TAXES AND DECLARED PROFITS: EVIDENCE FROM GOLD MINES IN AFRICA [1]

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Abstract

In this paper, we analyze the effects of tax changes on the declared profits of extractive firms. We consider a country that levies a profit tax and a royalty on the profits of extractive firms to maximize its tax revenues. Mining companies located in the country engage in overstating extractive costs to reduce their taxable income. We show that the higher taxes, the lower the declared profit. Then, we estimate the effect of the change of profit taxes and royalties on the extracting firms' profit in African countries during the period spanning from 2007 to 2018. We employ the Mining Intelligence database to constitute an individual data panel of gold mines located in Sub-Saharan countries. Our empirical findings also suggest an inverse relationship between the tax rate change of the tax instruments and the declared profit of the firms. This link indicates that firms decide on how much profit to declare depending on the tax levels.

Keywords: *Resource countries, Resource taxation, Royalties, Cost misreporting, Tax avoidance, Gold mines*

JEL Classification: *H25, H32, O13*

1 Introduction

Côte d'Ivoire, Ghana, Zambia, among other African countries, have recently taken several initiatives to redesign the mining tax regimes to increase tax revenues. These developing countries are financially dependent on extractive industries and in crucial need of tax policies that guarantee public money. However, a distinctive feature of extractive industries is information asymmetry, between the tax authority and the firms that may encourage tax avoidance practices.[1]The purpose of this paper is twofold. We first examine the relationship between declared profits and level of taxes in low-income countries in Africa. Specifically, we study whether tax changes following reforms in the mining sectors affect the declared profit of mining firms. This analysis informs about the efficacity of reforms to increase tax receipts. Secondly, being policy reforms exogenous to firms, by estimating the impact of policy reforms on declared profits, we can better identify possible profit manipulation with tax avoidance purposes. We pursue our research aim using a novel database and focusing on sub-Saharan African countries where governments have severe informational disadvantages vis-à-vis resource companies (Collier 2010).

Previous research in extractive industries suggests the use of mainly two taxation instruments, i.e. *profit taxes* and *royalties* (IMF 2012 ; Boadway and Keen 2010, 2015 ; Bourgain and Zanaj 2020). While profit taxes are standard corporate taxes that apply to any enterprise, royalties are typical tax instruments of mining industries, levied only on the firms' sales revenues. They shall be considered as a payment granting the firm with the right to exploit a non-renewable resource. On the one side, royalties may be distortionary because they only apply to the sales and do not take into account the cost of exploration, development and extraction. However, on the other side, royalties can be efficient in the presence of asymmetric information as they capture the impact on the residual value of the reserve left in the ground (Conrad et al. 2018). In addition, royalties play an important role as means of revenue mobilization for developing extractive countries.

In our paper, we explore how changes in profit taxes and in royalties affect firms' declared profits, when both tax measures are susceptible to information asymmetries between tax authorities and firms. Modification of declared profits in view of tax changes are interpreted as manipulations of profits to reduce tax liabilities and thus tax evade.

We first analyze theoretically the effect of tax changes on declared profits and then bring our theoretical predictions to data for gold mines in Africa. In the theoretical part, we assume a country, hosting many mine, that levies a profit tax and a royalty on the profits of extractive firms to maximize its tax revenues. While it is usually easy to show the distortive character of an ad-valorem tax levied directly on the extraction of the resource (the royalty), the analysis becomes more intricate, when considering a context of asymmetric information between mining companies and government. In this context, we consider the possibility for the mining companies to reduce taxable income by *cost overstatement*. We assume that the rate of cost overstatement does not depend on the firm but it is rather a feature of the mining country such as the country's lack of expertise, the level

[1]Since the pioneering work of Hotelling (1931) and Brown (1948), abundant literature on taxation engineering has been developed to model the effects of various taxes on extractive resources (cf. the survey by Smith 2013).

of corruption or the quality of its institutions. The higher the level of corruption or the weaker the audit on mining industries, the greater the rate of cost overstatement in the country, the greater tax evasion. We use the model to build a theoretical prior for the effect of changes in profit taxes and royalties on the declared profit of firms.

In the empirical part of the paper, we estimate the effect of a change in profit tax and royalty on the declared profits of extracting firms in African countries during the period spanning from 2007 to 2018. We use the *Mining Intelligence* database to constitute an individual data panel of gold mines located in Sub-Saharan countries. To the best of our knowledge, this is one of the first times this database is used for such an analysis. Working at the mine level limits the availability of accounting information (usually only reported at the firm level) but enables us to consider the production conditions of each extractive site. Our dependent variable is a proxy of the *declared* profit for each mine. Policy reforms that have brought changes in profit tax rate and royalty rate are our explanatory variables of interest.

Our main findings are as follows. Our estimations show a robust inverse relationship between the tax rate changes and the declared profits. The higher the tax, the lower the level of profit declared by the mining firms. We interpret these tax-motivated profit modifications as evidence of tax avoidance practices: when taxes are high, firms overestimate more their costs and declare less taxable profits. These results are in line with previous studies in different countries and sectors (Heckemeyer and Overesch (2017)) that have shown consistently an inverse correlation between statutory tax rates and reported profits. Our findings are robust to the introduction of various control at the mine level, country level controls, fixed effect for each mine, and interaction terms.

Finally, taking into account the multinational nature of most mining companies, we investigate whether the profit in a mine is sensitive to the change of the tax in other countries where the parent mining company has branches. Prior literature on international profit and price shifting is quite abundant (see Riedel, 2018, for an excellent survey). Existing studies unanimously report evidence of profit shifting by multinational firms with the aim of reducing the tax bill. In terms of shifting channels, there is evidence consistent with strategic mispricing of intra-firm trade, the location of valuable intellectual property at low-tax affiliates and debt-shifting activities. In our paper, a possible profit shifting strategy will be a tax motivated cost modification in a mine due to a tax rise in sister mine located in another country. We do find some evidence of such a link in group-related mines for royalties. Thus, on top of our finding that declared profits change as a response of changes in taxes, profit shifting in parent mines seems to be a strategy of tax avoidance in extracting industries in Africa.

Our paper contributes to the applied literature on the economics of tax evasion focusing on extractive resource taxation in countries where the asymmetry of information between governments and mining firms is very high. To the best of our knowledge, we are the first to provide an empirical study on taxation using microdata in extractive industries. The scarce related studies usually rely on firm level accounting data (as opposed to the more disaggregate mine level data that we adopt here) in OECD countries (Kawano and Slemrod 2016 ; Dwenger and Steiner 2012 ; Gruber and Rauh 2007). We naturally relate to prior literature on corporate tax avoidance that is quite extensive and develops along two directions (Slemrod, 2019): (i) the determinants of tax evasion and (ii) the magnitude tax evasion and measuring issues. As for the determinants, corporate tax

avoidance is affected by the financial characteristics of firms (Lisowsky, 2010), the presence or not of an internal revenue service (Hoopes et al., 2012), media exposure (Allen et al 2016), consumers' concentration (Huang et al 2016). As to the second branch of the literature, the extent of tax avoidance is difficult to estimate, by definition. Literature uses the effective tax rate (Wen et al, 2020 is one example), randomized controlled trials mostly delivered via letters from the tax authority or audits (as surveyed in Slemrod, 2019). Our paper complements this literature by tracing tax evasion via cost inflation, in a particular sector but in a multi-country setting, and using policy reforms to mitigate any endogeneity issues.

The structure of the paper is as follows. Section 2 sets out the model. The empirical analysis is presented in Section 3 and some conclusive remarks are provided in Section 4.

2 The model

In this section, we build a simple theoretical setting to capture the interactions of firms and the tax authority. Consider a two-period model and n resource firms each exploiting a mine. The extracted mineral, say gold, is traded in a competitive global market at a price p.[2] For simplicity, all firms share the same production function. More specifically, in the first period, the technology of each firm is composed by a fixed cash labor cost of exploration and development f_i and an initial capital investment K_i. In the second period, each firm faces only extraction costs. Hence, each resource firm generates a quantity of final processed gold $q(K_i)$ with certainty at the end of the second period. The corresponding extractive costs for each firm are given by $C\left[q(K_i)\right]$, $\partial C\left[q(K_i)\right]/\partial K_i > 0; \partial^2 C\left[q(K_i)\right]/\partial^2 K_i > 0$.

Under competitive and efficient global credit markets, each resource firm can borrow and lend at a competitive risk-free interest rate r which constitutes its discount rate factor for future period profits. The government of the country hosting the n mines imposes an *ad valorem royalty* at rate θ on the revenues in the extracting sector and *a profit tax* τ on reported profits. The tax authority relies on self-reporting by the firms in order to establish its tax liabilities, putting each firm at a significant informational advantage compared to the tax authority. To focus on extracting sector, we abstract from the decision of the profit tax that is defined in a larger fiscal policy concerning the whole economy and beyond the mining sector.

The key assumption of the model is that the resource firms may overstate production costs by multiplying these costs by a factor β that exceeds one (as in Bourgain and Zanaj, 2020). The tax authority is unable to know the nature of the cost of the firm, hence it is unable to determine whether the factor β is due to cost overstatement or it is part of the production costs of the firms. This is due either because of lack of expertise or because of corruption. The rate of overstatement β is a feature of the country and thus it is used by all mining firms located in the country.

The government is risk-neutral and it is able to commit to the tax policy it announces before investment decision. This time consistency of the tax policy may be guaranteed by international contracts law. The objective function of the government intervention is to raise tax revenues. Each firm maximizes her *real* profit

[2]The price-taking behavior of the extractive firm in the market for the resource is documented in O'Connor *et al.* 2016.

to fix the amount of capital to invest. To obtain closed form solutions, in line with the existing literature (Boadway and Keen 2010 and 2015), we assume that the final transformation process is a linear function $q(K_i) = \alpha K_i$ whereas extractive costs are, for simplicity, quadratic $C(q(K_i)) = \frac{1}{2}\left[\frac{1}{\alpha}q(K_i)\right]^2$ with α being an efficiency parameter. We assume $\alpha > 1+r$: the productivity of the transformation technology pays more than the intertemporal investment of a unit of capital.

Given taxes, each firm maximizes the following profit function:

$$\Pi_i(\theta,\tau) = (1-\tau)\left(-K_i - f_i + \frac{(1-\theta)\alpha K_i - \frac{1}{2}K_i^2}{1+r}\right),\ i = 1,...,n \tag{1}$$

where the extraction costs is $C(q(K)) = \frac{1}{2}\left[\frac{1}{\alpha}q(K_i)\right]^2 = \frac{1}{2}K_i^2$. Concavity conditions being satisfied, each firm makes the same capital investment $K(\theta)$ given by:

$$K(\theta) = \alpha(1-\theta) - r - 1 > 0 \tag{2}$$

Notice however that the firm may report a different profit to the tax authority - *the declared profit* $\Pi_i^D(\theta,\tau,\beta)$ where the firm overstates its extraction cost multiplying it by a factor β to limit its tax liability. Hence the *declared extractions costs* are $\beta\frac{1}{2}\left[K(\theta)\right]^2$ with $\beta \geq 1$. The government decides the optimal royalty θ^* maximizing tax revenues $R(\theta)$ and using declared profits of the n firms:

$$R(\theta) = \frac{n}{1+r}\left\{\theta\left[\alpha K(\theta)\right] + \tau\left[(1-\theta)\alpha K(\theta) - \beta\frac{1}{2}\left[K(\theta)\right]^2\right]\right\}$$

Due to cost overstatement the declared total extraction costs appearing in the tax revenue function are multiplied by the factor β. The optimal royalty obtains as follows:

$$\theta^* = \frac{(1+r-2\alpha+\beta(\alpha-1-r))\tau + (\alpha-1-r)}{\alpha(2(1-\tau)+\beta\tau)} \tag{3}$$

Positivity of the optimal royalty is guaranteed under the condition that the efficiency parameter α is relatively large, i.e. $\alpha > (r+1)\frac{1-\tau(1-\beta)}{1+\tau(\beta-2)}$. Comparative statics on optimal royalty yields $\frac{\partial\theta^*}{\partial\beta} = \tau\frac{\alpha-(1-\tau)(1+r)}{\alpha(-2\tau+\beta\tau+2)^2} > 0$. The more corrupted or the more severe is the lack of expertise of the tax authority, the smaller are declared profits because firms amplify more aggressively the declared extraction costs. This necessarily translates into smaller tax receipts deriving from the profit tax. As a consequence, the government increases the royalty over firms' revenues to compensate for the negative effect of amplified extraction costs. Put differently, our setting suggests that countries suffering from lack of expertise in mining industries or facing a high level of corruption will have higher royalty rates.

To discern the relationship between the royalty and the profit tax, we explore the sign of $\partial\theta^*/\partial\tau$. In a reasonable range of values for the coefficient of overstatement is that β does not exceed two, the inequality $\beta < 2\alpha/(\alpha-r-1)$ is always satisfied, leading to a negative relationship between the profit tax and the royalty. This is in line with the stylized facts presented in Figure 2 below. Hence, in presence of cost overstatement, a revenue-maximizing government selects the lowest royalty, given the profit tax. This property is reminiscent of well-known results in the existing literature on optimal taxation. Royalties bring distortive effects on tax

revenues because they increase the burden of taxation on firm revenues while neglecting the firm's costs. The optimal tax policy that alleviates this distortion will privilege high-profit taxes while reducing royalties as much as possible. In addition, this finding suggests that in a developing extractive country whose government maximizes tax revenues, two forces exist that have opposing effects on royalties. The profit tax exerts a negative pressure on royalties, whereas the rate of cost misreporting pushes royalties up. This implies that different countries may have very different royalty rates due to either different profit taxes or different levels of cost overstatement.

Using the optimal royalty θ^*, we can evaluate the *declared profit* Π_i^D, $i = 1, ..., n$ of each firm at the optimal royalty:

$$\Pi_i^D = (1-\tau)\frac{(2-\beta)(r+1)\tau\left[(r-4f_i+2\beta f_i+1)\tau-2(r-\alpha-4f_i+1)\right]-\beta(r-\alpha+1)^2-F_i}{2(2-2\tau+\beta\tau)^2(r+1)}$$

where $F_i \equiv 2\alpha(2r+2-\alpha)+8f_i(1+r)-4r-2r^2-2$.

We can now investigate the relationship between the declared profit and the tax rates. As far as it concerns the effect of a change in royalties on the profit of the firms, we shall proceed by first reminding that the effect of royalties must be measured indirectly by considering the effect of the overstatement coefficient on royalties, which affects the profit of the firms.

Proposition 1 *The higher the cost overstatement coefficient, the higher the level of royalties, the smaller the declared profits.*

Proof. Simply taking the partial derivative $\frac{\partial \Pi^D}{\partial \beta} < 0$ ■

The mechanism is as follows. An increase of the overstatement coefficient means higher corruption or lower quality of institutions. As a consequence, declared profits will certainly decrease indicating the effort to reduce tax liability. But this is not all. A vicious circle of effects is in place. In presence of high β, the government raises royalties in order to offset the negative impact of amplified declared costs that reduce declared profits. The higher royalty affects negatively the optimal invested capital in the first period and the optimal level of output extracted in the second period ultimately decreasing further the declared profit for each firm. Hence deterioration of the quality of institutions or increased corruption accompanied by increased royalties seriously aggravates the public money collected in mining sectors.

Turning to the effect of profit tax on profits, we know the profit tax rate has a negative direct effect on profit and an indirect effect with opposite sign. The indirect effect only appears when the tax government changes simultaneously the royalty with the profit tax. In fact, we know that $\frac{\partial \theta^*}{\partial \tau} < 0$. Then, a decrease of the profit tax affects positively profits via a direct effect, but a decrease in profit tax may yield an increase the royalty θ^* which in turn affects negatively firms' profit. These two drivers have different sizes depending on how large is the profit tax and how large is β. However, if the indirect effect is small or if the government changes the profit tax in the economy without bringing any changes in the royalty level of the mining sector, we find that

Proposition 2 *Declared profits depend negatively on the profit tax.*

Proof. Calculating the derivative of the declared profit with respect to to τ, we have $\frac{\partial}{\partial \tau}\Pi_i^D = \underset{<0}{-(K_i + f_i)} + \underset{<0}{\frac{\partial}{\partial \tau}(-K_i)}(1-\tau) \underset{<0}{-\frac{(1-\theta)\alpha K_i - \frac{1}{2}\beta K_i^2}{1+r}} + \underset{>0}{\frac{(2\alpha+\beta+r\beta-\alpha\beta)^2}{(+2-2\tau+\beta\tau)^3}}\frac{(1-\tau)}{1+r}$. The first three components are the direct negative effects of the profit tax on declared profits. The last is the spillover via the royalty. When the spillover effect is weak because the royalty is relatively small, then $\frac{\partial}{\partial \tau}\Pi_i^D < 0$. ■

In the empirical part, we test our theoretical priors on the effect of a policy change in profit taxes, in royalties on the declared profits of extractive firms.

3 Empirical Analysis

3.1 Data and specification

Our theoretical prior (Proposition 1 and 2) is that declared profits will move in the opposite direction of tax rates and royalties. In particular, the rise of profit tax rate and the royalty will have a negative effect on the profit declared by the mining firms. Following these theoretical predictions, our empirical specification is:

$$\Pi_{i,c,t}^D = f\left([\tau, \theta]_{c,t}, X_{i,c,t}, Z_{c,t}\right)$$

where $\Pi_{i,c,t}^D$ is the (declared) profit; $[\tau, \theta]$ are the profit and royalties rates, X and Z are mine and country specific variables, and indices i, c and t stand for mine, country and year.

The level of observation that we rely upon will be the mine level. Unlike mining companies which may be active across several countries, mine sites are clearly localized within a country or territory, allowing us to relate mines to national tax policies. On top of that, it allows us to control for a number of physical characteristics of mines, which contribute to the explanation of their profitability. From an econometric point of view, relying on disaggregate rather than macro data mitigates any potential reverse causality issue between the tax base and tax rates, unless mines act in a coordinated way and represent a substantial portion of the tax base. But in our sample, the share of mining public revenue over the total tax revenue never exceeds 12-14%.

We build a new data set merging information about mines from the Mining Intelligence and the Mining Tax database for Africa. All mining related data stems from the Mining Intelligence Database, which is a private data supplier in the mining sector, mainly for private and institutional customers. The database documents a very large number of companies and corresponding mines; it entails information on stakeholders, mine physical characteristics, production, accounting informations among others. For our purpose, we extracted total cash costs and realized prices to obtain a proxy of the declared profits for every mine site.[3] Furthermore, production conditions and physical covariates of mines have been exploited.

Tax regime data stems from the Mining Tax Database for Africa, initiated and developed by Laporte et al. (2015), and updated in 2018. We extended this database temporally and geographically for the purpose of this study. This database specifies the tax regime applied to industrial gold mining companies in 21 African

[3]Using mine level data reduces the availability of accounting information (available only at the company level) amongst other declared profits.

countries from the 1980s to 2016, and links each piece of tax information and its legal source. It provides information on the evolution, and allows to compare the gold mining tax systems of different African countries.

In our specification, we also control for macroeconomic factors as well as perception indicators, information on which has been extracted from the World Development Indicators. We focus on the World Bank Indicators of governance and institutional quality and use the Regulatory Quality Index to capture the capacity of governments to effectively formulate and implement sound policies. This indicator measures the perceptions of stakeholders on the incidence of market unfriendly policies and perceptions of regulatory burdens (World Bank, 2010). Despite of being usually considered as poor regressors, this indicator is the best available measure for the country-level cost overstatement coefficient of mining firms. In fact, our theoretical prior is that the Regulatory Quality in a country determine ultimately how easy it is to misreport the extraction costs when declaring profits for tax avoidance purposes. The lower the Regulatory Quality, the easier for a firm to amplify its costs with the purpose of decreasing her taxable profit. The time span for every mine can of course be different, and not every mine does provide information on the variables of interest. As a result, we end up with an unbalanced panel dataset, which in its maximal extension, covers 15 years (2001-2015) and 13 countries (corresponding to 113 mines and 630-836 observations).

Figure 1 provides a visual synthesis on mine data availability and variation in tax instruments. Dots represent gold mines in Africa (i.e. our data entails geographic coordinates of every mine complex), which appear in the tax database (i.e. corresponding countries are shaded).

Countries hatched with increasing lines refer to situations in which there has been at least one increase in royalties during the period under scrutiny, while downward sloping hatches refer to cases where corporate taxes have decreased at least once. Hatched countries will hence be the treated countries on which we will rely for the identification of the impact of tax regime on profitability, while the remaining countries are our control group. While most of our countries do highlight a change in the tax regime, some countries only have changes in the tax or royalties rates, while others do highlight changes in both tax instruments. Interestingly however, not only did average profit tax rates decrease and average royalties rates increase through time (as can be grasped from Fig.2), this is also true for every country taken individually.

Table 1 below displays descriptive statistics of our variables of interest. We can notice a substantial variation of tax and royalties rates across countries and years. The same is true for mine sites, proxied by the production volumes. The cash cost indicator allows us to compute profits, and is the parameter through which firms adjust their profits according to tax policy changes.

There are two physical characteristics of mines that may also influence profitability, and for which we will control in our regressions: the average grade of ore deposits and the estimated reserves of the mines. As to the gold price, it has been steadily increasing during the period under scrutiny. Lastly, the Regulatory Quality Index of the World Bank encompasses perceptions of the stakeholders on the ability of the government to formulate and implement sound regulations promoting the private sector development.

In Table 2, average figures by country are displayed. We notice that a large majority of mines are located in South Africa, Burkina Faso, Ghana, Mali and Zimbabwe, while the remaining ones are distributed across the

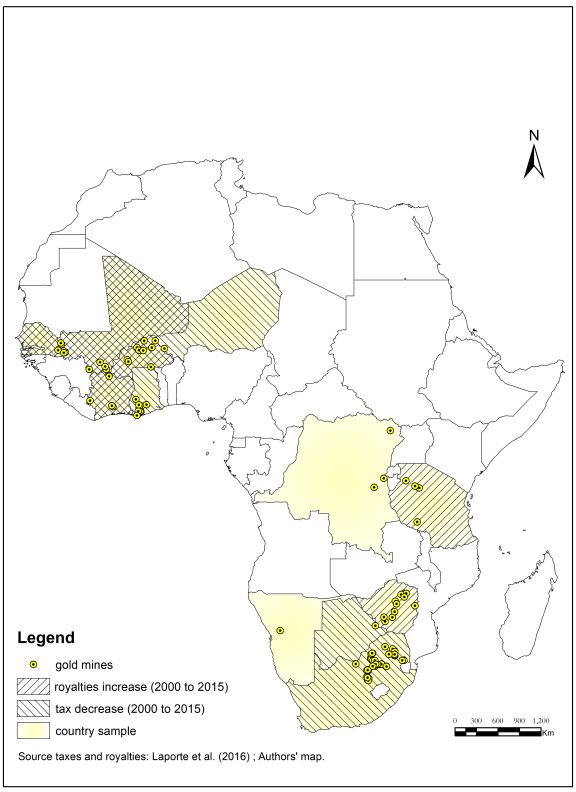

Figure 1: Gold mines and variation of tax instruments

remaining 6 countries. Profit tax rates range between 15.6% in Zimbabwe to 37.5% in Namibia. Interestingly, the Regulatory Quality index is the lowest in Zimbabwe indicating a very negative perception about the quality of regulation and implying, according to our setting, a very high chance of cost overstatement for tax avoidance purposes. Royalties range between 3% and 8.3% in Niger.

We are specifically interested in the reaction of firms exploiting the mining sites following changes in profit taxes and royalties. We therefore model these fiscal policies as dummy variables, i.e. 0 to 1 in case of increase and 1 to 0 in case of decrease. Notice that given the short period under scrutiny, in the overwhelming majority of the cases we only had one fiscal policy change. In the rare occurrences where it was not the case, we selected chronologically the first change. Furthermore, using dummies for policy changes allows us to circumvent the problem of tax rebates, i.e. cases where firms pay lower rates than the official rate. One may expect that changes in official rates, via domino effect, will translate in changes in the effective rates.

3.2 Econometric results

In Tables 3 and 4, we display results related to Proposition 1 and 2 relying on OLS estimations and FE estimators with specifications progressively more restrictive by adding various controls. Finally, in Table 5, we

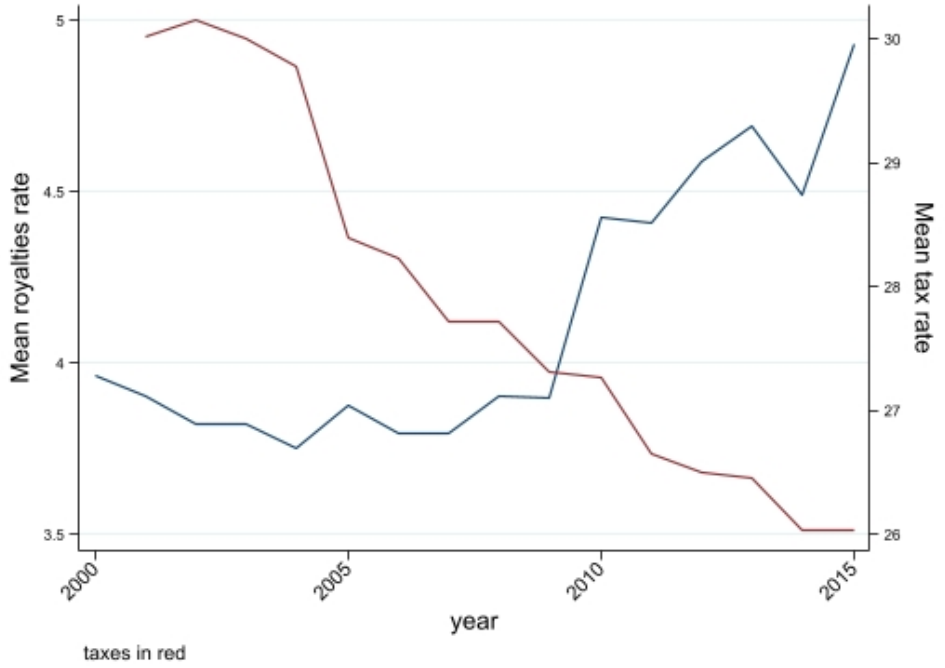

Figure 2: Profit tax and royalties rates

explore two additional explanations: the impact of the government's participation in the company that owns the mine and the effect of a tax reform in another country where branches of the same firm are present to isolate any spillover effect.

In Table 3, all regressions control for country-specific, time-invariant effects, as well as time dummies to account for macroeconomic shocks. The *log* of production is added to every regression, controlling for (dis)economies of scale. Column (1) serves as the benchmark specification where Column (5) is the preferred specification where we control for mine-level controls, country and time fixed effects.

The coefficient on profit taxes is negative and significant: a decrease in tax rates induces an increase in the level of declared profits. This is in line with the result in Proposition 1. The same is true for royalties rates. A higher royalty is associated with lower declared profits.

As highlighted in equation (1), royalties apply only to firms' production. It follows that we expect production levels to adjust as a consequence of a royalty change, hence the interaction term between the log of production and royalties in Column (2). The significance of the interaction variable shows that the marginal effect of production volume is indeed dependent on royalties increase. Column (3) displays results when accounting for physical characteristics of mines, i.e. the ore grade and the estimated reserves. In accordance with intuition, both coefficients have a positive sign, but insignificant. In the fourth and fifth column, we control for a perception indicator of institutional characteristics using the Regulatory Quality Index. Our theoretical model predicts that a decrease in overstatement coefficient, namely an increase of the regulatory quality, leads to a decrease of royalties leading to an increase of capital invested and firms' profit. The regulatory quality appears with a significant and a positive coefficient in column (5), where we control jointly for grade and reserves. This

	Observations	Mean	Std. dev.	Min.	Max.
Tax rate (%)	604	27.6	5.1	15	40.5
Royalties rate (%)	604	4.1	1.06	2.5	8.75
Prod. (10^3 troy ounces)	604	210201	237672	538	1854200
Profit (USD/ozt)	604	445.6	263.8	2.6	1154.4
Gold price(USD/ozt)	604	1148.8	398.3	271.2	1668.9
Grade (g/t)	561	4.05	4.05	.25	18.01
Reserves (t)	561	$5.99 \cdot 10^7$	$1.16 \cdot 10^8$	250000	$1.07 \cdot 10^9$
Regulatory quality	506	-0.013	0.60	-2.16	0.61
Gov. participation (yes/no)	593	0.27	0.45	0	1

Table 1: Descriptive statistics

	# mines	Profit (USD/ozt)	Production (10^3 ozt)	Reserves (t)	Grade (g/t)	Tax rate (%)	Royalties rate (%)	Regul. Quality	Gov. part. (y/n)
Botswana	1	334.19	32600	727000	1.29	22	5	.54	0
Burkina Faso	7	728.4	175925.2	44069093	1.75	17.6	3.9	-.218	0.7
Dem. Rep. of Congo	2	618.4	297130.8	97850000	2.08	30	2.5	N/A	0
Ghana	10	464.8	319725.6	77818025	2.47	29.9	5.2	.054	0.6
Ivory Coast	4	581.4	131092	38252750	1.98	25.3	3.3	-.73	1
Mali	8	424.9	202491.2	35086365	3.03	30.4	3.7	-.48	1
Namibia	1	351.2	75642.9	75030000	1.31	37.5	5	.077	0
Niger	1	418.9	62225	4937400	1.23	33.8	8.3	-.51	1
Senegal	1	777.1	189416.2	65442000	1.74	28	3	-.14	1
South Africa	52	394.6	221144.8	62759810	6.68	28.3	3.8	.38	0
Tanzania	4	492.7	137407	5119085	2.75	30	3.6	-.40	0
Zimbabwe	9	535.2	96780.6	109298180	3.78	15. 6	4.3	-1.88	0

Table 2: Descriptive statistics by country

result is in line with the result in Proposition 1: the higher the regulatory quality (namely the lower the chances to overstate costs for tax avoidance purposes), the higher the declared profits. For the rest of the estimations, we will rely on this latter specification, accounting for a number of possible covariates, while controlling for time and country fixed effects.

In Table 4, we have tested more restrictive specifications, by adding mine fixed effects, which will control for any mine specific, time invariant characteristic.

Column (1) corresponds to our benchmark estimation, while in columns (2) and (3) we do account for the controls introduced in the previous table (i.e. grade and reserves being time invariant, they are absorbed by the mine fixed effects). Column (3) is the most restrictive as it furthermore accounts for possible unobservable confounding factors of national tax policies, via country-specific time trends. Results do remain qualitatively unchanged compared to the previous table, i.e. profit tax rates decreases induce an increase in declared profits, while royalties increases tend to reduce these profits, while controlling for interaction with production. Better institutions do contribute to higher profits. Finally, the effect of Tax and Regulatory Quality become statistically

Basic regressions

Dep. Var : *log*(profit) of mines

	(1)	(2)	(3)	(4)	(5)
Tax	-0.153*	-0.135*	-0.0884	-0.241**	-0.196*
	(0.0780)	*(0.0773)*	*(0.0739)*	*(0.114)*	*(0.107)*
Royalties	-0.275**	-3.165***	-3.052***	-3.665***	-3.660***
	(0.123)	*(0.800)*	*(0.773)*	*(0.877)*	*(0.848)*
Log(production)	0.138***	0.119***	0.109***	0.104***	0.0852***
	(0.0194)	*(0.0199)*	*(0.0209)*	*(0.0236)*	*(0.0251)*
Royalties • *Log*(prod.)		0.252***	0.247***	0.286***	0.291***
		(0.0688)	*(0.0663)*	*(0.0743)*	*(0.0716)*
Reserves			2.80e-10		2.88e-10
			(2.31e-10)		*(2.46e-10)*
Grade			0.00152		0.00608
			(0.00771)		*(0.00924)*
Regulatory Quality				0.722	0.796*
				(0.498)	*(0.466)*
Constant	3.475***	3.619***	3.681***	5.178***	5.466***
	(0.416)	*(0.414)*	*(0.402)*	*(0.393)*	*(0.393)*
Country dummies	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes
Observations	604	604	561	506	469
Nr. of mines	100	100	90	97	88
R-squared	0.452	0.464	0.491	0.313	0.336

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3: Basic regressions

insignificant, although marginally so for the tax variable (p-value: 0.12), when we introduce country-specific time trends (jointly with time and mine fixed effects) on the last column.[4]

At last, in Table 5 we analyze the robustness of our results when controlling for (i) the public ownership of mines (columns (1) and (2), and (ii) the multinational nature of the mining companies (columns (3) and (4)).

Public ownership is captured with a dummy variable taking value 1 when there is government participation. We control for country and year fixed effects in column (1) and mine and year fixed effects for the remaining columns (i.e. as government participation is time invariant, it is absorbed by the mine fixed effect). From our results, no impact of government participation can be unearthed. However it is noteworthy that the sign of the coefficients of Tax and Royalties remain unchanged and statistically significant. In columns (3) and (4), potential spillover effects of tax optimization in the same multinational firm is taken into account. More

[4]One issue arises with the result on royalties in Tables 3 and 4. It may seem that the negative sign of the coefficient of royalties is driven by the fact that royalties typically represent a deductible expense under the profit tax. To tackle this, we recalculated the profit of mines to net out the royalties paid at the mine level, by subtracting Total Cash Costs from All-in-Sustaining Costs at the mine level. This cancels out royalties as the cost difference only includes exploration and sustaining capital costs. Consistently with previous results, an increase in royalties indicates a decrease of the declared profit. One should be cautious in interpreting this results as it relies on a substantially reduced sample (77 observations).

Robustness checks: taking account of unobservables

Dep. Var : *log*(profit) of mines

	(1)	(2)	(3)
Tax	-0.132*	-0.207**	-0.236
	(0.0720)	*(0.100)*	*(0.152)*
Royalties	-3.127***	-2.433**	-2.135*
	(-1.049)	*(-1.200)*	*(-1.288)*
Log(production)	0.397***	0.498***	0.471***
	(0.0488)	*(0.0815)*	*(0.0823)*
Royalties • *Log*(prod.)	0.242***	0.182*	0.176
	(0.0912)	*(0.103)*	*(0.109)*
Regulatory Quality		0.978**	0.607
		(0.481)	*(0.662)*
Constant	-0.224	-0.0119	-81.35
	(0.626)	*(0.971)*	*(125.6)*
Mine dummies	yes	yes	yes
Time dummies	yes	yes	yes
Country dum. • Time trend	no	no	yes
Observations	604	506	506
Nr. of mines	100	97	97
R-squared	0.549	0.404	0.422

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Robustness checks: taking account of unobservables

specifically, the two variables Tax/Royalties foreign branches referring to columns (3) and (4) indicate whether mine i is related to another mine in a foreign country through the parent mining company, in which there has been a change in the tax/royalties rates in year t. More specifically, in column (3), the variables Tax foreign branches and Royalties foreign branches, measure the proportion of countries where a parent mine is located and where there has been a change in tax/royalties rates, while in column (4) the variables Dummy tax foreign branches and Dummy royalties foreign branches are dummy variables equal to one when at least one parent mine is located in a country where there has been a tax/royalties change. From the results, one can be seen that while no such effect can be highlighted for tax policies, the royalties of foreign branch variable appears to be positive and significant in the third column. When royalties increase in a country where a parent mine is located, the declared profits in the reference country is increasing, as expected. Lastly, the coefficients of one of the variables of interest (i.e. Tax) becomes statistically insignificant in column (3).

	(1)	(2)	(3)	(4)
Tax	-0.252**	-0.282**	-0.133	-0.192*
	(0.117)	*(0.126)*	*(0.106)*	*(0.102)*
Royalties	-3.777***	-2.354*	-2.238*	-2.232*
	(0.888)	*-1.212*	*-1.199*	*(-1.226)*
Log(production)	0.103***	0.493***	0.500***	0.509***
	(0.0237)	*(0.0822)*	*(0.0810)*	*(0.0823)*
Royalties • *Log*(prod.)	0.293***	0.176*	0.172*	0.165
	(0.0752)	*(0.104)*	*(0.103)*	*(0.105)*
Regulatory Quality	0.778	1.027**	1.030**	0.977**
	(0.505)	*(0.487)*	*(0.482)*	*(0.483)*
Government participation	-0.162			
	(0.140)			
Gov. participation • Tax		0.142		
		(0.187)		
(Dum.) tax foreign br.			0.214	0.0793
			(0.163)	*(0.152)*
(Dum.) royalties foreign br.			0.325**	0.0874
			(0.134)	*(0.107)*
Constant	5.352***	0.0963		-0.184
	(0.413)	*(0.982)*		*(0.990)*
Mine dummies	no	yes	yes	yes
Time dummies	yes	yes	yes	yes
Country dummies	yes	no	no	no
Observations	499	499	506	506
Nr. of mines	96	96	97	97
R-squared	0.313	0.403	0.415	0.406

Table 5: Government participation and parent firms

4 Conclusion

In this paper, we explore how tax changes affect firms' declared profits in gold mines in Africa. The main ingredient of our analysis is that governments have severe informational disadvantages vis-à-vis resource extraction companies who may overstate their extraction costs to decrease their declared profits. In a two-period model, we show how profit taxes and royalties affect the amount of capital invested to exploit a mine and ultimately the declared profits. This setting provides a better understanding of the effects and interactions of these two tax instruments. Our main result illustrates tax-motivated modification of declared profits as a consequence of a tax change.

In the empirical analysis, we bring a novelty in the corresponding literature by using data at the individual mine level that allows considering production variables. Our estimations document a negative relationship between tax rate changes of the two instruments (profit tax and royalties) and the profit of the mine. This result (i.e. in particular for Royalties) remains unchanged to a set of robustness checks such as institutional

quality, physical characteristics of mines, as well as various mine, country and time specific unobservable characteristics. Finally, recognizing the multinational nature of mining companies we investigate if the profit of a mine is sensitive to the tax change occurring in countries of parent mines, belonging to the same mining company. In line with prior literature predicting profit shifting strategies to avoid taxes, we highlight that changes in royalty in parent firms in foreign countries do have a positive effect on declared profits in the home country mine.

From a tax policy point of view, these results underline the shortcomings of asymmetry of information for declared profit and consequently for government revenues. In this regard, our results tend to highlight that government participation in mine ownership is not sufficient to reduce this asymmetry effect.

Several future research paths can extend our work. Firstly, it will be interesting to analyze the effect of tax changes in other developing countries where tax authorities may suffer from the asymmetry of information on extraction costs. Secondly, it could be interesting to explore more sophisticated forms of cost overstatement as suggested by Boadway and Keen (2015). This would imply deeper thinking of the corresponding empirical variables and it would depend on data availability.

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