How does the exploitation of natural resources affect income disparities across regions and population groups? Evidence from Burkina Faso

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Abstract

In the past decade, Burkina Faso experienced a dramatic gold mining boom. In 2009, the gold sector represented 5% of GDP whereas it was around 0.3% in the early 2000s. This rapidly expanding gold sector has brought the country to the rank of the fourth largest gold producer among African nations. The main objective in this paper is to examine how the development occurred in gold sector has affected income disparities across regions and sub-populations. In addition, how this has resulted in a growing gap between formal and informal sectors. To this end, we will investigate whether the mining boom has led to an expansion in employment in Burkina and if it has contributed to raise household's income levels. The data from 2003 and 2009 household surveys will be employed including administrative data. Both surveys contain detailed information on individual's characteristics, consumption, employment, agricultural production and household enterprises.

Keywords: Gold mining, income disparities, schooling, employment, Burkina.

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1 Introduction

Burkina Faso is one of the poorest countries in the world. According to the recent Human development index, Burkina Faso is ranked 181st out of 187 countries. Poverty is still pervasive in the country. More than 46% of Burkinabè are poor (World Bank (2013)). The majority of the population depends on agriculture activities. While cotton and livestock were the major export products during the 90s, the last five years have seen gold as the main product of exports. According to the Ministry of Finance, export revenues amounted to 440 billion CFAF in 2011. Although, large scale industrial mining explains this fact, artisanal mining remains a dominant sector. The latter accounts for more than 200,000 people exploiting gold and it is estimated that 650,000 benefit from that activity (Cote 2013).

The rapid expansion of gold mining extraction has made the country the fourth largest gold producer among African nations. Being nonexistent in the last decade, this natural resource boom introduces a new landscape in the country regarding its welfare effects on the population. This leads us to the well-known literature on natural resources.

The recent literature on natural resource exploitation has focused on the relationship between the abundance of natural resources and income inequality or income growth in a macroeconomic framework (see for example Leamer, Maul, and Shott 1999, Fum and Hdler 2010 and Papyrakis and Gerlagh 2007). Mineral resource abundance as well as exploitation of natural resources has a negative correlation with long-term economic growth. Other studies based on a cross country analysis report some mitigated results (see for example Parcero and Papyrakis 2014).

In the case of micro data, the recent literature has focused on the links between natural resource exploitation and poverty and inequality. In particular, Gamu, Le Billon, and Spiegel (2015) review several empirical studies to determine the relationships between extractive industries and poverty. Two main findings emerge from their study. First, while industrial mining is considered to be more associated with poverty exacerbation, artisanal and small-scale mining has a positive effect on poverty reduction. Second, governance institutions along with national policies are deemed to be important factors that contribute to well manage resource revenues for poverty reduction. The existence of various empirical studies may provide sufficient insights on the relationship be-

tween extractive mining and poverty. However, few evidences are based on low income countries. Moreover, those evidences remain limited in some extent as they are specific to particular regions and are unlikely to be generalized at the national level. As Gamu, Le Billon, and Spiegel (2015) underlined, the scale of analysis is also a factor that matters in examining the poverty effects of extractive mining.

Thus, to date, little information is available about the extent to which natural resources exploitation has improved wellbeing, and particularly in the case of Burkina. This research project focuses on the development of gold mining occurred recently in Burkina and aims at investigating how the exploitation of natural resources affects income disparities across regions and population groups using nationally representative surveys as well as administrative data. In our best knowledge, this is the first study in Burkina that attempts to examine the impact of natural resources on income disparities across regions and sub-populations. The only evidence from Burkina concerning gold mining focused on informal and artisanal mining and highlights the reasons that may explain why women and girls are present in mining camps which are frequently represented by men (Werthmann 2009). The underlined research also intend to evaluate how employment in areas closer to gold exploitation evolved compared to those further away. Besides, it provides information related to the resulting growing gap between formal and informal mining. The project also offers other interesting questions that can be explored in this research. In terms of education, Burkina Faso is still lagged behind compared to the other African countries. It is therefore important to ascertain whether or not schooling gains were greatest in areas nearest to gold sites. Such an examination of changes in schooling behavior by subgroups will allow us to identify winners and losers from the advent of gold expansion.

We contribute to the empirical literature two-fold. First, it is the one that attempts to assess the impact of gold exploitation on income disparities and the overall wellbeing in Burkina. Second, it analyzes the changes in schooling behavior by subgroups and identifies winners and losers from the advent of gold expansion.

2 Methodology

Our methodology is composed of two stages. First, we develop a theoretical framework to assess the impact of natural resources exploitation on income disparities. Second, we perform an empirical strategy to estimate this impact using data from Burkina.

2.1 Theoretical framework

In this section, we develops a theoretical model that supports our empirical estimations. First, we present the main agent and describe the parameters and decision variables. Then, we derive the optimal outcomes and give some predictions about the effect of gold exploitation. Finally we explain how we empirically estimate the theoretical impact we predict for gold mining.

In this paper, the main variables of interest are the average households' consumption expenditure, child's schooling in the household (time spent at school), and employment (total time in working). A long with the poverty line, the consumption expenditure is used to find the theoretical poverty rate. Child's schooling is used to assess theoretically the literacy rate. Finally, the time spent by children in working affects their ability to stay in school.

2.2 Model

We consider the representative household of the department i. As in Soares, Krueger, and Berthelon (2012), we assume that the household has one parent and one child and its utility function is given by

$$u_i(c, h) = \alpha \ln c + \beta_i \ln h, \tag{1}$$

where c is the household's consumption expenditure and h is the human capital of the child. The human capital is produced according to the technology

$$h = A e_c^{\gamma} y^{1-\gamma}, \tag{2}$$

where e_c is the time devoted by the child to schooling (time spent in school), and y is the parent's investment in the child's human capital. Actually, y represents the material costs borne by the

household, and that are required to produce the child's human capital (equipment, tuition fees, etc.). Let us consider the following notations: l_c is the child's labor supply, i.e., the time spent by the child in mining activity, t_c is the total amount of time available for the child, l_a is the parent's labor supply in mining activity, l_x is the parent's labor supply in other activities than mining, t_a is the total amount of time available for the parent, $w_c > 0$ is the child's wage in mining activity, $w_a > 0$ is the parent's wage in the mining activity, $w_x > 0$ is the parent's wage in the other activities. We assume that $w_a \neq w_x$. Therefore, we have

$$t_c = e_c + l_c \quad \text{and} \quad t_a = l_a + l_x$$

We denote by $\mathbf{1}_D$ the indicator variable taking a value of 1 if the department where the household is living is a gold producing department. $\mathbf{1}_{D_I}$ is the indicator variable taking a value of 1 if there is an industrial production in the department where the household is living. We consider that if $w_x > w_a$ then $\mathbf{1}_{D_I} = 0$, and if $w_a > w_x$ then $\mathbf{1}_{D_I} = 1$. In fact, we reasonably assume that the wage in industrial production is higher than that of the artisanal production. We also assume that the price p of the commodity y is affected by the status of the department (producing or not producing), i.e.,

$$p = p_1 \mathbf{1}_D + p_0 \left(1 - \mathbf{1}_D\right) \tag{3}$$

A summary of our setup is as follows. For simplicity we abandon the subscript i.

Utility function: $u_i(c, h) = \alpha \ln c + \beta \ln A + \beta\gamma \ln e_c + \beta(1-\gamma) \ln y$.

The household is subject to the following budget constraint:

Budget constraint: $c + py + w_c \mathbf{1}_D e_c \leq w_c \mathbf{1}_D t_c + \left(w_a \mathbf{1}_D - w_x\right) l_a + w_x t_a$. We normalize the price of the consumption good to one.

The problem of the household is

$$\begin{aligned} &\max_{c, l_c, l_a, y} \left\{\alpha \ln c + \beta \ln A + \beta\gamma \ln e_c + \beta(1-\gamma) \ln y\right\} \\ &s.t \quad c + py + w_c \mathbf{1}_D e_c \leq w_c \mathbf{1}_D t_c + \left(w_a \mathbf{1}_D - w_x\right) l_a + w_x t_a \\ &\qquad e_c \leq t_c \end{aligned} \tag{4}$$

The optimal value for l_a is straightforward. If $w_x < w_a \mathbf{1}_D$ then $l_a = t_a$, and if $w_x > w_a \mathbf{1}_D$ then $l_a = 0$.

The Lagrangian of the problem 4 is

$$\begin{aligned}\mathfrak{L} &= \alpha \ln c + \beta \ln A + \beta\gamma \ln e_c + \beta(1-\gamma) \ln y \\ &+ \lambda \left[w_c \mathbf{1}_D t_c + w_x t_a - c - py - w_c \mathbf{1}_D e_c - (w_x - w_a \mathbf{1}_D) l_a \right] + \mu (t_c - e_c) \end{aligned} \tag{5}$$

Using the first-order conditions we can find the expression of e_c and y as a function the consumption expenditure c. Specifically, we have[1]

$$e_c = \frac{\beta\gamma t_c c}{\alpha w_c \mathbf{1}_D t_c + \beta\gamma c} \tag{6}$$

and

$$y = \frac{\beta(1-\gamma)}{\alpha p} c \tag{7}$$

To solve the problem we consider three different cases: case 1 where $\mathbf{1}_D = 0$, case 2 where $\mathbf{1}_D = 1$ and $\mathbf{1}_{D_I} = 1$, and case 3 where $\mathbf{1}_D = 1$ and $\mathbf{1}_{D_I} = 0$. For any variable Y we denote by Y_0, $Y_1.1$, and $X_1.0$ its values respectively in case 1, case 2 and case 3.

Case 1: The household is living in a non gold producing department ($\mathbf{1}_D = 0$).

If the household is in a non producing department then none of parent and child works in mining activity. Therefore, $l_{a_0} = 0$ and $e_{c_0} = t_c$. Moreover, using (7) the budget constraint (which is bounded) becomes $c_0 + \frac{\beta(1-\gamma)}{\alpha} c_0 = w_x t_a$. Therefore, the consumption expenditure is

$$c_0 = \frac{\alpha w_x t_a}{\alpha + \beta - \beta\gamma} \tag{8}$$

The parent's investment in the child's education is

$$y_0 = \frac{\beta(1-\gamma)}{\alpha p_0} . \frac{\alpha w_x t_a}{\alpha + \beta - \beta\gamma} \tag{9}$$

[1]The expression of y is simply derived from the first-order conditions on c and y. Using the first-order conditions on c and e_c we can find that $e_c = \frac{\beta\gamma\lambda c}{\alpha(\lambda w_c \mathbf{1}_D + \mu)}$. We also know that if $\mathbf{1}_D = 0$ then $e_c = t_c$. So, $\frac{\beta\gamma\lambda c}{\alpha\mu} = t_c$, i.e., $\mu = \frac{\beta\gamma\lambda c}{\alpha t_c}$. Plugging the expression of μ into that of e_c yields the result in 6.

Case 2: The household is living in a producing department with an industrial production ($\mathbf{1}_D = 1$ and $\mathbf{1}_{D_I} = 1$).

In case of industrial gold exploitation, the parent devotes all his time to mining activity, $l_{a_{1.1}} = t_a$. The budget constraint becomes

$$\frac{\alpha + \beta - \beta\gamma}{\alpha} c_{1.1} + \frac{w_c \beta\gamma t_c c_{1.1}}{\alpha w_c t_c + \beta\gamma c_{1.1}} = w_c t_c + w_a t_a \tag{10}$$

From (10), the consumption $c_{1.1}$ is given by

$$c_{1.1} = \alpha \frac{(\beta\gamma w_a t_a - (\alpha + \beta - \beta\gamma) w_c t_c) + \sqrt{\Delta}}{2\beta\gamma (\alpha + \beta - \beta\gamma)}, \tag{11}$$

where $\Delta = [\beta\gamma w_a t_a + (\alpha + \beta - \beta\gamma) w_c t_c]^2 + 4\beta\gamma (\alpha + \beta - \beta\gamma) (w_c t_c)^2$.

Using (6) and 7, we can find $e_{c_{1.1}}$ and $y_{1.1}$.

Case 3: The household is living in a producing department with an artisanal production ($\mathbf{1}_D = 1$ and $\mathbf{1}_{D_I} = 0$).

As we did for case 2, we derive the consumption amount $c_{1.0}$ which is given by

$$c_{1.0} = \alpha \frac{(\beta\gamma w_x t_a - (\alpha + \beta - \beta\gamma) w_c t_c) + \sqrt{\Omega}}{2\beta\gamma (\alpha + \beta - \beta\gamma)}, \tag{12}$$

where $\Omega = [\beta\gamma w_x t_a + (\alpha + \beta - \beta\gamma) w_c t_c]^2 + 4\beta\gamma (\alpha + \beta - \beta\gamma) (w_c t_c)^2$.

Using (6) and (7), we can find $e_{c_{1.0}}$ and $y_{1.0}$.

2.3 Theoretical effect of gold exploitation

To study the theoretical effect of gold exploitation, we calculate for each variable of interest Y the difference between case 1 and the other scenarios (case 2 and case 3). Specifically, we compute $Y_{1.1} - X_0$ and $Y_{1.0} - Y_0$. We find that the effect on consumption, child schooling time and parent's labor supply is ambiguous. The result depends on the parameters of the model. In the empirical model, we will estimate $E(Y_{1.1} - Y_0)$ conditionally on some control variables. We can also estimate $E(Y_1 - Y_0)$ where Y_1 is the value of Y when $\mathbf{1}_D = 1$.

2.4 Empirical strategy

The objective of the empirical strategy is to estimate the above-mentioned quantity denoted by $E(Y_{1.1} - Y_0)$ in the theoretical model. This can be done by following the approach used by Loayza, Alfredo, and Rigolini (2013) to assess the impact of mining activity on some socioeconomic variables in Peru. We rely on the hypothesis that 2003 refers to a period before the formal gold mining extraction. In fact, during that time, the government reformed its mining law in order to attract foreign direct investments in the gold sector for the purpose of developing a large scale mining industry. The 2009 year has seen an increase in gold production and is considered as a year of gold expansion. We exploit this source of variation in order to assess the effect of gold exploitation. We therefore consider the two nationally representative household surveys (*Enquête Burkinabè sur les conditions de vie des ménages*, EBCVM 2003 and *Enquête intégrale sur les conditions vie des ménages EICVM 2009*). During EBCVM 2003, 8,500 households were interviewed. In EICVM 2009, the sample was 14,520 households of which 1,815 households have been visited four times within a year.

Burkina Faso is divided into 13 administrative regions. Each region is composed of a group of provinces and each province is constituted of a set of departments. Altogether, there are 45 provinces and 350 municipalities. The department is the smallest administrative region where data can be recorded. Furthermore, the information related to gold extraction is available at the department level. We therefore stick to department units as units of observations. The sample of the 2009 survey contains 291 departments and the sample of 2003 contains departments 261. However, we rely on departments that are the same for both surveys. The final sample consists of 202 departments.

Following Loayza, Alfredo, and Rigolini (2013), we distinguish between three categories of departments: producing departments in which there existed a gold exploitation before 2009, non-producing departments in producing provinces and non-producing departments in non-producing provinces. Unlike Loayza, Alfredo, and Rigolini (2013), producing departments are not only those hosting an industrial gold mining, but also those including an artisanal mining. We do this in order to account for artisanal and small-scale mining when estimating the impact of gold exploitation on

population living standards. This is relevant given that artisanal mining has become an important phenomenon throughout the country.

We consider the departments which hosted an artisanal mining and for which licenses have been attributed to the holders to formalize small-scale mining activities. Because There are more 200 artisanal mining licenses, we select only those licenses attributed before 2009. Finally, the sample is composed of 25 producing districts of which 7 departments host industrial mining, 100 non-producing departments in producing provinces and 77 non-producing departments in non-producing provinces.

To formally assess the effect of gold exploitation, we rely on the following base regression model

$$Y = \beta_0 + \beta_1 \mathbf{1}_D + \beta_2 \mathbf{1}_{ND} + \beta_3 X + \varepsilon, \tag{13}$$

where Y refers to one of our outcomes variables, such as, the headcount ratio, the poverty gap, the inequality index (for instance the Gini coefficient), the literacy rate and the primary education level; $\mathbf{1}_D$ is a dummy variable equals to 1 if the department is producing gold and 0 otherwise; $\mathbf{1}_{ND}$ is a dummy variable equals to 1 if the department is non-producing in a producing province and 0 otherwise; X is a set of department characteristics (or control variables) and ε represents the error term.. Table 1 provide descriptive statistics of the outcomes variables. Producing departments are likely to be less poor than their counterparts in the same province. However, they exhibit higher illiteracy rate and a lower primary education level compare to the two other groups. In Table 2, we present some statistics related to control variables. This reveals that producing departments are higher than non-producing departments in terms of geographic area. A simple test shows that the difference is significant between producing and non-producing departments regarding area.

Table 1: Mean of outcome variables

	Producers	NPPP	NPNPP	All
Average per capita expenditures	173,829	181,839	191,713	185,462
	(58,675)	(71,595)	(69,903)	(69,455)
Headcount ratio (%)	48.80	49.59	46.11	47.91
	(19.24)	(23.51)	(19.64)	(21.32)
Poverty gap (%)	15.66	16.49	14.44	15.46
	(9.05)	(11.01)	(9.01)	(9.92)
Literacy rate (% of population >= 15	26.09	30.40	38.30	33.53
years old)	(11.51)	(16.21)	(19.72)	(18.00)
Gini index	0.38	0.39	0.40	0.40
	(0.04)	(0.03)	(0.04)	(0.04)
Education level >= primary school	20.95	22.81	30.09	25.94
(% of population >=6 years old)	(10.41)	(13.57)	(19.29)	(16.57)
Observations	25	100	77	202

Source: EICVM 2009 (Standard deviation in parentheses)

Table 2: Mean of control variables

	Producers	NPPP	NPNPP	All
Area (square km)	1317.45	968.40	820.53	955.23
	(763.91)	(789.49)	(703.56)	(766.29)
Headcount ratio in 2003 (%)	47.85	52.10	50.39	50.84
	(25.37)	(24.74)	(29.14)	(26.81)
Population in 2003	390,788	375,624	518,512	432,084
	(293,683)	(443,351)	(907,152)	(650,344)
Literacy rate in 2003	12.00	17.07	25.54	20.38
(% of population >= 15years old)	(12.55)	(16.10)	(19.49)	(18.04)
Education level 2003	12.12	19.32	28.61	22.77
(% of population >=6 years old)	(11.87)	(16.15)	(21.65)	(19.31)
Observations	25	100	77	202

Source: EBCVM 2003 (Standard deviation in parentheses)

Table 3: National poverty estimates

	Poverty estimates (%)			Inequality
Survey	P^0	P^1	P^2	Gini
2003 (adjusted)	48.6	16.9	7.8	0.43
2009	46.7	15.1	6.7	0.40

Source: EBCVM 2003, EICVM 2009

Table 4: Outcome variables at the regional level

	Headcount ratio (%)		Gini index		Literacy rate (%)	
Regions	Male	Female	Male	Female	Male	Female
Hauts-Bassins	42.17	42.35	0.42	0.40	42.88	21.77
Boucle Mouhoun	47.93	48.28	0.32	0.33	31.20	14.68
Sahel	41.57	41.48	0.45	0.43	22.90	9.11
Est	61.95	62.49	0.37	0.36	30.98	21.09
Sud-Ouest	57.67	56.32	0.39	0.36	27.29	11.58
Centre-Nord	38.51	39.63	0.37	0.35	27.43	11.41
Centre-Ouest	49.01	49.27	0.36	0.34	34.55	18.54
Plateau Central	51.97	51.64	0.33	0.33	34.67	16.79
Nord	63.95	65.03	0.38	0.37	29.37	13.93
Centre-Est	58.41	56.84	0.38	0.35	28.22	11.62
Centre	28.14	28.53	0.44	0.44	66.32	48.76
Cascades	26.55	28.21	0.33	0.32	35.65	16.22
Centre-Sud	41.39	44.07	0.32	0.29	29.76	14.65
National	46.53	46.87	0.40	0.39	37.43	20.40

Source: EICVM 2009

Table 5: Gold production in Burkina since 2001 (in tons)

Year	2001	2003	2008	2009	2010	2011	2012	2013
production	0.4	0.8	5.3	12.3	23.1	32.6	30.2	30.2

Source: Ministry of mines and energy

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