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The Impact of Formalization Assistance on Informality: Experimental evidence from Colombian mines*

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Abstract

More than 60% of global employees work in the informal economy. One of the reasons that firms remain in informality is the length and cost of the formalization process. I explore whether assisting in the formalization process could reduce informality in the mining sector in Colombia. The study is a randomized control trial with informal coal and gold mines. After two years of treatment, the formalization assistance treatment did not increase formalization rates, and attrition was high. However, the treatment increased miners' income but not expenses, suggesting the miners are saving more, possibly for the titling costs. The high attrition and unsuccessful treatment highlight the difficulties of formalizing the mining sector.
JEL: *E26, L72, O17*

Keywords: *Formalization; Mining; Colombia*

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1 Introduction

Worldwide, more than 60% of workers operate in the informal economy, far more than those working in formal jobs or businesses (World Bank, 2017). Even in advanced economies, informality is quite common: as of 2015, in the United States, about 20 percent of working-age adults generated "informal" income.[1] Workers and small business operators choose to remain informal for a range of reasons, including avoiding taxes and regulation, skipping paperwork or perceived bureaucratic red tape, or high costs to formalization. The benefits of formalization vary by sector, including higher sales prices and secure property rights, but may depend on the government's enforcement. In this paper, I study a randomized control trial that provided formalization assistance to informal miners in Colombia.

In the developing world, artisanal and small-scale mining (ASM) is an essential and growing part of the informal economy. ASM employs over 100 million people in 80 countries, contributing substantial shares of the world's gold and precious stone production (World Bank, 2013). Although often valuable for workers, illegality, corruption, social conflict, and environmental externalities threaten ASM workers' livelihoods, communities, and neighbors. A commonly proposed solution is to formalize ASM by licensing miners, increasing environmental regulations, and bringing the sector to the legal economy. Scholars and practitioners argue that this will improve property rights for miners, ease conflict and reduce negative externalities, such as pollution. However, previous efforts at formalization have experienced low take-up by miners. In Colombia, the context of this research, there have been numerous attempts to formalize the sector during the past decade, with weak results. Based on administrative records, during the 2010 formalization effort, artisanal miners submitted a total of 8,125 requests. As of 2013, 39%

[1] https://www.newyorkfed.org/microeconomics/sce#/

had been rejected three years later, 60% was still in process, and just a handful of licenses had been issued (Guiza & Aristizabal, 2013).

Despite an enormous economic footprint, many ASM activities are unlicensed or illegal. Many scholars and donors have proposed formalizing the sector to address these problems while maintaining the economic returns of ASM for the millions of households that depend on it (Soto, 2000). However, there is little rigorous evidence to date on the consequences. In this paper, I study a randomized control trial that provided formalization assistance to ASM miners. The formalization assistance included weekly calls for assistance with paperwork, tracking administrative procedures with the mining authorities, and a mining area demarcation map, the first step of the formalization process. The formalization assistance team comprised lawyers, engineers, geologists, and economists.

The study involved 603 miners in 151 informal mines. I randomly offer formalization to 97 of the mines. Only 51% of mines accepted the treatment. For the mines that accepted, the treatment was unsuccessful, given the delays in Government responses and the complexity of the process. I also find that attrition is high. In the three years between baseline and end-line, 70% of the study mines attrited, and 42% of the miners attrited. These results illustrate the difficulties of formalizing the sector. The mining titles are granted for 30 years, but artisanal miners are moving and switching occupations constantly. However, the treatment increased miners' income but not expenses, suggesting the miners are saving more, possibly for the titling costs. I also find that a quarter of miners experience conflict, a similar rate in treatment and control groups. Finally, treatment miners are less likely to be in a miners' cooperative. This result could be explained by the fact that the treatment provided information and advice that cooperatives provided.

We are not aware of other mining formalization Randomized Control Trials. There are numerous studies on firm formalization in urban areas (De la O et al., 2019; Galiani, Meléndez, & Ahumada, 2017; Benhassine, McKenzie, Pouliquen, & Santini, 2016), and

land titling in rural areas. Besides the sector, the main difference in our study is the number of steps and the high monetary cost of mining formalization. Similar to (De la O et al., 2019), we provide miners with information and help in the formalization process. One key difference is that the treatment provides help by directly contacting the government on the miners' behalf.

2 Institutional Background

Colombia, at the northern extent of the Andes mountain, has significant geological endowments, including hydrocarbons and minerals. In addition to major petroleum reserves, Colombia has Latin America's largest reserves of coal and is a leading producer of golf and nickel. Other notable products include platinum, silver, iron ore, aluminum ore, and copper.

In this project, we focus on two of Colombia's most important mining products: gold and coal. Colombia produces around 1% of the world's coal and gold production; a significant proportion of this production is small, artisanal mining done by small groups of miners. According to the Ministry of Mines, an estimated 340,000 people directly depend on ASM in Colombia, most of which operates in the gray or black market. Of the 14,357 mining-producing units (UPM) identified in the year 2010 by Colombia's Ministry of Mines census, 63% did not have a mining title. In the three states in our sample, the number of UPMs without a title varies widely: in Boyacá just 32% do not have papers, while in Antioquia and Chocó the informal rate is 79.1% and 99% respectively (Ministerio de Minas y Energía, 2012).

Rural Colombia, where ASM is prevalent, has experienced limited economic growth in recent decades, especially as the conflict between armed groups (some aligned against the state, some ostensibly in favor) has been a recurring feature of the countryside.

Since the 2016 peace deal between the Colombian government and the FARC rebels levels of violence have in general declined, but the threat of violence continues to play a significant political role. Natural resources have had a multi-faceted relationship with conflict in Colombia, in some cases exacerbating and under conditions easing the risk of violence (e.g. (Dube & Vargas, 2013)).

2.1 Formalization Process

Under Colombian law, an informal miner has various routes to becoming formal, depending on the conditions of their plot. A major consideration is whether the area where they do their mining overlaps with an already titled area. If the intended area does not overlap, the miner could make a differentiated concession contract with the government or request the area as a special reserve. If the area is overlapping with a titled area, however, they must make a deal with the existing title holder to make a concession subcontract or an operation contract.

Under Colombia's Constitution, all the 'subsoil' resources belong to the National government. Even if a miner owns the farmland, to mine formally in Colombia one must sign a concession contract with the National government following Law 685 of 2001. The miner must submit a range of documents that verify that your mining operation will not violate environmental, health, labor, or other regulations.

In October 2020, recognizing that previous iterations of the ASM formalization process had failed to bring most miners into legal status, the Colombian government issued a differentiated concession contract to ease the process for small miners. The decree aims at miners that do not work in an area greater than 100 hectares and whose production is under yearly limits that vary by mineral. A comparison of the new decree with the old rules is presented in Table

3 Data

3.1 Sampling

The sampling of eligible municipalities was done based on three characteristics. First, mining zones in areas affected by significant armed conflict or armed groups' presence were excluded. Gold and coal regions were prioritized: Antioquia and Chocó are the principal departments for gold mining activities, while Boyacá is one of the principals for coal mining. From a government database that registers mines that are in the formalization process, we selected municipalities that had more than 10 requests. In the end, we selected 38 municipalities in the aforementioned three Colombian departments (states): 21 municipalities in Antioquia, 9 in Boyacá, and 8 in Chocó. The final list was slightly different than the original one because as it turned out, we could not visit one municipality in Antioquia and four municipalities in Chocó due to a greater risk of armed conflict than we expected ex-ante.

3.2 Experimental Sample

From the (Coy et al., 2021) sample of 229 small-scale mines[2] that mine coal or gold, we selected the 151 mines that are not formal. Of the coal mines, 60% had a license and just 22% were operating informally without any active formalization effort in progress. In contrast, close to 60% of gold mines are informal without a first attempt at formalization, with just 7% of gold mines having a legal mining title. Based on power calculations (with 80 percent power, alpha .05), assuming a 20% effective sample size boost from stratification/pre-treatment covariates, we estimated a minimum detectable effect (MDE)

[2]Defined as less than 150 hectares by Colombian law.

of 0.4 standard deviations for mine-level effects. For individual miner-level effects, the estimated MDE was 0.34 standard deviations.

The baseline survey was collected from January to March 2020. This was before the start of the COVID-19 epidemic and associated lockdowns. The endline survey took place three years later from January to April 2023.

3.3 Formalization assitance treatment

Out of the 151 mines in the study sample, we randomly selected two-thirds to receive the call offering formalization assistance. We chose two-thirds because we anticipated low treatment acceptance given the lack of trust in outside agents in the informal mining sector. Randomization was stratified at the mine group level. A group is defined by: (1) the department where the mine is located (Boyaca, Choco, or Antioquia); (2) the mineral mined (gold or coal); (3) whether the mine has started or not the formalization process; and (4) size of the mine (above or below the median of area). Although theoretically, that implies 24 groups, effectively there are 11 groups because there are no coal mines in Choco or gold mines in Boyaca. The calls offering the formalization assistance treatment took place at the beginning of 2021 The formalization assistance included weekly calls for assistance with paperwork, tracking of administrative procedures with the mining authorities, and a mining area demarcation map, the first step of the formalization process. The formalization assistance team was composed of lawyers, engineers, geologists, and economists.

3.4 Summary statistics

Table 1 presents summary statistics of the study sample. Panel A for mine-level variables and Panel B is for miner-level variables. Recall that the survey was applied to 4 miners per mine so the number of mines is 151 and the number of miners is 603. In columns 1-2, 4-5, the first row of each variable is the mean, and below the standard deviation in parenthesis. Column 1 presents summary statistics for the mine and miners in the control group, while Column 2 is for the sample of mines and miners randomly selected to receive the treatment offer. Column 3 presents the difference between the two groups and in squared brackets the p-value of the test if the means are equal. In columns 4-5 of Table 1, I divide the mines randomly selected for treatment between those that accepted and not accepted treatment. Column 6 the difference between those that accepted treatment and those that did not accept the treatment offer.

Mines in the study sample mine mostly gold, work on average in 11 hectares of land with 9 miners. The average mine has 20% of its workers with social security, another measure of formalization. Attrition was high at 70%, meaning we could only resurvey 30% of the baseline mines. 59% of the attrition cases were because the miners on site could not provide information about the mine and 16% declined to answer. 13% of the attrition was for security conditions and in 12% of the cases there was nobody at the mine to be surveyed. Importantly the randomization is balanced in observables since no difference in column 3 is statistically significant. Note also that there are no differences in baseline observables between those that accepted treatment and those mines that did not accept treatment. The only statistically significant difference is in the attrition rate between mines that accepted treatment and mines that did not accept the treatment offer.

Panel B of Table 1, shows that miners in the study sample have less than 4 years of education and live in households of three people. The average monthly per capita income is COP 600,000, equivalent to U$ 150 at the time of the baseline survey. Individual miner

Table 1: Balance table

Variable:	Control	Assigned	Diff	Accepted	Not Accepted	Diff
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mine						
Mineral: Gold	0.72	0.75	-0.03	0.72	0.78	-0.06
	(0.45)	(0.44)	[0.73]	(0.45)	(0.42)	[0.59]
Workspace (Ha)	10.93	11.30	-0.37	11.30	11.29	0.01
	(21.13)	(24.20)	[0.93]	(23.81)	(24.84)	[1.00]
Number of workers	8.65	8.98	-0.33	9.71	8.23	1.48
	(8.91)	(11.35)	[0.85]	(14.65)	(6.53)	[0.52]
% with Social Security	20.08	18.32	1.76	23.40	13.13	10.27
	(38.82)	(38.13)	[0.79]	(41.92)	(33.47)	[0.19]
Attrition	0.70	0.71	-0.01	0.61	0.81	-0.20**
	(0.46)	(0.46)	[0.92]	(0.49)	(0.39)	[0.03]
N	54	97	151	49	48	97
Panel B: Households						
Household size	3.05	2.98	0.07	3.04	2.93	0.11
	(2.35)	(1.91)	[0.71]	(1.76)	(2.06)	[0.59]
Income pc (kCOP)	557.14	597.04	-39.90	596.58	597.56	-0.98
	(467.26)	(450.03)	[0.33]	(444.78)	(457.20)	[0.98]
Expenditures pc (kCOP)	421.13	459.29	-38.16	460.86	457.53	3.33
	(314.11)	(334.27)	[0.19]	(321.47)	(349.09)	[0.93]
Education (years)	3.93	3.73	0.20	3.67	3.80	-0.13
	(1.80)	(1.85)	[0.22]	(1.74)	(1.97)	[0.51]
Attrition	0.43	0.42	0.01	0.40	0.43	-0.03
	(0.50)	(0.49)	[0.70]	(0.49)	(0.50)	[0.51]
N	217	386	603	197	189	386

Notes: Panel A shows indicators at the mine level, and Panel B does so at the miner level. Mineral: Gold indicates if the mine extracts gold. Workspace indicates the mine working area in hectares. % with social security corresponds to the percentage of workers who make health and pension contributory payments. Attrition indicates that the mine/miner responded the baseline survey but not the end-line survey. Household size corresponds to the number of people in each miner's household, Income pc and Expenditures pc are monthly per capita income and expenses and are in thousands of Colombian pesos. Education corresponds to the number of years the miner has studied. $^{*}p < 0.10$, $^{**}\ p < 0.05$, $^{***}p < 0.01$

attrition was also high at 42%. Attrition at the miner level is lower than at the mine level because some recontacted miners no longer work in the mining sector. Consequently, we can obtain the miner income but not the production of the mine where they were working at baseline.

4 Empirical Framework

4.1 Main regression

I estimate treatment effects with a simple comparison of post-treatment outcomes for treatment and control mines. Y_{img} is one of the outcomes of interest such as formalization status, production, and the number of workers for mine i, on municipality m belonging to stratification group g. $OfferTreat_i$ is an indicator for whether mine i was randomly chosen to receive a call offering the formalization assistance treatment. Finally ε_{im} is an error term.

$$Y_{img} = \beta_{ITT} \times OfferTreat_i + \gamma_g + \varepsilon_i \tag{1}$$

Note that β_{ITT} is an intent-to-treat estimate, as only 49 out of 97 mines accepted the treatment. Consequently, I can estimate the treatment on the treated with a two-stage least squares procedure.

$$Y_{img} = \beta_{TOT} \times \hat{Treated}_i(OfferTreat_i) + \gamma_g + \varepsilon_i \tag{2}$$

Analogously, I can estimate treatment effects for individual-level outcomes of the miners. Where Y_{jimg} is one of the outcomes of interest such as income, violence experience, associativity for miner j, that was working at baseline on mine i, municipality m, stratification group g.

$$Y_{jimg} = \beta OfferTreat_i + \gamma_g + \varepsilon_i \tag{3}$$

5 Results

Table 2 Panel A presents the intent to treat (ITT) estimates from estimating equation (1) for different mine-level outcomes as dependent variables. Panel B presents the treatment

on the treated (ToT) estimates. As stated in the pre-analysis plan, I present Lee bounds given the high levels of attrition. Column 1 presents the results for the formalization dummy, the main objective of providing the formalization assistance treatment. I find that the treatment did not affect the formalization of treatment mines. This result illustrates the difficulties to formalize small mines. Column 2 presents the results for the dummy on whether the mines started the formalization process. As expected treatment mines are more likely to have started the formalization process, although the coefficient is not statistically significant. Columns 3-5, present the results for the percentage of workers with social security, the number of workers, and the area of the mine. As the treatment was not successful these variables are not affected.

Table 3 presents the results of estimating equation (3) for different mine-level variables. Column 1 presents the results for per capita income. I find that 10% of the miners are no longer mining, but this rate is similar in treatment and control groups. Column 2 has as dependent variable per capita income, and column 3 per capita expenses, both measured in thousands of Colombian pesos. I find that miners that worked in mines offered formalization assistance increased their income. However, these miners do not increase their expenses in the same proportion. This could be explained by the fact that miners are saving to pay for the formal titling costs. One concern is that treated miners might be self-reporting higher income. To address this issue, I study whether the treatment affected reported education, a variable that is unlikely to be affected by the treatment given that miners are past school age. Column 4 presents the results and I do not observe statistically significant changes.

Columns 5 and 6 study if the treatment affected the social interactions of the miners. Column 5, shows that treatment miners are equally likely as control miners to experience conflict. A quarter of miners experience conflict, a similar rate in treatment and control groups. Finally, column 6 shows that treatment miners are less likely to be in a miner's

Table 2: Treatment effects on mine level variables

Variable:	Formal	Process	Social Security	Workers	Area (ha)
	(1)	(2)	(3)	(5)	(6)
Panel A: ITT					
Treat Offer	-0.056	0.18	1.63	-2.88	-27.9
	(0.082)	(0.15)	(9.88)	(2.85)	(23.6)
Control Mean	0.25	0.38	14.00	12.38	41.82
Lee Bounds	(-0.07, -0.03)	(0.14, 0.18)	(0.58, 3.23)	(-3.48, -2.10)	(-27.76, -17.47)
Adjusted R^2	0.48	0.14	0.00	0.08	0.06
Observations	43	43	43	43	43
Panel B: ToT					
Treated	-0.077	0.25	2.26	-3.99	-38.7
	(0.098)	(0.19)	(11.9)	(3.36)	(27.8)
Control Mean	0.25	0.38	14.00	12.38	41.82
Adjusted R^2	0.48	0.10	-0.00	0.05	0.05
Observations	43	43	43	43	43

Notes: Panel A presents the outcome of the treatment assignment, while Panel B pertains to Acceptance and represents the results of the second stage of an Instrumental Variable analysis. The dependent variables include a binary indicator for having a formal title, being in the process of formalization, and the proportion of workers with Social Security. *$p < 0.10$, ** $p < 0.05$, ***$p < 0.01$

cooperative. This could be explained by the fact that the treatment was providing information and advice, that cooperatives provide.

6 Conclusion

Given the high informality rates in artisanal mining, I randomly offer formalization assistance to a group of miners. I surveyed 603 miners in 151 informal mines. I randomly offer formalization to 97 of the mines. Only 49 mines accepted the treatment. For the mines that accepted the treatment was not successful given the delays in Government responses and the complexity of the process. I also find that attrition is really high. In the three years between baseline and end-line, 70% of the study mines attrited, and 42% of the miners attrited. These results illustrate the difficulties of formalizing the sector. The mining titles are granted for 30 years, but artisanal miners are moving and switching occupations constantly.

Table 3: Treatment effects on miners

Dep var:	D Miner (1)	Income pc (2)	Expenses pc (3)	Education (4)	Conflict (5)	Association (6)
Panel A: ITT						
Treat Offer	-0.027	132.5***	22.9	0.23	-0.0036	-0.14***
	(0.035)	(49.9)	(34.0)	(0.23)	(0.052)	(0.052)
Control Mean	0.91	460.99	375.80	3.91	0.25	0.83
Lee Bounds	(-0.03, 0.02)	(64.99, 141.56)	(-17.21, 37.42)	(0.05, 0.33)	(-0.04, 0.01)	(-0.16, -0.09)
Adjusted R^2	-0.02	0.09	0.08	0.01	0.04	0.19
Observations	334	334	334	334	334	334
Panel B: ToT						
Treated	-0.051	255.1**	44.0	0.43	-0.0069	-0.27***
	(0.066)	(100.0)	(65.0)	(0.43)	(0.099)	(0.10)
Control Mean	0.91	460.99	375.80	3.91	0.25	0.83
Adjusted R^2	-0.02	0.04	0.07	0.02	0.04	0.17
Observations	334	334	334	334	334	334

Notes: This table displays the impact of being assigned to the treatment. The dependent variables encompass monthly income ("Income"), monthly mining income ("Mine income"), monthly expenses ("Expenses"), years of education ("Education"), as well as dummy variables indicating whether the individual has experienced conflict and if they belong to an association. Standard errors clustered by mine in parentheses. Significance level: *$p < 0.10$, ** $p < 0.05$, ***$p < 0.01$

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