

Original article

The impact of the Fairmined Certification on the well-being of small-scale miners: Evidence from Colombia and Peru

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ABSTRACT

In this study, we estimate the impact of the Fairmined certification scheme on the well-being of participating artisanal and small-scale gold miners in Colombia and Peru. First, we collected information through phone surveys of certified and non-certified miners. Second, we constructed a well-being index that covers multiple dimensions of well-being, including material and subjective measures. Third, through linear regression techniques and propensity score matching, we compared certified miners (treatment group) to non-certified ones (control group). The results indicate that, on average, Fairmined certified miners enjoy higher well-being scores than those who do not belong to a certified mining organization.

1. Introduction

Extractive industries produce important socio-environmental impacts on local communities and work conditions are often exploitative. The gold mining industry, in particular, is notorious for its practices that include extensive contamination and social impacts that, in markedly different manners, characterize both large-scale and small-scale operations (Bridge, 2004; Conde, 2017). The impacts of mining are the subject of contentious politics and social movements opposition, as discussed in the literature on environmental conflict (Arsel et al., 2016; Conde and Le Billon, 2017). In this context, voluntary certification schemes have been developed to ameliorate the shortcomings of the existing regulatory frameworks, improve the way mining operations are carried out and respond to the growing concerns of companies and consumers (Cashore, 2002; Schoderer et al., 2020). These schemes are expected to have positive impacts on the environment and the livelihoods of local communities and miners. However, assessing the impacts and effectiveness of these certifications is not trivial (Petrokofsky and Jennings, 2018) and, while many authors carry out quantitative impact evaluations of certification for tropical commodities such as cocoa, banana, coffee (Jena and Grote, 2017; Mitiku et al., 2017; Mojo et al., 2015; Nunn et al., 2018) and fish (Alemu and Azadi, 2018; Marschke and Wilkings, 2014), there are no impact evaluations of fair trade certification for artisanal and small-scale mining.

This study focuses on the case of the Fairmined Standard that covers

gold extracted by artisanal and small-scale miners. The long-term objective of the Fairmined standard is to improve the well-being of miners, their families and communities and environmental management (Alliance for Responsible Mining, 2015). To evaluate the impact of the Fairmined Certification on its members, partners and workers well-being, we use average treatment effect analysis. The members or partners of the artisanal and small-scale mining organizations are persons who belong to the cooperative or association or who own shares of a small-scale mining company. The workers are the persons who work for the company and engage in extracting, processing and/or cleaning of the minerals, as well as administration. The treatment is being part of a Fairmined certified mining organization and the control is non-membership.

To pursue our goal, we followed four steps. First, we defined the well-being dimensions to be assessed. Second, we designed a questionnaire to administer phone surveys to the miners. Third, we built an index to measure well-being, our dependent variable. Finally, we used linear regressions and propensity score matching (PSM) to compare treatment and control groups.

The rest of the article is organized as follows. Section 2 reviews the context of the artisanal and small-scale gold mining and the relevant literature in well-being indexes and impact evaluation of certifications, especially, those analyzing the minerals sectors. Then, we present the methodology in Section 3, the context in Section 3.1, the data collection process in Section 3.2, the well-being index construction in Section 3.3

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and Section 3.4 points out the impact evaluation methods. Finally, the findings are presented in Section 4 and the conclusions in Section 5.

2. Gold mining and certification

Up to 20% of the world gold production comes from Artisanal and Small-scale Mining (ASM) (World Bank, 2013). According to a popular definition "ASM is the formal and informal mining operations with predominantly simplified forms of exploration, extraction, processing, and transportation. ASM is normally low capital intensive and uses high labor-intensive technology" (Organisation for Economic Co-operation and Development (OECD), 2016, p. 65). The ASM gold sector employs 10-20 million miners (50% of global ASM miners) and contributes to 90% of the total employment in gold mining (Intergovernmental Forum on Mining Minerals Metals and Sustainable Development (IGF), 2017).

The ASM sector holds the potential to contribute to local development through employment and entrepreneurial opportunities. However, exploitative practices and socio-environmental impacts are common. In fact, ASM is often associated with criminal activities such as money-laundering and financing of illegal armed forces (McDonald, 2019), it is linked with human rights violations (Human Rights Watch, 2018) and it presents challenges for government management and regulation in relation to mercury pollution, environmental degradation and health and safety issues (Sippl, 2015). Thus, ASM is significant for poverty alleviation and the promotion of local development in Africa, Latin America and Asia (Echavarría, 2014; Hentschel et al., 2002; Hilson, 2002; Hruschka and Echavarría, 2011; Siegel and Veiga, 2010), but it is a commonplace to recognize that this potential is conditional on measures that support formalization, regulatory compliance, technology transfer and training.

There are 19 certification schemes in the minerals supply chains, 11 of them covers the gold industry (Kickler and Franken, 2017; Tröster and Hiete, 2019); 10 of such schemes focus on production by large-scale mining (LSM), 3 for Artisanal and Small-scale Mining (ASM), 4 for all scales and 3 for smelters (Kickler and Franken, 2017, p. 20). Fairmined and Fairtrade certification schemes certify gold extracted from artisanal and small-scale miners and connect the miners to ethical markets to improve the well-being of the miners and the commercial conditions (Hilson et al., 2018, p. 896). The schemes ensure price premiums and include third-party verification (Hilson et al., 2018; Stähr and Schütte, 2016; Tröster and Hiete, 2019).

Fairmined is managed by the NGO Alliance for Responsible Mining (headquartered in Colombia) and Fairtrade by the Fairtrade Foundation (headquartered in Germany¹). We focus on the Fairmined Certification which is the larger scheme for ASM: until 2020 it has covered 24 mining organizations in Colombia, Peru, Bolivia and Mongolia (Alliance for Responsible Mining, 2020) while Fairtrade has certified 13 mining organizations in Peru, Kenya and Uganda (Fairtrade, 2020).

The application of certification to the gold sector creates challenges and opportunities (Hilson et al., 2018). In particular, ASM gold in Sub-Saharan Africa is mostly acquired by governments that use it as foreign exchange, as opposed to tropical agricultural products that reach retail consumers more directly. This difference puts a limit on the potential of certification to leverage on the willingness of Western consumers to pay a premium for fair gold and would require substantial adaptations to become mainstream. However, the explicit emphasis on participation, characteristic of the Fair Trade model, makes it possible to adapt Fair Trade Gold standards and practices to local conditions (Childs, 2008) and align the interests of stakeholders, primarily miners and certifiers (Sippl, 2020). Evidence from Tanzania suggests that Fairtrade Gold certification faces important challenges in raising prices for ASM but holds the potential to improve the recognition of the sector

and hence to contribute to more just outcomes (Childs, 2014a; 2014b). The certification schemes are focusing on miners that are relatively better off prior to joining the programme if compared to the average person in the sector, but these miners have still substantial needs (Fisher, 2018; Sippl, 2020) and can employ workers whose livelihoods are precarious. Overall, the private governance theory underpinning the diffusion of the commodity certification model to new sectors in heterogeneous contexts is viewed rather critically. The certification project is bound to face the challenges commonly faced by development initiatives compounded with the low expectations engendered by a history of limited success with projects focusing on the ASM (Childs, 2014b; Fisher, 2018; Sippl, 2020) and the informality ruling the sector.

Impact evaluations of fair trade schemes for other commodities include qualitative evaluations carried out by the standards-setting organization (e.g. Havelaar France (2009)) as well as independent quantitative studies (e.g. Bray and Neilson (2017); Elliott (2018); Giuliani et al. (2017); Negash (2016); Oya et al. (2018)). Our methodology borrows from the works of impact evaluations of certified coffee farmers by Bro et al. (2019); Jena et al. (2012); Jena and Grote (2017); Lampach and Morawetz (2016); Mojo et al. (2015).

3. Context, data and methodology

Our objective is to estimate the impact of belonging to a certified mining organization on miners well-being. To this effect, we first describe the context where we collected data. Second, we describe the data collection process. Then we construct a well-being index and use the average treatment on the treated effect and propensity score matching as estimation techniques.

3.1. Context

Colombia and Peru are significant players in global gold production: in 2018 they produced 43 and 158 tonnes of gold, respectively (World Gold Council, 2020). They are the sixth and the twentieth country in the global ranking. ASM contributes to 46% of production volumes in Colombia and 28% in Peru (UN Environment programme, 2020).

Fairmined certified gold mining operations in Colombia are in the Huila and Cauca departments. They exploit underground hard-rock deposits. The mining areas are within coffee regions and often the miners engage with artisanal mining and coffee cultivation, alternating them seasonally. One of the organizations included in this study is a cooperative where we surveyed 127 miners. It was the first certified organization of Colombia in 2014. The second one is a small company where we surveyed 23 miners and got the certification in 2018. The non-certified organizations included are in the Nariño (3), Caldas (1) and Antioquia (1) departments. They also exploit underground hard-rock mining, the areas are within coffee regions and miners engage in both agriculture and mining. The non-certified organizations are cooperatives (1), associations (1) and small companies (3). In Peru, the Fairmined certified organizations are from two Andean regions: Arequipa and Puno. In Arequipa, there is one certified ASM organization that is a hard-rock mining operation. In Puno, there are 3 ASM organizations, two exploit alluvial deposits and one exploits hard-rock mining. The operations in the study include all certified companies in Peru. The non-certified organizations are in Ayacucho (15) and Puno (14), also in the Andes. For Peruvian miners from all areas, it is common to combine mining with agriculture and commerce. The certified organizations reached that status in 2016, 2017 and 2018. The certified, as well as the non-certified organizations, are cooperatives and small companies. The total of certified miners surveyed is 58 and the non-certified 54. Table 1, presents the details of the mining organizations included in the study.

3.2. Data

We collected primary data through a survey administered to miners

¹ For an overview of the history of the two organizations and their pattern of collaboration and competition, see Fisher (2018) and Sippl (2020).

(partners and workers) of certified and non-certified mining organizations in Colombia and Peru. The survey consists of 50 questions divided into four sections (see the survey in Appendix A). The data collection took place between July 1 and November 1, 2020. Our final sample comprises 321 completed surveys: 208 certified miners, partners or workers (150 in Colombia and 58 in Peru) and 113 non-certified miners (59 in Colombia and 54 in Peru). The certified miners are from 2 (out of 3) organizations in Colombia and 4 (out of 4) certified mining organizations in Peru (Alliance for Responsible Mining, 2020). Due to the Covid-19 pandemic, the survey was carried out by phone. Although this is not a large sample, we managed to collect data on over 50% of the total certified miners. The sample covers six out of the nine Fairmined

Table 1
Certified and non-certified surveyed miners in Colombia and Peru.

Organization name	Type	Cert years	Miners (#)	Department
COLOMBIA				
Certified organizations			150	
Coop Iquira	Cooperative	6	127	Huila
Chede	Small company	2	23	Cauca
Non-certified organizations			59	
Coodmilla	Cooperative	0	45	Nario
Fortaleza	Association	0	3	Nariño
El Tablon	Small company	0	3	Nariño
Sky minerals	Small company	0	2	Caldas
La Maria SAS	Small company	0	6	Antioquia
PERU				
Certified organizations			58	
Cecomip	Cooperatives group	4	23	Puno
Oro Puno	Small company	3	1	Puno
Cruz Pata	Small company	1	4	Puno
Macdesa	Medium company*	3	30	Arequipa
Non-certified organizations			54	
Coop.Min. San Franc. De Rinconada	Cooperative	0	1	Puno
Comunidad campesina upina	Cooperative	0	1	Puno
Diasac	Cooperative	0	1	Puno
Carmelitas de chavin	Cooperative	0	1	Puno
Corporacin minera de oro	Cooperative	0	1	Puno
Gavilan Rio Pararani	Cooperative	0	1	Puno
Independent	Small company	0	3	Puno
Pea de ore	Cooperative	0	1	Puno
Productores mineros pomasi sac	Cooperative	0	1	Puno
Coop. Independiente	Cooperative	0	1	Puno
San Francisco de Asis	Cooperative	0	2	Puno
Cencomip	Cooperative	0	1	Puno
Tumi de Oro	Small Company	0	2	Puno
Trapiche de oro	Small Company	0	1	Puno
Empresa San Luis	Small company	0	11	Ayacucho
Sancos	Small company	0	1	Ayacucho
Diatomita Ayacucho	Small company	0	1	Ayacucho
San Pedro	Small company	0	1	Ayacucho
Samana	Small company	0	3	Ayacucho
Puquio	Small company	0	1	Ayacucho
Pullo	Small company	0	1	Ayacucho
Las Lomas	Small company	0	3	Ayacucho
Independent	Small company	0	4	Ayacucho
Incapacha	Small company	0	1	Ayacucho
Chillona	Small company	0	1	Ayacucho
Chillacupro	Small company	0	1	Ayacucho
Chilawuito	Small company	0	1	Ayacucho
Coop. Nueva Teresita	Cooperative	0	2	Ayacucho
Nueva Victoria	Small company	0	3	Ayacucho

Note: * Though Macdesa practices artisanal and small-scale mining, it has enough employees to be considered a medium company according to the Peruvian law.

certified mining organizations² and we get a sample of each organization in Colombia and Peru. Thus the sample is small but representative since it covers an initiative that is itself still on a small scale (Sippl, 2020). We collected information also from non-certified mining organizations—the control group. These organizations share some key attributes with the certified ones; they are formal organizations, are located in the same regions and their members have similar demographic features.

3.3. Well-being index

We constructed a miners well-being index following the Better life index (Organisation for Economic Co-operation and Development (OECD), 2020) that embodies an integrated approach to well-being, capturing a variety of aspects of the living conditions of the miner and their families. The dimensions include measures of subjective well-being (Division of Mental Health. World Health Organization, 1995; Organisation for Economic Co-operation and Development (OECD), 2013) and the material well-being measured by the national quality of life surveys from Colombia (Departamento Administrativo Nacional de Estadística, 2018) and Peru (Instituto Nacional de Estadística e Informatica, 2019). Our index can be criticized as reductionist (or simplistic) since it attempts to produce a single metric to proxy for human welfare. While clearly, this is a valid concern, if compared to standard well-being indicators based on monetary metrics (e.g. average income, or poverty lines), it has the advantage of covering several dimensions of well-being that go beyond material wealth.

Our index comprises 27 indicators distributed in six well-being dimensions: Education, Health and Safety, Income, Wealth and Housing, Work and Job Quality, Social Connections and Subjective Well-being. Table 2 describes the indicators per dimension, the weight we assigned to each indicator, the possible range of answers and its relation to the OECD Better life index. The index ranges from 0 to 1, with higher values indicating higher well-being.

We collect data on 50 variables for 321 individuals, including their characteristics, observable material and subjective well-being elements³. Table 3 presents the descriptive statistics of the data⁴.

3.4. Impact evaluation methods

The most common methods employed in impact evaluations such as the one carried out here are linear regression, difference in difference, propensity score matching (PSM) and discontinuity regression (Greene, 2012). The propensity score matching (PSM) method pairs individuals that are similar on observable characteristics and estimates the average treatment effect by difference in outcomes, reducing the bias created by unobservable confounding factors when the treatment and control group are not randomized (Becker and Ichino, 2002; Greene, 2012, p. 935).

Since our treated and control groups are not randomized and ASM organizations are self-selected into the treatment group, after using simple linear regressions, we use PSM. PSM consists of finding two individuals who share the same characteristics except for having (or not) received a given treatment. To find the matching individuals, we compute a propensity score denoted by \mathcal{S}_i for each individual. \mathcal{S}_i accounts for observable characteristics—denoted by x_i . The propensity score is, in other words, the probability of being treated given certain characteristics. We denote by $T_i = 1$ the individual who received the

² The additional two organizations are from Mongolia. These were not included since the sample would become very heterogeneous.

³ The questionnaire and basic information on data collection, management and analysis are included in Appendix A, available online.

⁴ For further details about the data management, see Appendix Appendix B, available online.

Table 2
Well-being index: components and dimensions.

Indicators	Weight	Range of answers	OECD dimension	
Level of education	1.00	0 (None)- 7 (university)	Knowledge and skills	
Health status	0.40	0 (very bad)- 3 (very good)	Health	
Health today satisfaction	0.15	0-Worst -10 best		
Healthy Physical environment satisfaction	0.15	0-Worst -10 best	Environmental condition	
Type health care	0.30	0 No health care 3- Special	Income and Wealth	
Access electric power	0.05	0 No - 1 Yes		
Access water	0.05	0 No - 1 Yes		
Access sewage	0.05	0 No - 1 Yes		
Access garbage collection	0.05	0 No - 1 Yes		
House property condition	0.20	0 Colective - 5 Own		
Monthly expenses	0.10	0 Min Data		
Monthly Savings	0.20	0 Min Data		
Appliances	0.20	0 Min Data		
Other types of income	0.10	0 No - 1 Yes		
Frequency EPP use	0.20	0 Never - 4 Very frequent		
Level of job safety	0.10	0 Worst - 10 best	Work and Job Quality	
Job satisfaction	0.10	0 Worst - 10 best		
Training level satisfaction	0.10	0 Worst - 10 best	Social connections	
Type of contract	0.30	0 Verbal - 2 Associate		
Accidents in mining last year	0.20	10 Worst - 0 best		
Time to social and community activities	0.50	0 Never- 4 Very frequent		
Support from relatives and friends	0.50	0 Worst - 10 best		
Current income satisfaction	0.20	0 Worst - 10 best		
Life today satisfaction	0.20	0 Worst -10 best		Subjective Well-being
Level of happiness yesterday	0.20	0 Worst - 10 best		
Level of worries yesterday	0.20	10 Worst - 0 best		
Level of sadness yesterday	0.20	10 Worst - 0 best		

treatment—individuals that belong to a Fairmined certified mining organization—and by $T_i = 0$ the individuals who did not receive the treatment. Following Rosenbaum and Rubin (1983), the probability of having received the treatment is:

$$\mathcal{S}_i = Pr(T_i= 1 | x_i) \tag{1}$$

The score \mathcal{S}_i can be easily estimated using a Logit or Probit model. Because the coefficients of the Logit model can be interpreted as odds-ratios, we prefer this model, but we also perform the estimation using the Probit model to test for the sensitivity of our results.

After the estimation of the propensity score for each individual, we find their match using one of the algorithms proposed in the literature: nearest-neighbour, radius, kernel, or stratification matching. Once we have the matched pairs, that is, individuals with *the same* characteristics apart from the treatment, we estimate the Average Treatment Effect on the Treated (ATT) as:

$$\begin{aligned} ATT &= \mathbb{E}[y_{1i} - y_{0i} | T_i = 1] \\ &= \mathbb{E}\{\mathbb{E}[y_{1i} - y_{0i} | T_i = 1, \mathcal{S}_i]\} \\ &= \mathbb{E}_{\mathcal{S}_i | T_i=1} \{\mathbb{E}[y_{1i} | T_i = 1, \mathcal{S}_i] - \mathbb{E}[y_{0i} | T_i = 0, \mathcal{S}_i]\} \end{aligned} \tag{2}$$

The ATT is the average difference in the dependent variable between the treated and non-treated individuals.

4. Findings

Out of the 321 miners sample, we have 208 certified and 113 non-certified miners, 127 partners and 193 workers. There are 273 men (164 workers and 109 partners) and 47 women (29 workers, 18 partners). In terms of miners demographics, for certified and non-certified miners the average age is 37 and 42 years old, respectively. The minimum age of the (non-) certified miners is (20) 18 years and the maximum is (72) 67 years. Concerning the level of education, both groups of miners have, on average, completed high school. The mean of the well-being index is 0.64 and 0.61 for certified and non-certified miners, respectively. The difference in well-being is moderate but it is statistically significant. Certified miners report higher life satisfaction in terms of health, life and income. Certified and non-certified miners have similar monthly expenses of \$325 and \$344, respectively. Monthly savings are \$96 for the certified miners and \$120 for the non-certified ones. The descriptive statistics are presented in Table 3.

Fig. 1 presents empirical densities and the average well-being index of certified (green colour) and non-certified miners (red colour). The well-being index for certified miners is 3 percentage points larger if compared to non-certified ones. The difference is equivalent to approximately one-third of a standard deviation and the Welchs test indicate that it is statistically significant⁵. The observed t-statistic is -2.241 with a p-value of 0.026; hence we reject the null hypothesis of no difference in mean. Furthermore, the well-being index of certified miners shows less dispersion than the non-certified miners, implying that a higher proportion of the certified miners are around the same quality of life level.

We explored the differences in well-being between partners and workers. See Fig. 1. The observed difference in the well-being of the certified vs the non-certified miners is mainly due to the higher well-being of the workers, see the plot in Fig. 2. The index is 0.63 and 0.59 for the certified and non-certified workers, respectively. The difference is equal to almost half a standard deviation. Performing Welch’s test of difference in mean, the observed t-statistic is -2.836 with a p-value of 0.006; hence we reject the null hypothesis of no difference with higher confidence if compared to the whole sample.

Finally, we also compare the well-being index by country and find no significant difference when we compute the Welchs test. The observed t-statistic is 1.162 and the p-value is 0.246. These results suggest that there is little difference across countries in our sample.

Furthermore, we estimated three models using linear regressions and propensity score matching to verify the descriptive results and evaluate the factors associated with the quality of life. Following the literature, the variables include demographic characteristics, wealth, housing conditions, subjective well-being satisfaction, level of pride with the job and environment and social awareness. Table 4 presents the results.

The first model is a linear regression of the well-being index against the binary variable of being certified or not. The second model evaluates the well-being index with the binary variable plus age, number of children and type of house. The third model includes the previous variables and sex, country of origin, the houses wall materials, daily leisure hours, pride level for working in the company and job security.

We find that belonging to a certified mining organization (Model 1) increases the miners well-being by 4 percentage points that is approximately half a standard deviation. The result is statistically significant at the 1% level. Model 2 also shows that belonging to a certified mining organization is statistically significant and increases the miners well-being by 4.5 percentage points. Moreover, the type of house increases the miners well-being by about 3 percentage points. Conversely, the

⁵ The Welchs test of difference in the mean is calculated to identify if two sample means are significantly different. As opposed to the Students t-test, the Welch’s test does not require that the variance of the samples is the same. However, it maintains the assumption of normality in the samples.

Table 3
Descriptive statistics.

Variable	Fairmined	Mean	St dev	Min	P.50%	Max
Wellbeing Index	Non-certified	0.61	0.11	0.38	0.61	0.85
	Certified	0.64	0.08	0.40	0.64	0.90
Age	Non-certified	42.40	13.06	20.00	41.00	72.00
	Certified	36.99	11.03	18.00	35.00	67.00
Monthly Expenses (Dollars)	Non-certified	344.67	439.97	15.97	212.93	3,932.58
	Certified	325.23	444.79	0.00	226.24	4,790.93
Monthly savings (Dollars)	Non-certified	120.19	211.88	0.00	53.23	1,330.81
	Certified	96.12	183.50	0.00	47.91	1,330.81
Appliances	Non-certified	24.50	9.33	8.00	23.00	51.00
	Certified	25.21	9.45	3.00	24.00	54.00
Years in mining	Non-certified	18.73	12.15	0.00	17.00	54.00
	Certified	21.21	9.10	0.00	21.00	55.00
Year in company	Non-certified	8.28	8.52	0.20	5.00	45.00
	Certified	6.69	5.55	0.00	5.00	22.00
Working hours	Non-certified	38.01	12.02	0.00	40.00	60.00
	Certified	45.32	9.63	0.00	48.00	84.00
Level of education	Non-certified	3.15	2.27	0.00	3.00	7.00
	Certified	3.07	2.10	0.00	3.00	7.00
# Dependents	Non-certified	2.49	1.68	0.00	2.00	8.00
	Certified	2.81	1.48	0.00	3.00	7.00
Health Satisfaction (0-10)	Non-certified	8.15	1.68	3.00	8.00	10.00
	Certified	9.10	1.24	5.00	10.00	10.00
Life Satisfaction (0-10)	Non-certified	8.41	1.49	5.00	8.00	10.00
	Certified	9.38	1.00	5.00	10.00	10.00
Income Satisfaction (0-10)	Non-certified	7.19	1.66	3.00	7.00	10.00
	Certified	7.87	1.87	2.00	8.00	10.00
Environment Awareness (0-10)	Non-certified	8.03	1.90	3.00	9.00	10.00
	Certified	8.73	1.43	4.00	9.00	10.00
Social Awareness (0 and 10)	Non-certified	7.66	2.00	2.00	8.00	10.00
	Certified	8.43	1.48	0.00	9.00	10.00
Better Fairmined	Non-certified	7.76	1.94	0.00	8.00	10.00
	Certified	8.88	1.68	0.00	9.00	10.00

Note: The level of education is between 0 to 7, with 0 being incomplete elementary school and 7 a university degree. For variables with responses ranging between 0 to 10, 0 is the smallest and 10 is the maximum possible value. Appliances is a score between 0 (no appliances) and 54.4 (maximum number of appliances). Source: own dataset.

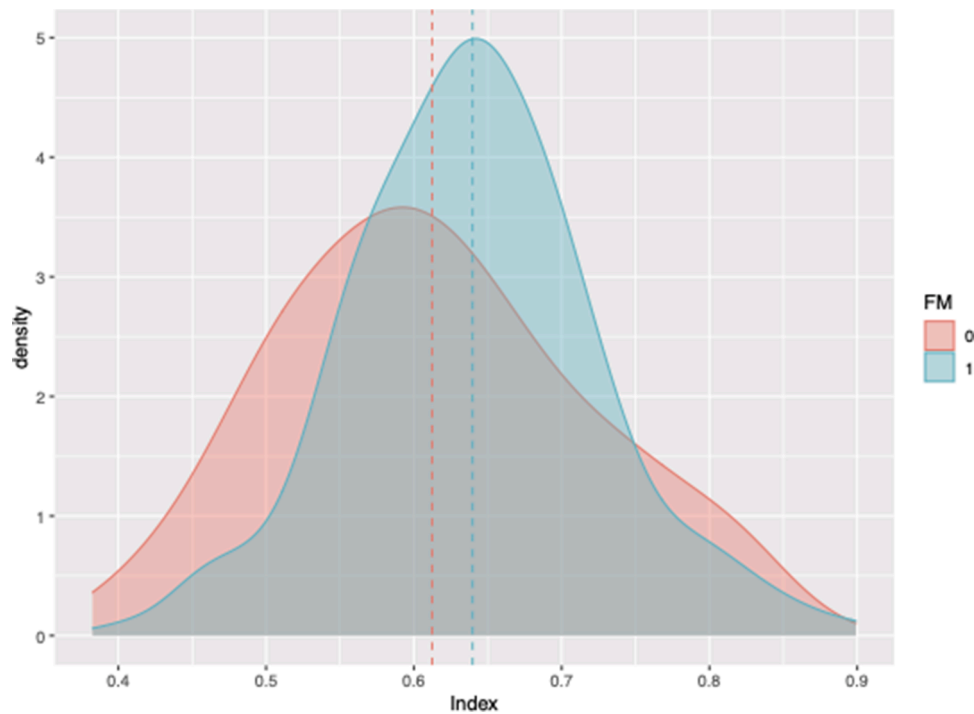


Fig. 1. Well-being Index density for all miners (workers and partners) Note: Well-being density. Miners belonging to a certified (FM=1) or non-certified FM=0) mining organization.

variable number of children is associated with a reduction of well-being by less than 1 percentage point. Model 3, which includes more variables, presents similar results but, as expected, the Fairmined certification is

associated with a more modest coefficient since some of the control variables might introduce endogeneity. Our treated and control groups are not random since our sample has a self-selection problem—the miners

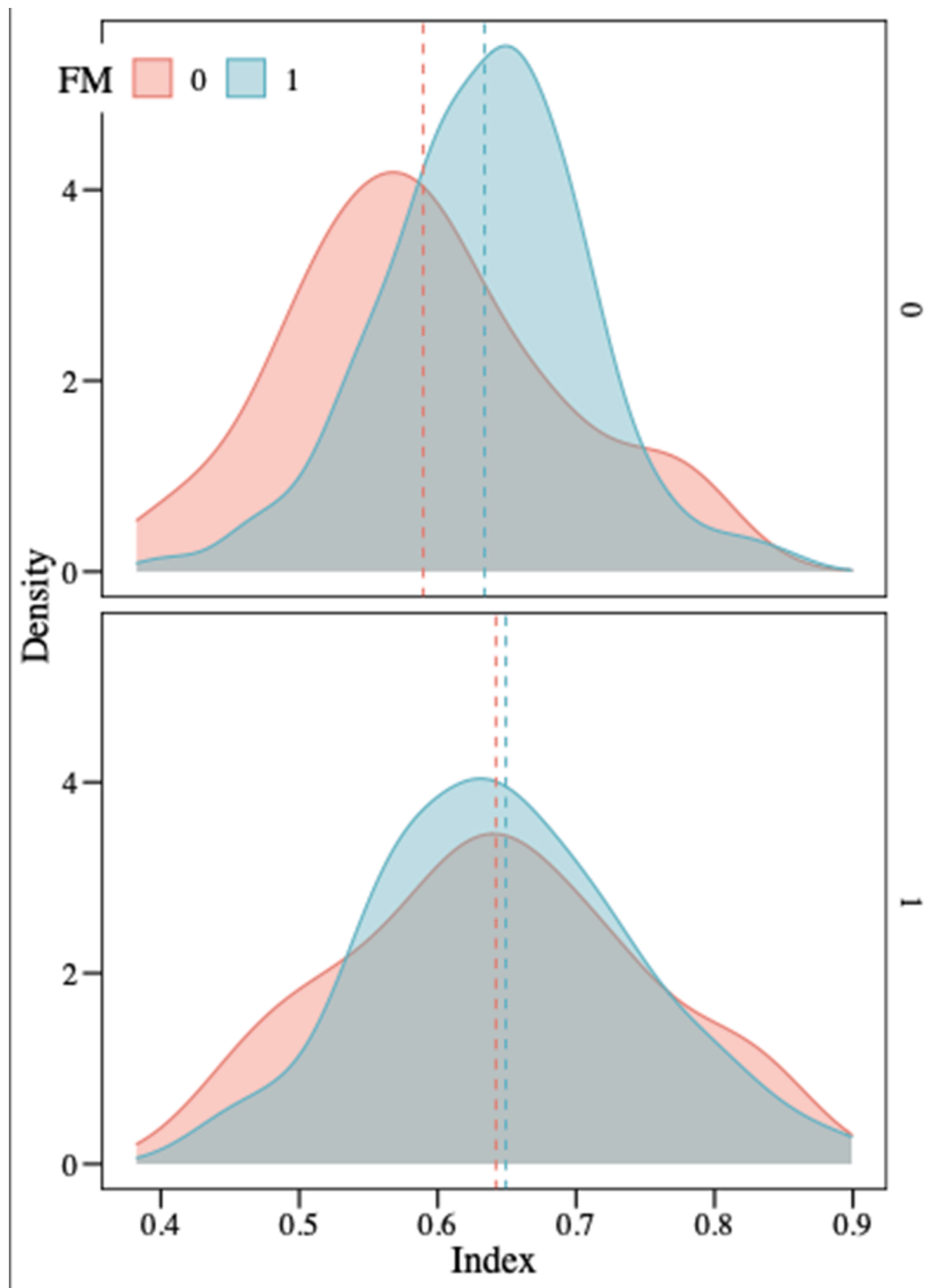


Fig. 2. Well-being Index density classified by workers and partners. Note: This plot compares the densities of the well-being index for workers (top) and partners (bottom) for certified (blue) and non-certified (red) mining organizations.

who are in the certification have chosen to do so. Thus, the decision to join the certification scheme might be related to some underlying characteristics and a direct comparison through linear regression would result in biased estimates. To reduce the risk engendered by self-selection, we checked the regression results with propensity score matching, as discussed in section 3.4.

That is, we matched control units (non-certified miners units) for each of the treated (certified miners) using the nearest-neighbour algorithm⁶. For our 129 treated units, we find 62 control units and discarded 2. After having a data set with the matched treated and control units, we perform the same regressions having reduced the risk of

selection bias. The results indicate that the effect is about the same as the one estimated with the simple linear regression (Table 5). Miners well-being increases by about 4 percentage points by being part of a Fair-mined certified mining organization. The other two models results are also consistent, though model 2 shows slightly higher coefficients.

We consider that a possible explanation for the consistency of the results, between the simple regression (Table 4) and the regressions with the matched data (Table 5) is that including data on the workers reduces the potential selection bias, since workers most likely do not participate in the decision to be certified.

5. Concluding remarks

Artisanal and small-scale gold mining is often associated with poor working conditions, little regulatory supervision and socio-

⁶ As a robustness check, we also used other matching algorithms. The results were consistent and are available upon request.

Table 4
Linear regression models.

	Model 1	Model 2	Model 3
(Intercept)	0.594*** (0.011)	0.467*** (0.042)	0.139** (0.065)
FM1	0.040*** (0.013)	0.045*** (0.013)	0.020 (0.013)
Age		0.001* (0.001)	0.002*** (0.001)
Childen		- 0.017*** (0.006)	- 0.017*** (0.006)
House.type		0.027*** (0.009)	0.015* (0.009)
Sex			0.005 (0.015)
CountryPer			0.002 (0.015)
WallMat			0.012** (0.006)
LeisureHrs			- 0.002 (0.001)
Proud			0.010** (0.005)
JobSec			0.018*** (0.005)
EnviAware			0.002 (0.005)
SocialAware			0.008 (0.005)
R ²	0.047	0.118	0.338
Adj. R ²	0.042	0.099	0.294
Num. obs.	193	193	193

****p* < 0.01; ***p* < 0.05; **p* < 0.1 Source: own dataset.

Table 5
Linear regression models with matched data.

	Model 1	Model 2	Model 3
(Intercept)	0.594*** (0.011)	0.457*** (0.042)	0.129** (0.064)
FM1	0.039*** (0.013)	0.046*** (0.013)	0.020 (0.013)
Age		0.002** (0.001)	0.002*** (0.001)
Childen		- 0.020*** (0.006)	- 0.019*** (0.006)
House.type		0.029*** (0.009)	0.015* (0.009)
Sex			0.005 (0.015)
CountryPer			0.000 (0.016)
WallMat			0.012** (0.006)
LeisureHrs			- 0.001 (0.001)
Proud			0.010** (0.005)
JobSec			0.018*** (0.005)
EnviAware			0.002 (0.005)
SocialAware			0.007 (0.005)
R ²	0.045	0.127	0.350
Adj. R ²	0.040	0.108	0.306
Num. obs.	191	191	191

****p* < 0.01; ***p* < 0.05; **p* < 0.1 Source: own dataset.

environmental impacts. In this context, voluntary certification schemes might improve the way mines operate and produce benefits for the miners. We examined whether participation in the Fairmined scheme improves gold miners' well-being in Colombia and Peru and the results indicate that this is the case. We used a comprehensive approach to build a well-being index with six components and 27 indicators of quality of life. We observe that the improvement in the well-being of certified miners applies to all the components of our index, including satisfaction in relation to health, life, and income. The results suggest that the certification scheme is associated with the improvement of (material and subjective) well-being and that the outcome might be driven principally by the effect on the salaried workers. Similar results were obtained when using the simple linear regression method as well as propensity score matching. This study fills a gap in the literature by providing the first estimates of the impact of certification in the gold sector on the well-being of miners. However, several questions remain open. Gold mining operations have impacts that go well beyond the ones on the miners themselves and several other socio-environmental impacts could be studied—occupational and non-occupational health, community-level development, employment opportunities, just to mention a few. Moreover, the impact of certified operations in the mining sector could be examined taking into consideration a variety of control groups: artisanal versus large-scale, informal versus formal operations. Also, mining standards are being promoted in several countries in different parts of the world and more countries could be included. Finally, data collection for this study took place during the COVID-19 pandemic and the robustness of the results should be tested on larger samples with data collected in situ, at a different point in time and complemented with more qualitative data.

Declaration of Competing Interest

The first author works for the Alliance for Responsible Mining (ARM), where she is the Standards and Certification Manager. Nonetheless, the research was carried out independently from the ARM and the NGO did not influence the content of this article. Data collection has been performed by independent enumerators and financed by an academic institution. The first author has direct experience in the sector and has worked for 7 years in mining certification. This background implies familiarity with the sector and contextual knowledge but might imply strong a priori. The quantitative focus of this study could be seen as a limitation from the epistemological perspective, however, it makes it possible to generate results challenging previous knowledge. This is the case because data were gathered through enumerators and the analysis followed standard techniques and was carried out jointly with the other authors. To balance interests, the second author reviewed thoroughly the data and analysis. Additionally, the third author is convinced that the best way to do mining is to radically reduce its operations, together with the rest of the inputs into global social metabolism. The preferred first steps with respect specifically to gold mining would be to increase recycling, prohibit the hoarding of precious metals by financial institutions and the use of gold as an ornament. The (anonymized) data and programs scripts are available for replication purposes.

Appendix A. Questionnaire

Consent: We have obtained your contact information through the representative of the cooperative / company. Mr (s). —. For which I kindly request if you can answer some questions that will contribute to assess the impact of responsible mining. Your data will be used Anonymous and Confidential. Do you consent and authorize your data to be used in the study? If you do not want to answer any questions, please let me know. When answering the questions, put yourself before the COVID-19 situation, that is, in February.

Please, complete the information or select ONE option by marking an X.

1. Consent:
 - Yes: No:
2. Name of the organization:
3. Sex: Man Woman
4. Birth year:
5. What is or was the highest level of education achieved?
 - Some elementary school years
 - All elementary school
 - Some high school years
 - All high school
 - One or more years of the technical or technological program
 - Complete technical or technological program
 - One or more years of university
 - Complete university
 - None
 - Does not know
6. How many people you live with?
7. How many people are financially dependent on you?
8. How many sons/daughters do you have?
9. What is the type of housing where you live?
 - House
 - Apartment
 - Room(s)
 - Indigenous traditional housing
 - Another type of housing (tent, container, wagon, boat, cave, natural refuge, bridge, etc.)
10. The housing occupied by your home is:
 - Own fully paid
 - Own, they are paying it
 - For rent or sublet
 - With the permission of the owner, without any payment (usufructuary)
 - Untitled possession (de facto occupant)
 - Collective ownership
11. What is the main material of the exterior walls of your house?
 - Block, brick, stone, polished wood
 - Tapia tread, adobe
 - Rough wood, board, plank
 - Precast material
 - Guadua, cane, mat, other vegetable
 - Zinc, cloth
12. What is the main material of the floors in your home?
 - Tile, brick, vinyl, tablet, laminate
 - Cement, gravel
 - Polished and lacquered wood, parquet
 - Raw wood, board, plank, other vegetable
 - Sand, land
13. Including living room and dining room, how many rooms or pieces does this home have. Exclude kitchens, bathrooms, garages and rooms for business
14. Which of the following public, private or communal utilities does your home have?
 - Electric power Yes No
 - Water Yes No
 - Sewage Yes No
 - Garbage collection Yes No
15. Are you affiliated (contributor or beneficiary) to any health social security entity? (Health-promoting entity [EPS] or subsidized health-promoting entity [EPS-S]). Yes Not Don't know
16. Which of the following social security schemes in health is you affiliated with?
 - Special (Armed Forces, Ecopetrol, public universities, teaching)
 - Contributory (EPS)
 - Subsidized (EPS-S)
 - Don't know, don't report
17. The state of your general health is:
 - Very good
 - Good
 - Bad
 - Very bad

18. How many years have you been in the mining activity?
19. How many years have you been working in this cooperative/company/organization?
20. How proud are you where you work? 0 not at all and 10 very much
0 1 2 3 4 5 6 7 8 9 10
21. What is your position or main job in the cooperative / company/organization?
22. If you are worker, What type of contract do you have? Verbal Written
23. How many hours, weekly, do you normally work at this job?
24. How many hours daily do you spend per day on leisure or personal care?
25. How often do you spend time in social or community activities?
- Very frequent
 - Frequent
 - Rarely
 - Very rarely
 - Never
26. How many accidents in mining have you had in mining during 2019?
0 1 2 3 4 5 6 7 8 9 10
27. How often do you use personal protection elements to carry out your work?
- Very frequent
 - Frequent
 - Rarely
 - Very rarely
 - Never
28. How many of the following appliances do you have at home?
- Washing machine
 - Fridge or refrigerator
 - Electric or gas stove
 - Electric or gas oven
 - Microwave oven
 - Electric or gas water heater or electric shower
 - Tv
 - Iron
 - Blender
 - Video player (DVD, Blue-ray, others)
 - Stereo
 - Air conditioning
 - Video games: Play Station, X-box, Wii, Nintendo, Gameboy, etc.
 - Particular car
 - Motorbike
 - Bicycle
 - Subscription television service cable, satellite
 - Digital or video player (DVD)
 - Computer
 - Tablet
29. Do you have any other type of income other than labor?
Yes No
30. How much money do you spend on average per month?
31. What percentage of your income do you monthly save?
The following questions ask about your satisfaction, on a scale of 0 to 10. Where 0 - means that you feel "totally dissatisfied" and 10- means that you feel "totally satisfied".
32. Overall, how safe do you feel doing your job? 0 not safe at all 10 very safe
0 1 2 3 4 5 6 7 8 9 10
33. Overall, how satisfied are you... with your life?
0 1 2 3 4 5 6 7 8 9 10
34. Overall, how satisfied are you... with your current income?
0 1 2 3 4 5 6 7 8 9 10
35. Overall, how satisfied are you... with your health?
0 1 2 3 4 5 6 7 8 9 10
36. Overall, how satisfied are you... with your current level of security?
0 1 2 3 4 5 6 7 8 9 10
37. How satisfied are you with your personal relationships (friends and relatives)?
0 1 2 3 4 5 6 7 8 9 10
38. Overall, how satisfied are you... with your job/activity currently?
0 1 2 3 4 5 6 7 8 9 10
39. Overall, how satisfied are you with the training you receive on the job?
0 1 2 3 4 5 6 7 8 9 10

40. Overall, how healthy is the physical environment where you work? 1 very unhealthy 10 very healthy
0 1 2 3 4 5 6 7 8 9 10
41. How concerned are you about social issues in mining?
0 1 2 3 4 5 6 7 8 9 10
42. How concerned are you about environmental issues in mining?
0 1 2 3 4 5 6 7 8 9 10
- The following questions ask about how you felt yesterday on a scale of 0 to 10. Where 0 means that you did NOT experience that feeling "at all" and 10 means that you experienced that feeling "all the time"
43. How happy did you feel... yesterday? 0 not happy at all... 10 all the time happy
0 1 2 3 4 5 6 7 8 9 10
44. How worried did you feel... yesterday? 0 not at all worried 10 all the time worried
0 1 2 3 4 5 6 7 8 9 10
45. How sad did you feel... yesterday?
0 not at all sad... 10 all the time sad
46. Do you know what is Fairmined certification?
Yes No
47. Are your living conditions better because you are part of a Fairmined certified organization?
0 1 2 3 4 5 6 7 8 9 10

Appendix B. Data

The data have been managed and analysed with R. The Propensity score matching was performed through R package `MatchIt` (Ho et al., 2007). We have 115 missing data in the individuals answers, or 0.72% of the total data. The majority of missing answers were age and level of monthly expenses, 15 and 14 observations, respectively. To avoid data loss we impute these missing observations using multivariate imputation by chained equations method (Azur et al., 2011). Before performing the analysis, we assigned a value to the categorical variables such as level of education, position, type of contract, health status, health affiliation, housing floor and walls materials. One additional calculation is the computation of a score to define the level of wealth with the 21 appliances and goods list. We normalized the goods and appliances with one of the smaller prices plus 1 (to avoid errors computing natural logs of the data). Then, we calculate the logarithm of each good and sum up each good score to produce the overall score of appliances. Moreover, we expressed the saving and expense figures to Dollars to make the information comparable. We used the average exchange rate of \$1 for 3,757.10 Colombian Pesos and \$1 for 3.56 Soles the average of the official exchange rates for the data collection period⁷.

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⁷ The exchange rates were taken from Colombian central bank (<https://totoro.banrep.gov.co/estadisticas-economicas/faces/pages/charts/line.xhtml?facesRedir=ect=true>) and the financial authority in Peru (https://www.sbs.gob.pe/app/pp/seriesHistoricas2/paso3_TipodeCambio_Descarga.aspx?secu=03&paso=3&opc=1).

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