Tax design and rent sharing in mining sector: Evidence from African gold-producing countries

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Abstract

Based on the innovative database, we use a discounted cash flow model to study the rent sharing and the mining tax design in African gold-producing countries. Two main tax designs emerge. Those that favour *production-based taxes* in order to secure government' revenues and those that favour *profit-based taxes* to support economic efficiency. From the estimation of a panel model regression, we show that tax design depends essentially on the evolution of world prices and not on institutional variables. The recent "innovations" in mining taxation to introduce more progressivity have had mitigated results. In the best of cases, the regressivity of tax regimes has been reduced.

Keywords: Mining sector, Natural resources taxation, Database, African gold-producing countries, rent-sharing

JEL : Q38, K34, H30, C80

1. Introduction

The Addis-Ababa Conference on Financing for Sustainable Development in July 2015 stressed the importance for developing countries to increase the mobilization of domestic fiscal resources. Taxing mineral resources is then challenging for all resources rich countries and particularly so for many African countries. Over half of African countries produce mineral resources, and twenty of the continent's fifty-four countries are rich in mineral resources according to International Monetary Fund (IMF) criteria (IMF 2012). African countries have 30% of world's mineral reserves, and most of the minerals are present, including gold, copper, cobalt, bauxite, iron, and diamonds. Gold is the only ore extracted in almost every country on the African continent. The sharing of rents is therefore a particular challenge for the African countries. The current political context of the sector is strained for decades. The governments want to increase their share of the mining rent and companies fear 'hold-ups' or expropriations similar to what occurred in Latin America in previous upward price cycles (Daniel et al. 2010; Duncan 2006). Today, the issue of expropriation is no longer on the agenda, but countries such as Chile and Peru, the world's top two copper-producing countries, are reviewing their mining tax regimes in order to increase taxation considerably. In Peru, the sharing of mining rents was an important campaign theme for Pedro Castillo, the president elected in July 2021. In Chile, deputies are in a battle since May 2021 with the Senate and the government to create an additional 3% tax on the value of certain minerals. The fair sharing of rents is indeed a question shared by all resource-rich countries. The answer to this question is not homogeneous across continents. Trench et al (2015) show, in a comparative study between Africa and South America, that government share of the rent varies from 36.3% to 66.6%, without a continental profile emerging: Ghana 66.5%, Guyana 63.9%, Mali 60.4%, Tanzania 58.8%, Peru 58.5%, Colombia 55.0%, Burkina Faso 52.2%, Brazil 44.8%, Chile 44.3% and South Africa 36.3%. In most countries, the State owns the natural resources of the subsoil (minerals, oil, and gas). States rarely have the technical and financial capacity to extract the resource on their own, forcing them to concede the exploitation to private firms, often of foreign assets (such as Canada, the United States, Australia, and South Africa). The definition of the tax regime ("tax design") is therefore the result of a trade-off between the need to attract the international investors necessary to extract

mineral resource rent, and sufficient capturing of this rent by and for the government (Laporte and Rota-Graziosi 2014). This trade-off is particularly challenging by the characteristics of the mining sector (non-renewable resources, irreversible investments, high uncertainty), and international competition to attract foreign technical expertise, which is limited but essential to extract the resource.

To begin investment, the firm asks for at least the "normal" expected return on capital. Mining activity has the particular feature of generating a surplus of income called a "rent".[1] The objective of maximizing the government's revenues implies taxing 100% of the rent. Indeed, according to the optimal taxation theory, taxing up to 100% of the mining rent is "economically neutral", i.e. it should not change either the decision to invest or the production path (Boadway and Keen, 2010). However, uncertainty about the operating conditions of and benefits generated by the mining project does not allow governments to assess accurately the mining rent *ex ante*, either for geological, economic, or political reasons. Therefore, it is impossible to define this economically "neutral" taxation for the investor from the beginning of the mining project.

In practice, each State tries to define the tax regime that it considers most appropriate to capture a sufficient share of the rent according to its own objectives: either securing short-term revenues or smoothing them over the life of the project, improving the progressivity of tax regimes, adapting to countries' administrative capacities, reducing information asymmetries, or even more broadly influencing the behavior of mining operators (Kumar and Radetzki, 1987; Baunsgaard, 2001). The mining sector then can be governed by a complex tax regime that combines multiple taxation instruments and which may derogate from the general regime and include own levies, some of which are sources of economic distortions.

Depending on the objectives set, the levies constituting the mining regime vary, with different economic implications for the investor each time. The nature of the levy, its base, its rate, and/or its calculation method not only influences the government's share of the mining rent but also determines its adaptability

[1] The mining rent is measured as "the amount by which revenues exceed all production costs, including those of discovery and development, as well as the normal return on capital" (IMF, 2012).

to a change in operating costs and/or the price of the resource. Thus, Otto (1998, 2006),[2] distinguishes two types of tax levies: (i) *in rem taxes* (or "*production-based taxes*"), which cover mining royalties, fixed duties, annual ground fees, customs duties, taxes on petroleum products, and turnover minimum tax. These levies secure the government's revenues from the beginning of production, regardless of the profitability of the mining project, but they increase production costs for the firm. (ii) *in personam taxes* (or "*profit-based taxes*") recover corporation tax, withholding tax on dividends and interest, rent tax, etc. These taxes have the advantage for the firm of being based on profit alone, but the revenues collected by the government may be eroded in the event of a fall in the profitability of the project and by the misuse of transfer prices. In addition to these tax levies, the mining sector is subject to other parafiscal taxes, such as State participation in the company's capital.[3] Governments are thus looking for the best mix between *production-based taxes* and *profit-based taxes* and are innovating on the application modalities of tax instruments, to find the tax design that allows a fair sharing of the mining rent. Given the current context of instability in world prices, the reversal of the commodity cycle, the complexity of mining contracts (stability clauses, special agreements), and the strengthening of international initiatives to promote transparency, the question of the progressivity of the tax regime takes on importance. The literature offers many definitions of the progressivity of a tax or tax system (Slitor, 1948, Musgrave and Thin, 1948; Kakwani, 1977; …). In relation to the issue addressed with Kakwani, a tax regime is progressive if the government's share of the mining rent increases when the profitability of the mining project improves and decreases when it does not. If the government’s share of the rent is measured by the average effective tax rate (AETR),

A progressive mining tax regime is thus characterized by an AETR that increases with the rent (Boadway and Keen, 2010). The progressivity of the tax regime should allow the overall tax burden borne by the firm to adapt automatically to changes in economic conditions (Garnaut and Clunies-Ross, 1983; Daniel

[2] Further developed in Boadway and Keen (2013).

[3] In the rest of the article, the term "tax" will be used whether it is either a tax in the literal sense or a parafiscal tax.

et al., 2010; Hogan and Goldsworthy, 2010). According to Lund (2009, 2013) and Boadway and Keen (2013), rather than seeking neutrality, Governments must, above all, find a fair balance between *profit-based taxes* and *production-based taxes* to succeed in building a progressive mining tax regime, probably by favoring *profit-based taxes* in the overall structure of tax instruments (Kumar and Radetzki, 1987 ; Calder, 2010). According to Wen (2018), the issue of progressivity is relevant when the taxation aims to achieve objectives other than maximizing government's revenues and involves economic distortions. The progressivity of certain tax instruments must then be a means of restoring the economic neutrality of the tax regime. The introduction of elements of progressivity among *profit-based taxes* would only aim to reduce the distortions introduced by *production-based taxes* that modify investors' choice. However, this trade-off is not easy because *production-based taxes* as royalties can contribute, under certain conditions of information asymmetry, to an optimal tax system (Conrad *et al.*, 2018).

In practice, the progressivity of the mining tax regime should have several advantages: (i) avoid the sometimes difficult renegotiation of special conventions and revisions of mining Acts at each reversal of the price cycle, as is the case today in Latin America, (ii) allow the government to benefit from a larger share when the world price rises, (iii) reduce the risk for the investor by reducing the tax burden when the profitability of mining is low,[4] and (iv) avoid the introduction of stability clauses that may be unfavorable in the long term for each party according to changes in the economy. Progressivity has been introduced into African tax regimes in several forms: a progressive rate of the corporate income tax according to the mine's profitability rate (South Africa and Madagascar) and a progressive rate of the mining royalty according to either the mine's profitability rate (South Africa and Niger) or the world price of ore (Burkina Faso, Côte d'Ivoire, and Mauritania).

There are few studies mapping and benchmarking the mining rent sharing between firms and governments. The valuation methods, the assumptions made, or even the tax levies modelled vary from

[4] By reducing risk, a progressive regime can reduce the rate of return required by the investor to start his project, which increases the taxable income.

one study to another. As a result, comparing countries is not possible (Smith, 2013; Laporte and de Quatrebarbes, 2015).

The tax and legal database[5] published by the Foundation for studies and Research on International Development (FERDI) in partnership with the Centre d'études et de recherches sur le développement international (CERDI) and The International Centre for Tax and Development (ICTD), provide the statutory tax regimes for the gold mining sector in the main gold-producing countries in Africa (21 countries). This database features three major innovations: (i) an inventory of top twelve taxes, fees and duties (rate, base and exemptions) payable during the prospecting phase and exploitation phase of a gold mining project; (ii) an entirely new level of historical depth covering the period 1980-2018; (iii) the link between each piece of tax information and its legal source (nearly 1500 legal texts identified).

Applied to the economic data of three African representative gold mines, this database allows calculation of the AETR for each tax regime to assess the sharing of the mining rent between firms and government according to each mining tax regime and compare the overall tax burden and its composition between countries. With these data, it is now possible to calculate the elasticity of AETRs to pre-tax IRRs to assess the progressivity of tax regimes. Finally, by combining this database with other international databases, it is possible to study the determinants of the African tax design.

The rest of the article is organized as follows: Section 2 presents the database and methodology, Section 3 the results on rent sharing and the progressivity of mining tax regimes, Section 4 estimates the determinants of tax design and section 5 concludes.

2. The average effective tax rate (AETR): an indicator of rent-sharing

The objective here is to be able to compare, in time and space, the statutory tax regimes of African gold producing countries. Therefore, the rent sharing results from the legal system that is being studied and not the actual sharing. Indeed, calculating the actual rent sharing is very difficult because of problems of getting access to annual accounts (financial and tax) from the multinational mining companies. Often these are either confidential in nature and/or at a level of aggregation (adding operations in multiple

[5] FERDI website: www.fiscalite-minière.ferdi.fr.

countries and regions) that makes scrutiny of individual investment projects, mines and country operations very difficult. In addition, some complications due to tax evasion and aggressive tax avoidance transactions can render the accounts almost useless as a basis of analysis. Similar problems exist with the contract agreement tax terms of different investments at mine or firm levels. Often there are widespread variations and exceptions between countries and even between different firms in a country that can fundamentally affect the actual tax burden (Laporte and de Quatrebarbes, 2015).

In the past, mining companies were able to negotiate more favorable tax and customs conditions and to keep mining conventions confidential. In Mauritania, for example, the MCM convention[6] signed in 2009 provides for the exemption of almost all taxes (not covered by the mining code), with the exception of the mining royalty (rate of 4% on gold, higher than the 3% of the mining code) and the corporate income tax (with an exemption period of 5 years and an unlimited loss carry forward not covered by the mining code).Today, this practice is much more difficult, as more and more countries require that conventions cannot derogate from the mining code (Benin, Cameroon, Congo, Côte d'Ivoire, Gabon, Guinea, Chad). In addition, efforts are made to improve transparency in the extractive sector. Some mining codes stipulate that all conventions must now be published in the official gazette (Burkina Faso, Senegal) or on the website of the Ministry of Mines (Mali). More than half of the countries (12) in the sample now publish mining conventions.[7] In Burkina Faso, for example, of the recent mining conventions that are available[8] (Essakane 2008, Inata-Belahouro 2007, Mana 2007, Perkoa 2008, Yaramoko 2015), none include tax provisions that differ from mining code. The calculation of an AETR from tax law therefore seems so quite relevant.

The calculation of AETR is based on national legislation and economic data representative of African industrial gold mines, published on the FERDI website[9]. The AETR is calculated as the ratio between the discounted revenue received by the government on the project and the pre-tax discounted net cash flow of the project (Daniel *et al.*, 2010; IMF, 2012; Luca and Mesa Puyo, 2016).

[6] ResourceContratcs.org
[7] ResourceContratcs.org
[8] ResourceContratcs.org
[9] Bouterige *et al.*, 2018

2.1. Sample country and period covered

The tax and legal database covers 21 gold producing countries, declared as rich in natural resources, with at least one industrial mine, or with significant proven but not yet industrially exploited resources: Benin, Burkina Faso, Cameroon, Chad, Democratic Republic of Congo, Republic of Congo, Côte d'Ivoire, Gabon, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Tanzania, and Zimbabwe. Some countries with significant resources are not included due to unavailable of data. The period covered by the database varies between 1980 and 2018 depending on the tax information available in each country.[10]

2.2. Models and assumptions for calculating the AETR

Two main models are used in the literature to study the sharing of the mining rent (Smith, 2013; Laporte and de Quatrebarbes, 2015). The discounted cash flow (DCF) model and the modern asset pricing (MAP) model. Both models calculate the net present value (NPV) of a mining project before and after taxation[11]. DCF model has several limitations (Bradley 1998; Daniel et al. 2010; Mackie-Mason 1990; Samis et al. 2007; Smith 2013; Salahor 1998). It requires perfect information of the economic indicators involved in calculating NPV. The risk associated with each stage of the project must be known, which the case is rarely. Most of the time, risk is assumed uniform, which is unrealistic for long-term projects whose risk decreases over time. DCF model also assumes that taxation is neutral in respect of production and investment decisions. Finally, the model does not take account of managerial risk, as suspension or cessation of production before the end of its life cycle (Smith and McCardle 1998). The MAP model is an elementary form of the 'real option value' model, which takes into account, within a stochastic forecasting model, the price dynamics of the mineral and incorporates the interaction between the uncertainty as to price and the risk in terms of the project's value (Brennan and Schwartz,1985 ; Laughton, 1998; Grinblatt and Titman 2002). The main difficulty of the MAP method lies in identifying the right risk profile. Most of the time, only the price is regarded as uncertain, and the costs of the project are considered to be known. Our model to calculate the AETR is a DCF model with a logic close to the

[10] For more details, www.fiscalite-minière.ferdi.fr.
[11] Further developed in Laporte and de Quatrbarbes, 2015.

Fiscal Analysis of Resource Industries Model (FARI) developed by the International Monetary Fund (IMF) (Luca and Mesa Puyo, 2016)[12], or the *Gold Benchmarking Model* developed by the Columbia Center on Sustainable Investment (CCSI).[13]

The sharing of mining rent depends not only on the tax regime but also on the economic structure of the mine and world prices. The diversity of gold mining in the world and in Africa requires the choice of one or more "representative" economic structures of the gold sector. The three "representative mine" structures, characteristic of African gold mines (low, medium and high grade), were retained to test the sensitivity of the mining rent sharing indicator to the economic data used. The economic structure of a mine is characterized by: (i) the life of the mine, (ii) its production potential, (iii) the ore grade of the deposits, (iv) capital costs (CAPEX), and (v) operating costs (OPEX). Total production over the thirteen-year life of the mine is 1.6 million ounces for the low and medium grade and 3.8 million ounces for the high grade. The total average cost (without any taxes) of the three representative mines are $917/oz, $668/oz, and $404/oz, respectively for low, medium an high grade which is within the range of African gold mines. African gold mines mainly have a total cash cost that range from just under $400/oz to over $1100/oz (Gajigo *et al.*, 2012). The world median total cash cost is $749/oz (GFMS, 2015). Detailed economic and technical data for the three representative mines used for calculating the AETR can be found on the FERDI website (Bouterige *et al.*, 2018).[14] The pre-tax discounted net cash flow of the project is then measured as the discounted difference between total revenues and total costs, without the levying of any taxes, for each representative mine.

[12] https://www.imf.org/external/np/fad/fari

[13] http://ccsi.columbia.edu/work/projects/open-fiscal-models

[14] https://ferdi.fr/dl/df-FhQFRVqPgkW7V39yDBzq2yLW/ferdi-b179-a-model-for-sharing-mineral-resource-rent-in-african-countries.pdf

2.3. The tax system used to calculate the mining rent sharing

The tax data used in the discounted cash flow model come from the FERDI database. They are derived from the national laws of each country: Mining Acts, Income Tax Act, annual finance laws, and all other tax laws. Most of these texts have been collected from the websites of government institutions.[15] Each component of the tax data (rate, base, exemption) is associated with its legal reference (reference of the law text and article number), which makes it possible to validate the origin of the information and facilitate additional research, for example, on the understanding of either a taxation or a calculation rule. The database makes it possible to identify the legal tax regime that applies to an industrial gold mine according to public and official information, excluding tax enforcement difficulties and special agreements.

During the investment and operating phases, the model includes eight levies paid by the mining company, including fixed fees, annual ground fees, mining royalties, corporate income tax, turnover minimum tax, withholding taxes on dividends and interest, and the payment of dividends to the State. No tax is due in the year of rehabilitation of the mine (13th year). Of these eight taxation instruments, five concern *production-based taxes* (fixed fees, annual ground fees, mining royalties, turnover minimum tax, and withholding taxes on interest) and the other three concern *profit-based taxes* (corporation income tax, withholding taxes on dividends, and the payment of dividends to the State). Although the turnover minimum tax is often considered as an advance payment of corporation tax, it is definitively levied and taxes the turnover, and therefore production, directly.[16]

[15] Ministries of Mines, Chambers of Mines, Ministries of Finance, General Tax Departments, General Secretariats of Governments, or National Assemblies and Parliaments. Access to national legal texts is very uneven across countries. Although most administrations have set up websites, this does not guarantee either that the texts of laws are available in large numbers or that they are updated regularly. Other sources have also made it possible to obtain legal texts that are not available through these institutions; several tax guides published by audit and accounting firms have made it possible to complete and verify certain information.

[16] The FERDI database presents the taxation modalities for each tax.

Fees are fixed sums payable in return for the granting of mining rights and/or the potential renewal of such rights. Ground fees are due annually, according to the surface area of the mine allocated by the mining right. Mining royalties tax the value of mineral extracted. The tax base for mining royalties varies from country to country. However, the legislative information does not enable precise calculation of the amount due: 'starting pit-head value of the substances extracted, whether exported or not, minus intermediary fees and charges' in Mali, 'total revenue' in Ghana, 'sale price of the product of the final stage of processing' or 'free-on-board (FOB) value of the mineral if it is exported in Mauritania. Therefore, the model uses just two types of tax base: gross turnover and net turnover; that is, turnover excluding refining and sales costs.

Corporate income tax (CIT) applies to the company's taxable earnings. Its precise definition varies according to each country's accounting rules. For the purposes of simplification, the model adopts a unique calculation method: the accounting income is obtained by deducting all accounting costs from the gross turnover. Accounting costs include operational costs, interest charges, depreciation costs, fees, ground fees, and mining royalties. Depreciation costs are calculated in accordance with national legislation (linear, declining balance, exceptional depreciation, or pooling), making a distinction between two categories of fixed asset: industrial buildings and capital goods. Taxable earnings are obtained by subtracting from the accounting income any deferred losses carried over from previous years. In English-speaking countries, there is rarely a time limit on deferments. In French-speaking countries, deductions often have to be made within a limit of between three and five years, and only depreciation costs can be carried forward indefinitely. Therefore, the model draws a distinction between the deferment of 'ordinary' losses (excluding depreciation) and deferred depreciation. This model makes it possible to consider cases where the rules on deferring losses and deferred depreciation influence the payment of corporate income tax. In French-speaking countries, a company's gross turnover is taxed through a minimum tax. This tax is subject to a minimum and, sometimes, a maximum collection threshold. In the model, the amount of tax due as turnover minimum tax is always considered an allowable deduction with regard to the amount of corporate income tax due.

Withholding tax on interests taxes payments made to non-resident creditors. Withholding tax on dividends taxes payments made to non-resident shareholders. The mining company used in the model is a company under local law that only operates a gold mine. Its corporate capital is held entirely by non-resident actors, with the exception of countries where the government requires the company to grant it a share of the capital free of charge. The payment of dividends to non-resident shareholders represents 20% of the annual earnings after tax, rising to 100% of such earnings during the final year of production. Accumulated earnings not paid out during the course of the project are used for either internal financing or extending the mine. Where the State requires the company to transfer a part of its share capital to it free of charge, the part transferred shall take the form of shares with preferential dividends. Consequently, an additional distribution of dividends is made to the State up to the amount of its shareholding. The model does not provide for the case where the State acquires an additional share of the share capital as a payment.

The model also covers country-specific provisions according to legislative information: for example, the annual ground fees in Sierra Leone are replaced by an annual fixed charge according to the legislation. Malian law provides for two mining royalties, one calculated on gross turnover and the other on net turnover. In South Africa, the withholding tax on interest did not exist until 2015. Thus, within the limits of what is possible and the information available, the model comes closer to the legal reality.[17]

Three taxes that can influence the AETR are not taken into account in the model because of the complexity of the tax information needed to calculate them. These are VAT credits not refunded by the tax authorities to mining companies, customs duties levied on imports of capital goods, and fuels and taxes on petroleum products. Nevertheless, this is not really an obstacle to cross-country comparisons as governments apply them in a relatively homogeneous way (including generous exemptions for the last two). This constraint certainly underestimates the share of the rent collected by all the governments.

[17] In some cases, the AETR is calculated despite a lack of information on fixed fees, annual ground fees, or the thin-capitalization ratio, which have only a marginal impact on the indicator.

Although the database specifies the conditions and duration of the stability clauses, the model assumes that the company benefits from a stability clause that guarantees the maintenance of the tax regime in force on the date of obtaining the operating permit throughout the life cycle of the project (bases, rates, benefits, and exemptions granted). In this way, the results obtained reflect the sharing of rent defined by the legislation in force in a country for a given year. On the other hand, the stability clause does not mean that tax rates will remain unchanged throughout the life cycle of the mine. Indeed, the tax regime of a mine is not uniform over the entire duration of a mining project; it evolves according to the progress of the project. Rates may vary from year to year, depending on the period of the title (grant or renewal) and the phase of the project (research, investment, or exploitation).

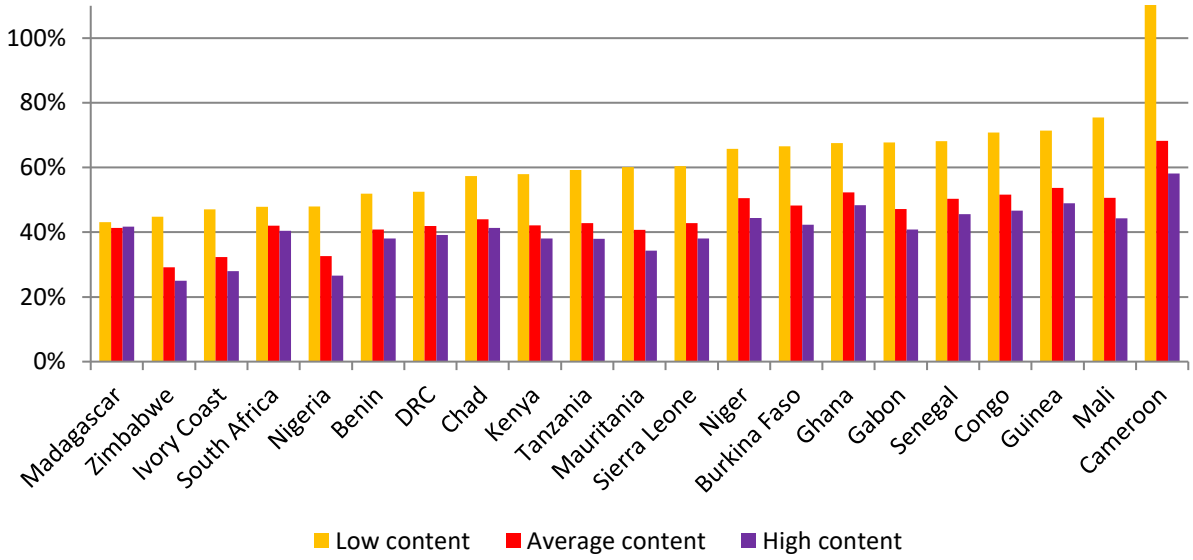
3. Results

3.1. A heterogeneous level of the average effective tax rate

For an initial analysis of the tax systems in force, *ceteris paribus*, the results are based on AETR calculated for the year 2016 and a gold price of $1,200 (representative 2016 price) for the three representative mines. By 2016, most of the countries in the sample had changed their tax systems in response to the surge in world prices over the past decade.

Large disparities appear between countries in the level of AETR. For 2016, the AETRs range from 43% to 111% for the low-grade mine, 41% to 68% for the mid-grade mine, and 42% to 58% for the high-grade mine (Figure 1). This heterogeneity is found on other continents, such as Latin America, with a comparable magnitude (Trench *et al*, 2015). Madagascar, Zimbabwe, and Côte d'Ivoire are among the countries with the lowest AETRs, whereas Cameroon, Mali, and Guinea are among the countries with the highest AETRs. For a low-grade standard mine, the Malagasy AETR is more than two and a half times lower than is the Cameroonian AETR. This last AETR even exceeds 100%. However, it does not mean that the government manages to collect the full rent, but, rather, it means that the tax burden makes the mine economically inoperable for a gold price set at $1,200/oz. This illustrates the significant impact of the tax regime and the price of gold on the profitability of a mining project. Indeed, a typical mine that is economically viable in one country may not be economically viable in another. Similarly, a typical economically viable mine for a given gold price may become loss-making in the event of a fall in prices.

Figure 1. Average effective tax rates by country and representative mines in 2016



Source: Authors. For a discount rate of 10% and a gold price of 1,200$/oz.

The government's share of the rent is much higher when the levies apply to a low-profit mine compared to a medium- or high-profit mine. For all the countries, the gap is sometimes twice as large.

The historical depth of the AETRs provides a long-term view of the successive tax reforms, with different trajectories depending on the country (Laporte *et al.*, 2015). The two main mining rent levies show a contrasting trend: the CIT rate has tended to decline, whereas the royalty rate has increased. Mining CIT rates have risen from 40% in the 1980s to 30% and even 25% in the last ten years, but with a recent increase in some countries (Ghana in 2012, Senegal in 2013, and Burkina Faso in 2015). Mining royalty rates have tended to increase, especially in the last decade or so, with the objective of capturing a larger share of the rent. At the same time, four countries have introduced variable-rate royalties that are supposed to be more appropriate to a change in gold prices for both the government and the investor (Niger since 2006, Burkina Faso in 2011, Mauritania in 2012, and Ivory Coast in 2014).

The other taxation instruments have also seen their application modality change over time. Interests and dividends tax rates have been converging over a long period and tend towards 10% for dividends and 15% for interest. The rent tax, which is supposed to be the tax most likely to collect revenue for the government without influencing investors' decisions, is increasingly less common and has even been

abolished in most countries due to difficulties in its administration. Finally, more and more governments are requiring the operating company to transfer a share of the capital to them free of charge.

With the sharp increase in world gold prices between 2002 and 2012 (multiplied by 5 between 2005 and 2012), all countries reformed their tax regimes to capture a larger share of the significantly increasing mining rent. These reforms took the form of amendments to existing mining Acts and/or a complete revision of them. Between 2002 and 2016, mining legislation was amended between 3 and 7 times, depending on the country. In most cases, these reforms have increased AETRs, mainly through increases in *ad valorem* royalty rates (Burkina Faso, Cameroon, Democratic Republic of Congo, Côte d'Ivoire, Gabon, Kenya, Mali, Mauritania, Senegal, and Zimbabwe), and, more marginally, for some countries in CIT rates (Burkina Faso, Ghana, and Senegal) (Table 1). The year 2010 marks a significant break with the acceleration of reforms in all countries. The average *ad valorem* mining royalty rate increased from 2.19% in 2010 to 5.67% in 2016, whereas the average CIT rate remained constant at 29.6%. Senegal is the most striking example. Though the 2003 Senegalese mining Act was particularly advantageous for investors, the reforms undertaken in 2012 and 2013 resulted in an increase of 53 points in AETRs for the low-grade mine and approximately 25 points for both medium- and high-grade mines. This is due to the introduction in 2012 of a second mining royalty, called the "special contribution on mining and quarry products" (at a rate of 5%), followed by the adoption of the new General Tax Code in 2013, which increases the CIT rate (from 25% to 30%) and removes most exemptions granted to mining concession holders. Similarly, in Ghana, the shift in 2010 from a variable rate mining royalty (between 3% and 6%) to a fixed rate royalty (5%), followed by a 10 percentage point increase in the CIT rate applicable to mining companies in 2012, resulted in a 25 percentage point increase in the AETRs for the low-grade mine and a 10 percentage point increase for both medium- and high-grade mines.

Table 1. Evolution of the corporate income tax rate and the *ad valorem* mining royalty rate between 2010 and 2016

	Corporate Income Tax rate (%)		*Ad valorem* mining royalty rate (%)	
	2010	2016	2010	2016
Benin	25	25	2	2
Burkina Faso	17.5	27.5	3	between 3 and 5
Cameroon	35	30	3	15
Chad	40	35	5	5
Congo	30	30	5	5
DRC	30	30	2,5	3
Ivory Coast	25	25	3	between 3 and 6
Gabon	35	35	6	8
Ghana	25	35	between 3 and 6	5
Guinea	35	30	5	5
Kenya	30	30	2,5	5
Madagascar	between 25 and 40	between 25 and 40	2	2
Mali	35	25	3	8
Mauritania	25	25	4	between 4 and 6.5
Niger	30	30	between 5.5 and 12	between 5.5 and 12
Nigeria	30	30	na	3
Senegal	25	30	3	5
Sierra Leone	30	30	5	5
South Africa	between 28 and 34	between 28 and 34	between 0.5 and 5	between 0.5 and 5
Tanzania	30	30	4	4
Zimbabwe	15	15	3,5	5
	29.60	29.60	4.18	5.67
Mean	6.40	5.09	2.19	3.08

Note: the mean is based on the maximum rate.
Source: FERDI database.

3.2. A structure of the average effective tax rate that varies from country to country

The combination of different tax instruments makes each tax regime unique. The share of each tax instrument in the formation of the AETR gives a first assessment of the importance of each tax in mining tax regimes (Table 2). On average, nearly 85% of the AETR consists of the CIT and the ad valorem mining royalty. Nearly 75% of the AETR depends on *profit-based taxes* whose base is subject to tax optimization by mining companies.

The correlation matrix indicates that there is a real opposition between tax regimes that "favor" mining royalties and those that "favor" CIT. This is reflected in a strong negative correlation between these two instruments in their contribution to the AETR (Table 3).

Table 2. Contribution of each tax instrument to the AETR

	number of obs.	Average	Standard deviation	Minimum	Maximum
Share of mining royalty	5151	25.64%	14.56%	5.94%	99.99%
Share of CIT/minimum tax	5151	59.28%	17.60%	0.00%	92.91%
Share of fixed fees	5151	0.01%	0.02%	0.00%	0.26%
Share of the ground fees	5151	0.63%	2.21%	0.00%	35.13%
Share of interest tax	5151	0.74%	1.12%	0.00%	15.08%
Share of dividends tax	5151	4.72%	2.80%	0.00%	18.34%
Share of State participation	5151	8.99%	9.22%	0.00%	37.39%

Note: All grades and years combined, for prices ranging from $1,000 to $1,800/oz.
Source: authors' calculations based on FERDI database.

Table 3. Matrix of correlations of the contributions of each tax instrument to the AETR

	Share of the mining royalty	Share of the CIT	Share of State participation	Share of dividend tax	Share of interest tax	Share of ground fees	Share of fixed fees
Share of mining royalty	1,000						
Share of CIT/minimum tax	-0,838	1,000					
Share of State participation	-0,034	-0,482	1,000				
Share of dividends tax	-0,150	0,048	-0,110	1,000			
Share of interest tax	0,369	-0,332	-0,084	0,012	1,000		
Share of ground fees	0,231	-0,321	0,067	-0,209	0,043	1,000	
Share of fixed fees	0,332	-0,278	0,042	-0,200	0,127	0,035	1,000

In an attempt to distinguish between different mining tax regimes, a principal component analysis (PCA[18]) was conducted for the three grades and over three periods (9 different situations): (i) For 2009, by using a world price of $1,000/oz; (ii) for 2012, by using a world price of $1600/oz; and (iii) for 2016, by using a world price of $1200/oz. 2009 was one of the last years before the reform phase of the mining tax regimes; the mining tax regimes are those implemented during periods of low prices. The year 2012 is characterized by the peak of the bull cycle of gold prices. The year 2016 is marked both by a gold price that stabilizes at approximately $1,200/oz and by reformed mining tax regimes following the surge in prices. Tables 4 and 5 present the results of the PCA for the medium-grade mine in 2016.

The first two main components summarize around 50% of the information, irrespective of the grade and the year chosen. The first main component is correlated strongly and positively with the CIT's contribution to the AETR and negatively with the mining royalty's contribution to the AETR in the 9 situations studied. Correlations with the second main component vary much more by grade and year. However, the dividend tax's contribution to the AETR, which is positively correlated, is most often opposed to the negatively correlated contributions of fixed fees and/or ground fees. The first component focuses information on activity-based taxes and the second component on capital-based taxes.

Table 4. Eigenvalue and variance explained by the components for the medium-grade mine in 2016

Component	Eigenvalue	Cumulative proportion
1	2.2155	0.32
2	1.4065	0.52
3	1.1587	0.68
4	0.9057	0.81
5	0.8658	0.93
6	0.4476	1
7	0	1

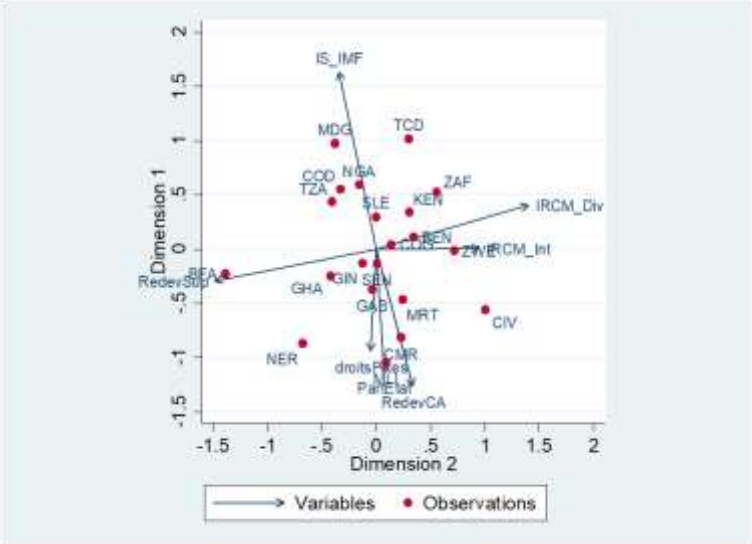
[18] PCA is used to analyze and visualize a dataset containing individuals described by many quantitative variables. This statistical method allows for the exploration of multivariate data. It synthesizes this information into just a few new variables (principal components). These new variables correspond to a linear combination of the original variables.

Table 5. Principal components and original variables for the medium-grade mine in 2016

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6
Share of mining royalty	0.4890	0.1455	-0.4652	0.4279	-0,1578	-0.0697
Share of CIT/minimum tax	-0.6319	-0.1488	0.2363	0.0696	0.1285	0.0448
Share of fixed fees	0.3633	-0.0240	0.5562	0.1160	-0.4697	0.5692
Share of the ground fees	0.1140	-0,6464	-0.2394	-0.0447	0.4684	0.5293
Share of interest tax	-0.0024	0.4117	0.3653	0.4875	0.6676	0.1135
Share of dividends tax	-0.1572	0.6065	-0.3292	-0.4281	0.0198	0.5511
Share of State participation	0.4380	0.0311	0.3452	-0.6130	0.2693	-0.2691

The complexity of mining tax regimes means that there are few similar tax regimes between the countries. If some are close for a given grade and year, they may be further away for another grade or year. The PCA makes it possible to identify the preferred instruments in each country to identify mining tax regimes that would be similar (Figure 2). Two main groups of countries stand out with the first component. Burkina Faso, Mauritania, Senegal (and to a lesser extent Mali) are linked by the importance of the mining royalty in the AETR. Cameroon, Chad, the Democratic Republic of Congo, Kenya, Madagascar, Nigeria, South Africa, and Tanzania are linked by the importance of the CIT. Ivory Coast and, to a lesser extent, Niger have a mining tax regime that differs quite strongly from those of the other countries. These two countries have the particularity of having an exemption from CIT during the operating period, during the first three years for Niger and the first five years for Ivory Coast, to which is added an exemption from the minimum tax during the same period for Niger. They are also among the few countries that apply a progressive mining royalty, based on gold prices for Ivory Coast and mine profitability for Niger. The second component distinguishes between two sub-groups, countries that favour a tax on capital income (interest and dividend withholding taxes) and those that favour a tax on capital (ground fees). However, the correlations of this second component are less stable across time and grades than those of the first component.

Figure 2. Distribution of countries by tax regime for the medium-grade mine in 2016



3.3. Are African mining tax regimes progressive?

Progressivity depends not only on the tax instruments used, their combination, and, in particular, the mix between *profit-based taxes* and *production-based taxes* that defines the tax regime but also on whether a "progressive" component is introduced into the calculation method of each of the tax instruments. The aim here is to "characterize" and compare the progressivity of different tax regimes applied on the African continent. To date, no study has calculated and compared an indicator of the progressivity of mining tax regimes in African countries.

The literature on measuring tax progressivity is old (Slitor, 1948, Musgrave and Thin, 1948, Kakwani, 1977…). Several indicators, more or less complex[19], have been thought of most often based on income tax, which is designed to be progressive in most countries. In accordance with Boadway and Keen (2010), the progressivity of mining tax regimes is assessed by the elasticity from the AETR to the pre-tax net cash flow (PT-NCF)[20], for each of the representative mines, each country, and each tax regime change. In particular, this indicator is consistent with Kakwani's measurement, which links the value of tax elasticity to the tax progressivity. If the elasticity is negative, an increase in the PT-NCF results in a

[19] Siltor's indicator of progressivity is based on the comparison of marginal and average tax rates. For Musgrave and Thin, or Kakwani, the measurements are based on a comparison of indicators of income inequality and taxation.
[20] Pre-tax net cash flow (the Net Present Value before tax) is a proxy of the economic rent.

decrease in the AETR. The tax system is regressive. The progressivity elements of the tax system do not "compensate" for the regressivity of certain taxes. If the elasticity is positive, the tax system is progressive. Table 6 presents the possible values of the progressivity indicator. The elasticity is obtained from the estimation of the following equation:

$$(1)\ lnAETR = blnPTNCF + \varepsilon$$

The value of the AETRs and PT-NCF is the result of a variation in gold prices from $1,000 to $1,800/oz, in increments of $50/oz.

Table 6. The elasticity of the AETR to the pre-tax NCF

Elasticity value	Meaning and intensity of the relationship	Progressivity vs. regressivity
$\varepsilon \leq -1$	The variation in the AETR is either equal to or more than proportional to that of the PT-NCF, and it changes in the opposite direction	"Strong" regressivity of the tax regime
$-1<\varepsilon<0$	The variation in the AETR is less than proportional to that of the PT-NCF , and it changes in the opposite direction	"Low" regressivity of the tax regime
$\varepsilon=0$	The AETR is constant, regardless of the PT-NCF	Neutrality
$0<\varepsilon<+1$	The variation in the AETR is less than proportional to that of the PT-NCF, and it evolves in the same direction	"Low" progressivity of the tax regime
$\varepsilon \geq +1$	The variation in the AETR is either equal to or more than proportional to that of the PT-NCF, and it evolves in the same direction	"Strong" progressivity of the tax regime

The necessary condition for a tax system to be progressive is that the rate of at least one of the *profit-based taxes* must be variable. Consider a simple one-period model with two levies: an *ad valorem* royalty and a CIT. The mining firm pays the royalty at fixed rate “r” on revenues R and a CIT at fixed rate “p” on profit defined as R – C, where C is operating costs. The AETR, assuming the royalty is deductible, is then defined as:

$$(2)\ AETR = \frac{rR + p((1-r)R - C)}{R - C}$$

The derivative of the AETR with respect to R is:

$$(3)\ \frac{\partial AETR}{\partial R} = \frac{(r + p(1-r))(R-C) - (rR + p((1-r)R - C))}{(R-C)^2} = \frac{r(R-C) - rR}{(R-C)^2}$$

$$= \frac{-rC}{(R-C)^2} < 0$$

An increase in revenue increases the PT-NCF, and the AETR falls as the PT-NCF increases. The tax system can only be regressive. However, if the profit tax rate is variable, the "p" is a function of (R-C). The derivative is now:

$$(4)\ \frac{\partial AETR}{\partial R} = \frac{\left(\left(r + p(1-r)\right) + \frac{\partial p}{\partial (R-C)}\left((1-r)R - C\right)\right)(R-C) - (rR + p((1-r)R - C))}{(R-C)^2}$$

$$= \frac{-rC + \frac{\partial p}{\partial (R-C)}\left((1-r)R - C\right))(R-C)}{(R-C)^2}$$

So, the tax system is progressive if:

$$(5)\ rC < \frac{\partial p}{\partial (R-C)}\left((1-r)R - C\right)(R-C)$$

This last condition (equation 5) is not satisfied in any country but some countries are close to it. The estimated elasticities show that all mining tax regimes are regressive over the period studied despite possible differentiation according to the degree of profitability of the mining project (Appendix 1). Tax regimes are regressive for the low-grade mine (elasticity is around -0.5). Low-grade mines have high production costs and, therefore, relatively low profitability. The firm then pays the *ad valorem* royalty from the first unit produced, regardless of the operating results, which reinforces the regressive nature of the tax regime. For medium- and high-grade mines, tax regimes are slightly regressive for all countries (elasticity is between 0 and -0.2).

The tax regime is quasi-neutral for South Africa, over the entire period, regardless of the representative mine. The taxation varies according to the profitability of the mining project: the mining royalty rate varies between 0.5% and 5%, and the CIT rate between 0% and 34%, and both are based on the company's profitability. Madagascar's situation is close to that of South Africa. The mining royalty rate

is fixed but low (2%), and the CIT rate varies between 25% and 40%, depending on the IRR of the mining project. In addition, Burkina Faso, Ivory Coast and Mauritania, which have introduced a progressive royalty, are also approaching neutrality, only with high-grade mines. The progressivity element of these taxes offsets the regressivity elements of the other tax instruments that make up the tax regime.

With the latest reforms implemented over the past decade, the regressivity of tax regimes has increased in almost half of the countries: Cameroon, Chad, Congo-Kinshasa, Gabon, Guinea, Kenya, Mali, Niger, Sierra Leone, South Africa, Tanzania and Zinbabwe. Most of these countries have favored increasing *ad valorem* royalty rates and/or creating new *ad valorem* taxes to increase tax revenue mobilization in the short-term.

4. What are the determinants of tax design?

The mix of *profit-based taxes* and *production-based taxes* aims to maximize the share of the rent captured by the government. Some governments have chosen to favour one or the other or to balance the two types of taxation instruments. In order to explain these choices, we built an indicator of tax design as dependent variable, the share of *production-based taxes* in the AETR. Governments that wish to maximize their income by capturing a large share of the mining rent generally prefer these taxes because the rent is taxed from the first unit extracted. This tax regime then reduces production incentives and taxable rent. We borrow from the literature on tax effort and tax revenue curse of natural resources some independent variables to explain tax design (Crivelli and Gupta, 2014; Bothole et al., 2012, among many others), focusing on institutional variables. The effects of the quality of institutions and of the rent-seeking activities on tax efficiency are well established. They are particularly important in mining activities, which can generate a significant rent. Poor quality institutions lead to inefficiency public policy choices and affect tax collection. High corruption affects confidence in the government and leads to reduced incentives to pay taxes. In this context, the Extractive Industries Transparency Initiative (EITI) aims to mitigate the negative effects of resource abundance by promoting the transparency of resource revenues and accountability of the governments. The literature on the effects of the EITI is recent and results are mitigates. Corrigan (2014) suggests that EITI has no (little) impact on the capacity of the government to formulate and implement sound policies, on the level of rule of law, level of democracy, political stability and corruption. Kasekende et al. (2016) and Papyrakis et al. (2017) find significant reduction of corruption in developing and developed countries. Mawejje (2019) suggests that

EITI membership helps countries to offset the negative impact of natural resource dependence on tax revenues in Sub Saharan African countries. Better institutions could encourage better collective choices, as a tax regime that balances *production-based* taxes and *profit-based* taxes. Institutional variables are Voice and Accountability, Government Effectiveness, Rule of Law (see Kaufmann et al., 2010 for these three institutional indicators) and a dummy variable for EITI member countries (1 if countries are members). The control variables are lagged world price, GDP per capita, Aid as a percentage of GDP, and a dummy for each years. Lagged prices are introduced because the reversal of the commodities cycle generally triggers changes in legislation, particularly when the tax system is not progressive. GDP per capita is a proxy of the level of development. The higher the level of development, the more efficient tax governance is. The aid variable focuses on the effect of ODI partners support on public policy choices. The control variables are taken from World Development Indicators, Worldwide Governance Indicators and Commodity prices databases published by the World Bank. Table 7 presents the descriptive statistics of these variables.

Table 7. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Production-based taxes share	799	0,267	0,137	0,070	0,794
Lagged world price	1071	811,8	476,7	271,0	1668,8
GDP_per_capita	1071	1656,7	2223,9	273,8	10137,5
Aid	1071	7,563	6,662	-0,189	62,187
Voice and Accountability	1008	-0,536	0,617	-1,734	0,746
Government Effectiveness	1008	-0,782	0,488	-1,884	0,729
Rule of Law	1008	-0,795	0,525	-1,905	0,255
Eiti	1071	0,375	0,484	0,000	1,000

The analysis, based on panel methods with random effects, covers a period of 17 years during 2000-2016 for 21 resource rich African countries. The years prior to 2000 have missing data for most of the selected variables and countries. The years selected are only those that present a reform of the tax regime during the year.The results show that mining tax regimes in African countries are built with a short time horizon (Table 8). Each cycle reversal results in tax reforms. The increase in world prices encourages governments to increase *production-based tax*, which captures immediately a larger share of the growing rent. The third cycle of commodities' prices has led to the strengthening of *production-based taxes* in tax design, which, even in innovative forms, have maintained regressive tax regimes. Neither the quality of institutions nor the support of ODI partners changes this choice in mining tax design. One of the reasons is that the two main Ministries in charge of the sector (Mining Ministry and Finance Ministry) are lacking in competences to analyse the economic effects of various taxation instruments, models to simulate their impacts, despite technical assistance that has increased over the last decade. The poor results of ODI partners support can be explained by their difficulty in identifying which structures should receive technical assistance, particularly because agencies and ministries that manage this sector do not really cooperate and often have conflicting objectives. The Ministry of mine wants to develop the sector and believes that low taxation and multiple exemptions are necessary. The Ministry of Finances wants to secure the mobilization of revenue from non-renewable resources. The EITI initiative, by introducing more transparency, could influence the tax design (significant variable in one of the three regression). EITI member countries could adopt tax regimes that lead to fewer tax distortions. This mitigate result was expected, as it is difficult to measure the EITI's impact on development goals, which are outside its

mandate (Rustad et al., 2017). The level of development reduces the share of *production-based taxes* in AETR. One explanation lies in the greater ability of tax administrations of higher level of development to manage less distortive but more risky tax regimes based on *profit-based taxes*.

Table 8. Econometric results

Share of *production-based taxes* in AETR	Low-grade mine	Medium-grade mine	High-grade mine
Lagged World Price	0,0001**	0,0001*	0,0001**
	(-0,0001)	(-0,0001)	(-0,0001)
Gdp per capita	-0,0000**	-0,0000	-0,0000**
	(0,0000)	(0,0000)	(,0000)
Aid as a percentage of GDP	0,0016	0,0013	0,0009
	(0,0018)	(0,0012)	(0,001)
Voice and Accountability	-0,1011	-0,0584	-0,0367
	(-0,0704)	(-0,0575)	(-0,0478)
Government Effectiveness	0,081	0,0493	0,0189
	(0,0642)	(0,0572)	(0,0468)
Rule of Law	0,0313	0,0041	0,0057
	(0,0622)	(0,0493)	(0,0432)
EITI	-0,0362	-0,0526	-0,0579**
	(-0,0397)	(-0,0334)	(-0,0279)
idyears	0,0099*	0,0075*	0,0049
	(0,0059)	(0,0051)	(0,0043)
constant	0,2807***	0,1413***	0,1085***
	(0,0432)	(0,0362)	(0,0346)
Observations	83	83	83
Overall R-square	0,32	0,23	0,12
Hausman test	0,9763	0,9666	0,6095

Notes: Robust estimator of variance ; The coefficients are tabulated; standard errors are in parentheses. *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

5. Conclusion

Extractive industry investment decisions are primarily based on the quality of the resources, as these resources are fixed assets and the price off-take opportunities are clear from market information. The tax regime should therefore not be an important element in the decision making of investors. However, in many cases it is the subject of negotiations with the government to reduce the tax burden. In contrast,

increasing the mobilization of domestic revenues, i.e. maximizing the share of the rent captured by the government, i.e. the AETR, is the main issue addressed to the mining tax design.

In this context, it should also highlight the importance of the progressivity of tax regimes, i.e., their ability to generate an AETR that automatically adapts at least in proportion to the change in the mining rent. The objective is then to reassure investors in times of low world prices and to guarantee a sufficient revenue to the government in times of soaring world prices. Reconciling stakeholders in the sector through a progressive tax regime should reduce (i) the derogations offered to companies and (ii) the interest shown by companies in the stability clause.

As mentioned in this study, the evolution of world prices and the need to mobilize more domestic revenues have led governments to innovate in tax design. Though taxation instruments are relatively standard between countries, the rates, bases, and exemptions, as well as their duration, are specific to each State. Multiple combinations of tax instruments and modalities of taxation are observed, which means that each country has a "specific" tax regime and, therefore, a rather different modality of rent sharing from one country to another.

Analyzing the progressivity of mining tax regimes by studying tax legislation alone is insufficient, and necessarily involves calculating synthetic indicators. We have built an indicator of the progressivity of mining regimes through the calculation of the elasticity of the AETR to the pre-tax internal rate of return. Our results show that all countries have regressive tax regimes. The most recent reforms have even led to a slight increase in the regressivity of tax regimes in almost half of the countries. However, according to Wen (2018) and Conrad (2018), the issue of progressivity is relevant in presence of economic distortions or under certain conditions of information asymmetry to build an “optimal” tax regime. With the new boom cycle of commodity prices, governments should therefore focus reforms of mining tax regimes on the issue of progressivity.

Finally, our results show that good governance and technical assistance have no effect on the choice of tax design. However, the level of development and EITI initiative, by introducing more transparency, could influence these choices and could lead to a reduction in the share of *production-based* taxes in the

AETR. EITI member countries would adopt tax regimes that lead to fewer tax distortions. In contrast with Corigan (2014), our results show that more transparency improves the ability of the government to formulate less distortive policies. The EITI should be seen as a prerequisite for improving the mining tax design to improve domestic revenue mobilization.

These results show that the calibration of a tax regime remains a complex exercise. The balance between *profit-based taxes* and *production-based taxes*, and the choice of taxation methods (proportional or progressive), is poorly controlled by governments of developing countries. These governments would have every interest in appropriating the models at their disposal (IMF FARI, CCSI cash flow models, Ferdi tax database, etc.) to build their tax regimes by simulating the effect of their reform on key indicators.

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Appendix 1: Progressivity indicator: elasticity from AETR to pre-tax NCF

Countries	Mining Act	Low-grade Elastcity	Low-grade P>(t)	Low-grade R^2 adj.	medium-grade Elastcity	medium-grade P>(t)	medium-grade R^2 adj.	High-grade Elastcity	High-grade P>(t)	High-grade R^2 adj.
Benin	2015	-0,560	*	0.90	-0.115	*	0.96	-0.056	*	0.98
Burkina Faso	1998	-0.536	*	0.89	-0.111	*	0.96	-0.054	*	0.98
Burkina Faso	2003	-0,562	*	0.90	-0.127	*	0.97	-0.061	*	0.98
Burkina Faso	2008	-0,579	*	0.91	-0.139	*	0.97	-0.066	*	0.98
Burkina Faso	2011	-0,651	*	0.93	-0.183	*	0.95	-0.051	*	0.74
Burkina Faso	2014	-0,652	*	0.93	-0.187	*	0.95	-0.054	*	0.76
Burkina Faso	2015	-0,614	*	0.92	-0.155	*	0.95	-0.051	*	0.74
Cameroon	2002	-0,572	*	0.90	-0.118	*	0.97	-0.058	*	0.98
Cameroon	2010	-0,553	*	0.89	-0.107	*	0.96	-0.053	*	0.98
Cameroon	2015	-0,767	*	0.95	-0.237	*	0.97	-0.111	*	0.98
Chad	2006	-0,571	*	0.90	-0.103	*	0.94	-0.044	*	0.93
Chad	2015	-0,585	*	0.90	-0.112	*	0.94	-0.048	*	0.93
Congo-Brazaville	2011	-0,617	*	0.62	-0.157	*	0.97	-0.111	*	0.98
Congo-Brazaville	2015	-0,617	*	0.92	-0.156	*	0.97	-0.110	*	0.98
Congo-Kinshasa	2003	0.534	*	0.89	-0.107	*	0.96	-0.077	*	0.98
Congo-Kinshasa	2013	-0.535	*	0.89	-0.107	*	0.96	-0.077	*	0.98
Congo-Kinshasa	2014	-0,562	*	0.90	-0.112	*	0.95	-0.051	*	0.98
Congo-Kinshasa	2015	-0,552	*	0.89	-0.108	*	0.96	-0.051	*	0.98
Congo-Kinshasa	2016	-0.550	*	0.89	-0.109	*	0.96	-0.051	*	0.98
Ivory-Coast	1997	-0,638	*	0.93	-0.195	*	0.97	-0.098	*	0.98
Ivory-Coast	2006	-0,644	*	0.94	-0.205	*	0.97	-0.103	*	0.98
Ivory-Coast	2008	-0,647	*	0.94	-0.207	*	0.97	-0.104	*	0.98
Ivory-Coast	2014	-0,627	*	0.92	-0.146	*	0.85	-0.025	*	0.16
Ivory-Coast	2015	-0,627	*	0.92	-0.146	*	0.85	-0.025	*	0.16
Gabon	2007	-0,607	*	0.92	-0.147	*	0.97	-0.073	*	0.98
Gabon	2009	-0.607	*	0.92	-0.148	*	0.97	-0.073	*	0.98
Gabon	2014	-0,605	*	0.91	-0.150	*	0.97	-0.074	*	0.98
Gabon	2015	-0,641	*	0.94	-0.204	*	0.97	-0.101	*	0.98
Gabon	2016	-0.637	*	0.94	-0.200	*	0.97	-0.099	*	0.98
Ghana	2005	-0.517	*	0.86	-0.032	*	0.85	-0.060	*	0.99
Ghana	2006	-0.552	*	0.88	-0.080	*	0.94	-0.051	*	0.99
Ghana	2007	-0,553	*	0.88	-0.080	*	0.94	-0.051	*	0.99
Ghana	2009	-0.551	*	0.88	-0.079	*	0.94	-0.050	*	0.99
Ghana	2010	-0,615	*	0.92	-0.142	*	0.96	-0.056	*	0.97
Ghana	2011	-0,615	*	0.92	-0.143	*	0.96	-0.056	*	0.97
Ghana	2012	-0.580	*	0.90	-0.113	*	0.96	-0.050	*	0.98
Ghana	2013	-0,587	*	0.90	-0.119	*	0.96	-0.051	*	0.98
Ghana	2016	-0,586	*	0.90	-0.176	*	0.95	-0.050	*	0.98
Guinea	2004	-0,563	*	0.90	-0.129	*	0.97	-0.063	*	0.98
Guinea	2011	-0,565	*	0.90	-0.130	*	0.97	-0.056	*	0.97
Guinea	2012	-0,571	*	0.91	-0.134	*	0.97	-0.050	*	0.98
Guinea	2013	-0,583	*	0.91	-0.215	*	0.96	-0.051	*	0.98
Kenya	2002	-0,561	*	0.89	-0.111	*	0.96	-0.049	*	0.98
Kenya	2010	-0,561	*	0.89	-0.111	*	0.96	-0.049	*	0.98

Kenya	2013	-0.662	*	0.92	-0.156	*	0.96	-0.067	*	0.98
Kenya	2015	-0,627	*	0.92	-0.151	*	0.96	-0.067	*	0.98

			Low-grade			medium-grade			High-grade	
Countries	Mining Act	Elastcity	P>(t)	R^2 adj.	Elastcity	P>(t)	R^2 adj.	Elastcity	P>(t)	R^2 adj.
Madagascar	2004	-0.485	*	0.81	-0.003		0.01	-0.013		0.01
Madagascar	2005	-0.485	*	0.81	-0.003		0.01	-0.013		0.01
Madagascar	2007	-0.485	*	0.81	-0.003		0.01	-0.013		0.01
Madagascar	2007	-0.485	*	0.81	-0.003		0.01	-0.013		0.01
Madagascar	2010	-0.485	*	0.81	0.004		0.01	-0.013		0.01
Madagascar	2011	-0,485	*	0.81	0.004		0.01	-0.013		0.01
Madagascar	2015	-0,485	*	0.81	0.005		0.01	-0.013		0.01
Mali	1991	-0.596	*	0.91	-0.132	*	0.96	-0.062	*	0.98
Mali	1994	-0,631	*	0.92	-0.159	*	0.96	-0.075	*	0.98
Mali	1999	-0,558	*	0.90	-0.117	*	0.97	-0.058	*	0.98
Mali	2007	-0,557	*	0.90	-0.116	*	0.97	-0.058	*	0.98
Mali	2010	-0.550	*	0.89	-0.109	*	0.96	-0.052	*	0.98
Mali	2012	-0,646	*	0.93	-0.168	*	0.95	-0.077	*	0.98
Mali	2013	-0,652	*	0.93	-0.174	*	0.96	-0.081	*	0.98
Mali	2014	-0,687	*	0.94	-0.200	*	0.96	-0.093	*	0.98
Mauritania	2002	-0,652	*	0.93	-0.199	*	0.97	-0.100	*	0.98
Mauritania	2003	-0.657	*	0.93	-0.184	*	0.99	-0.108	*	0.98
Mauritania	2004	-0.657	*	0.93	-0.184	*	0.99	-0.108	*	0.98
Mauritania	2007	-0.650	*	0.92	-0.183	*	0.99	-0.108	*	0.98
Mauritania	2008	-0.690	*	0.95	-0.306	*	0.98	-0.166	*	0.98
Mauritania	2009	-0.642	*	0.94	-0.232	*	0.97	-0.116	*	0.98
Mauritania	2012	-0.633	*	0.93	-0.188	*	0.93	-0.053	*	0.77
Niger	1995	-0.667	*	0.95	-0.226	*	0.97	-0.111	*	0.98
Niger	2006	-0,611	*	0.93	-0.196	*	0.88	-0.142	*	0.98
Niger	2008	-0,610	*	0.93	-0.200	*	0.88	-0.133	*	0.98
Niger	2012	-0,620	*	0.92	-0.202	*	0.83	-0.148	*	0.98
Nigeria	2011	-0,616	*	0.94	-0.284	*	0.98	-0.155	*	0.98
Senegal	2004	-0?640	*	0.93	-0.197	*	0.97	-0.097	*	0.98
Senegal	2006	-0.650	*	0.93	-0.204	*	0.97	-0.101	*	0.98
Senegal	2012	-0,726	*	0.96	-0.295	*	0.98	-0.149	*	0.98
Senegal	2013	-0,646	*	0.93	-0.186	*	0.97	-0.090	*	0.98
Senegal	2014	-0,630	*	0.93	-0.175	*	0.97	-0.085	*	0.98
Senegal	2015	-0.615	*	0.92	-0.164	*	0.97	-0.080	*	0.98
Senegal	2016	-0.598	*	0.92	-0.152	*	0.97	-0.074	*	0.98
Sierra Leone	2010	-0.660	*	0.92	-0.170	*	0.96	-0.070	*	0.98
Sierra Leone	2013	-0,646	*	0.93	-0.179	*	0.97	-0.082	*	0.98
Sierra Leone	2016	-0,666	*	0.92	-0.170	*	0.96	-0.070	*	0.98
South Africa	2009	-0.438	*	0.83	-0.049	*	0.97	-0.046	*	0.98
South Africa	2012	-0.439	*	0.83	-0.050	*	0.97	-0.046	*	0.98
South Africa	2015	-0.469	*	0.84	-0.064	*	0.97	-0.053	*	0.98
Tanzania	2004	-0,570	*	0.91	-0.136	*	0.97	-0.066	*	0.98
Tanzania	2010	-0.599	*	0.92	-0.157	*	0.97	-0.076	*	0.98
Tanzania	2012	-0,615	*	0.92	-0.173	*	0.97	-0.082	*	0.98
Zimbabwe	2004	-0.654	*	0.93	-0.181	*	0.96	-0.082	*	0.98
Zimbabwe	2009	-0.628	*	0.92	-0.155	*	0.96	-0.066	*	0.98
Zimbabwe	2010	-0.651	*	0.93	-0.176	*	0.96	-0.076	*	0.98

Zimbabwe	2012	-0.725	*	0.96	-0.259	*	0.97	-0.119	*	0.98
Zimbabwe	2015	-0.690	*	0.94	-0.216	*	0.97	-0.096	*	0.98
Mean**		-0,594			-0,157			-0,076		
standard **deviation		0,135			0,051			0,029		

Note: *significant at the 1% threshold. The year refers to the change in legislation. **without Madagascar.