council, 2015. The social and economic impacts of gold mining. World Gold Council.