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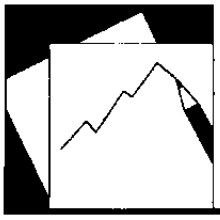

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Diamond Smuggling and Taxation in Sub-Saharan Africa

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Diamond Smuggling and Taxation in Sub-Saharan Africa

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Abstract

This paper provides an overview of diamond mining in sub-Saharan African countries, and explores the reasons for substantial differences in their tax rates and fiscal revenues from the sector, which mainly arise from differences in the incentives for smuggling. In a theoretical model, we show that optimal diamond tax rates increase with the degree of competition among diamond buyers, as well as with the corporate share of diamond production, which is confirmed by the data. We then discuss policies to increase revenue, including by enhancing mining productivity, stimulating the exploration of new areas, reducing barriers to entry, and attracting investment into value-adding downstream operations.

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I. INTRODUCTION

Diamond mining is an important economic activity in many sub-Saharan African (SSA) countries. It often represents some 10 percent of national GDP and in several cases about 50 percent or more of total exports. This paper provides an overview of SSA diamond mining, and explores the reasons for the substantial differences in tax rates and fiscal revenues observed in these countries, which we attribute mainly to differences in the incentives for smuggling. While the focus of the paper is on sub-Saharan Africa, most of its analysis applies equally to other diamond-exporting countries.

The appropriate tax regime for diamonds and the ensuing fiscal revenue depend importantly on the sector's industrial organization, which in turn is largely determined by the nature of diamond deposits (kimberlite/primary or alluvial/secondary). In countries with so-called kimberlite diamond deposits (e.g., Botswana and South Africa), diamonds are concentrated in a small area, which allows for large-scale corporate diamond production. In these countries, fiscal revenue derives mainly from corporate income taxes (and dividends to state-owned equity holdings), and is generally high, amounting to as much as 46 percent of the estimated production value in Botswana.

In contrast, corporate diamond production is difficult or unprofitable in countries with so-called alluvial diamond deposits (e.g., Angola, Guinea, Liberia, Sierra Leone, and the Central African Republic), where diamonds are spread out over a large surface. In such diamond sectors, production is typically carried out by small-scale independent artisanal miners, whose incomes are difficult to monitor. Tax regimes therefore tend to be built around export levies, the fiscal revenue from which generally remains low—at levels below 5 percent of the estimated value of diamond production.

The substantial differences in fiscal revenue from diamond sectors are, to an important extent, the result of equally large differences in tax rates. Countries with kimberlite deposits and corporate production apply tax rates of about 10 percent, while the tax rates applied by countries with alluvial deposits and artisanal production are generally on the order of about 3 percent. This paper aims to explain these differences in tax rates, and suggests that they stem from the fact that countries with artisanal production face significantly larger incentives for smuggling than countries with corporate production.

Although incentives for smuggling are always present (due to the fact that diamonds are very small and have an unusually high value per weight unit), they are expected to be larger in countries with artisanal production for two reasons. First, artisanal mining typically takes place in areas that are large, insecure, and difficult to control, which makes it more difficult to detect smuggling. Second, artisanal mining is often associated with limited competition between diamond buyers, due to barriers to entry and implicit contracts, which gives rise to uncompetitive domestic prices, thus increasing the benefits of smuggling.

The paper is organized in seven sections. Section II provides an overview of diamond mining operations throughout SSA countries. Section III then briefly discusses the economic principles underlying taxation of nonrenewable resources, and relates this to the variety of tax regimes applied to diamond mining activities in SSA countries. Incentives for tax evasion

are discussed in Section IV, and are incorporated into a model of diamond smuggling and optimal taxation, which is presented in Section V. In this model, a government chooses the diamond tax rate and an enforcement rate (i.e., the probability of detecting a smuggler) in order to maximize fiscal revenue from diamonds, while taking into account the effect that tax rates and enforcements rates have on the incentives for smuggling.

The analysis shows that the optimal tax rate is lower for countries where diamond sectors are more artisanal in nature, and is higher for countries with a higher degree of competition between diamond buyers. Based on the results of the model, Section VI suggests and analyzes reform options to generate higher domestic fiscal revenue, including by increasing diamond mining productivity through support for the establishment of mining cooperatives; increasing competition among diamond buyers; developing attractive legal, institutional, and fiscal frameworks to encourage the exploration of new areas; and attracting downstream activities with considerable value-added to the mining countries, such as diamond cutting and polishing. Section VII summarizes and draws conclusions.

II. An Overview of Diamond Production in Sub-Saharan Africa

SSA diamonds are generally of high quality, and most of them are jewelry diamonds. The total value of rough (uncut) diamond production in SSA was estimated at some US$5.2 billion in 2001, corresponding to a share of about 57 percent of worldwide production in terms of weight, and a share of 68 percent in terms of value.[2] Table 1 provides an overview of diamond production in selected SSA countries. The wide range of prices for African diamonds indicates that not all stones are of jewel quality: the average price per carat ranges from about US$25 for diamonds from the Democratic Republic of the Congo (D.R.C.) to US$215 for diamonds found in Namibia.

The diamond mining industry makes a major contribution to GDP and exports in many SSA countries.[3] Diamond production amounts to roughly 10 percent of GDP in Sierra Leone, Namibia, the Democratic Republic of the Congo, the Central African Republic (C.A.R.) and Angola, and to about 4 percent in Guinea. Diamonds have by far the biggest impact on the national economy in Botswana, where production accounts for about 42 percent of GDP (Table 1). Official exports of diamonds in percent of total exports were recorded at 7 percent in Guinea, 9 percent in Angola and Sierra Leone, 32 percent in Namibia, 46 percent in the

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[2] Terraconsult (2002). We ignore exports of cut or polished diamonds, since virtually all SSA diamonds are exported in uncut form. Appendix I reports diamond mining data from the 13 largest producers among all 44 SSA countries. Other SSA countries have only minor or no diamond mining operations.

[3] These estimates only account for the market value of mined uncut diamonds and not the total contribution of the diamond mining sector to economic output.

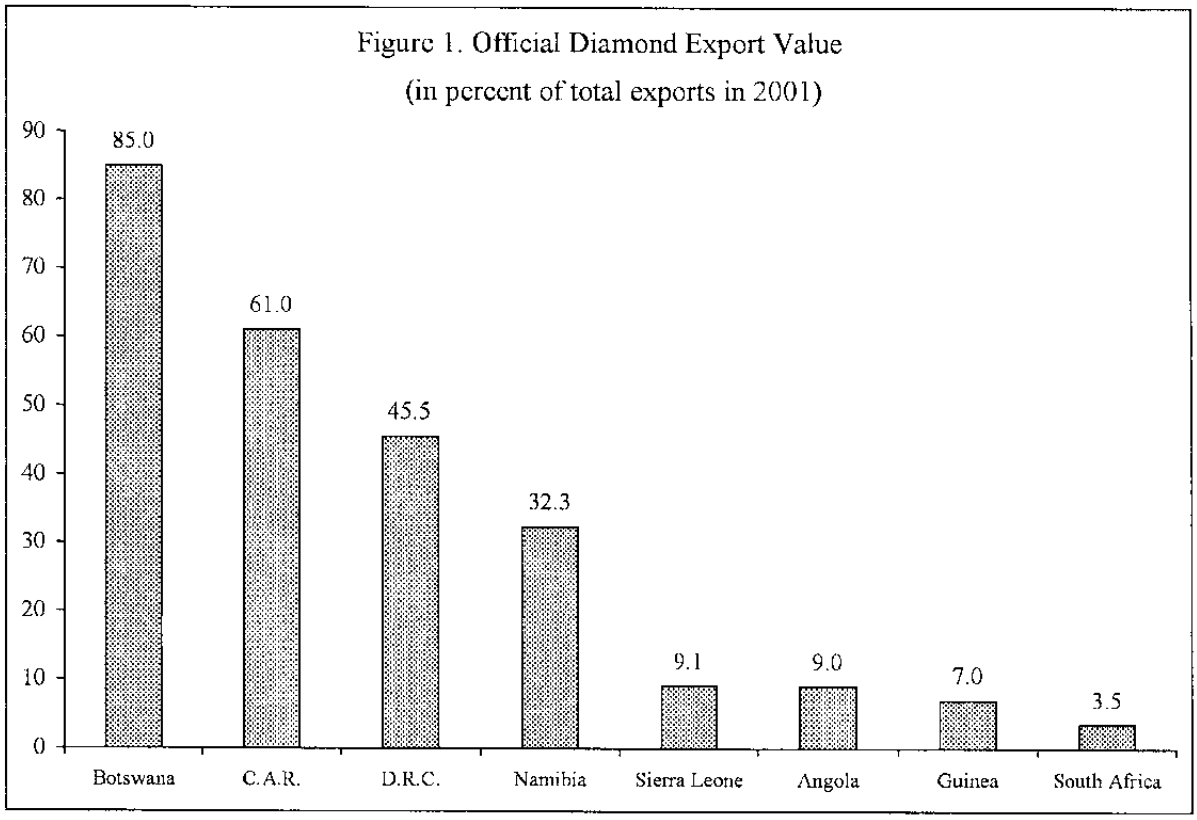
Democratic Republic of the Congo, 61 percent in the Central African Republic, and 85 percent in Botswana (Figure 1). [4]

Table 1. Volumes, Values, and Average Prices of Uncut Diamond Production in Selected Sub-Saharan African Countries in 2001, Based on Expert Estimates

	Volume (In million carats)	Average Price (In US$)	Value (In million US$)	Share of official GDP (In percent)
Angola	5.9	137	803	8.5
Botswana	26.4	83	2,194	41.9
Central African Republic	0.6	150	92	9.5
Democratic Republic of the Congo	19.6	25	496	11.1
Guinea	0.8	170	128	4.3
Liberia	0.2	150	23	0.6
Namibia	1.5	215	322	10.2
Sierra Leone	0.4	180	68	9.5
South Africa	11.3	101	1,145	1.0
Other SSA countries	0.8	75	60	...
Total SSA countries	67.5	79	5,331	...
Total world	118.7	66	7,885	...

Source: Terraconsult, 2002; and IMF staff estimates.

[4] The higher costs involved in mining alluvial deposits raise the question of whether the production value—considered without reference to mining costs—is a valid indicator for the sector's economic importance. For instance, using the share of production value in GDP, highly profitable mines like Botswana's Jwaneng mine, where the operating profit after all mine costs approaches 90 percent, make diamond mining appear economically even more important than in Namibia, where the mining costs are much higher.



Sources: Terraconsult, 2002; and IMF, International Financial Statistics.

As Table 2 shows, the nature of a country's diamond deposits (kimberlite or alluvial) partly explains the extent to which production is corporate or artisanal in nature. Kimberlite deposits, on the one hand, are concentrated in volcanically derived, cone-shaped pipes, which allows for diamond production by large-scale corporations that use highly mechanized mining technology on sites that are well fenced and have tight security. Alluvial deposits, on the other hand, consist of diamonds that have been released from eroded kimberlite pipes and may have been transported by river systems over long distances. They are found on the floors and banks of ancient and contemporary rivers, and are spread out over extended areas that cannot be fenced off, which makes corporate production impossible or unprofitable. Nevertheless, these areas are still exploited by independently operating artisanal miners,[5] who either work by hand or use rudimentary equipment, such as picks, shovels, primitive pumps, and sieves.[6] They sell their diamonds to intermediate diamond traders (sometimes

[5] Artisanal miners (called "artisans" in most francophone countries, and "garimpeiros" in Angola) may also employ groups of manual workers for a wage (or in-kind payments) in order to do the actual mining work.

[6] These miners are often among the poorest groups in the country, which may seem surprising given the high value of diamonds. However, to the extent that almost anyone can

Table 2. The Diamond Sector in Selected Sub-Saharan African Countries in 2000

Country	Type of Deposits	Diamond Quality (Percent Distribution)		Diamond Production (Percent Distribution)		Official Export Value (In percent of total exports)
		Gem	Non-gem	Corporate	Artisanal	
Angola	Kimberlite and alluvial deposits	87	13	34	66	9.0
Botswana	Kimberlite deposits	73	27	100	0	85.0
Central African Republic	Alluvial deposits	64	36	0	100	61.0
Democratic Republic of the Congo	Kimberlite and alluvial deposits	13	87	30	70	45.5
Guinea	Kimberlite and alluvial deposits	80	20	21	79	7.0
Liberia	Alluvial deposits	40	60	0	100	2.0
Namibia	Kimberlite and alluvial deposits	98	2	100	0	32.3
Sierra Leone	Alluvial deposits	62	38	0	100	9.1
South Africa	Kimberlite and Alluvial deposits	>70	<30	100	0	3.5

Sources: Country authorities; Terraconsult, 2002; and IMF staff estimates.

referred to as "collectors"), who eventually sell them to an export company, if they do not smuggle them abroad.

III. Diamond Tax Regimes in Sub-Saharan African Countries

While no specific literature on diamond taxation exists, the more general literature on taxation of nonrenewable resources suggests that the economic rent associated with such resources justifies a separate fiscal regime.[7] The economic rent represents the difference

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mine alluvial diamonds, it is to be expected that the number of miners in a country with alluvial deposits will grow as long as the expected revenues from diamond mining are higher than what can be earned in other sectors (the "reservation wage"). The fact that the average earnings of alluvial miners are, in fact, often lower than those in other sectors suggests that these agents are risk-searching, and prefer to mine alluvial diamonds as long as there is a positive probability of finding a big stone and striking it rich one day.

[7] E.g., Baunsgaard (2001).

between the market price of the resource and its opportunity cost.[8] Since a redistribution of the entire rent from the owner of the resources to the government would not influence production decisions, taxation of rents from nonrenewable resources represents, in principle, no distortion of the economic allocation.

However, the high degree of uncertainty associated with the extraction of most nonrenewable resources increases the supply price of investment through a higher risk premium.[9] This risk premium needs to be taken into account in the design of the fiscal regime applied to economic rents from nonrenewable resources. For example, while most countries apply their standard corporate income tax regime to projects of nonrenewable resource extraction, tax rates are sometimes higher for these projects in order to capture the economic rent.

Diamond tax regimes can be either profit-based (e.g., corporate income taxes) or production-based (e.g., export levies or royalties).[10] Although corporate profits may not be a good measure of economic rent, profit-based taxation generally has the advantage of being less distortionary than production-based taxation. However, since profit-based taxes require a corporate structure of the industry to be enforceable, SSA countries with a low degree of corporate organization typically have no choice but to resort to production-based taxation, such as export taxes. Moreover, even countries with significant corporate diamond production may choose to combine profit-based taxes with production-based royalties, which have the advantage of creating a stream of fiscal revenue as soon as production starts. For example, Angola, Botswana, and Namibia complement corporate income taxes with export levies or royalties, most likely in order to generate some fiscal revenue upfront (Table 3).

The appropriate tax regime for the diamond sector thus depends largely on the degree of corporate organization, which in turn depends on the nature of diamond deposits. Corporate income taxes, for example, dominate in Botswana, Namibia, and South Africa, where kimberlite deposits are predominant and virtually all production is in the hands of diamond mining companies. Similarly, production-based taxes (in particular export levies) dominate in countries where diamond deposits are mainly alluvial, and where production is largely in the hands of individual artisanal miners, whose incomes are virtually impossible to verify.

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[8] While there are private and social opportunity costs, only private opportunity costs matter for the investment decision, unless social costs are internalized.

[9] This uncertainty stems from geological, commercial, political (security, nationalization, etc.) risks associated with many investment projects targeting the extraction of nonrenewable resources.

[10] Fiscal regimes applied to the extraction of nonrenewable resources in general have typically evolved over the past decades from royalty-based tax systems into indirect tax regimes that attempt to encourage investment and maximize total gains for the domestic economy. State equity, production sharing arrangements, and fixed fees (e.g., license fees) represent other widely used means to generate fiscal revenue from the mining sector, although production sharing arrangements are generally not used for diamond mining (with the exception of a few former Soviet Union republics).

While export levies and royalties are different forms of production-based taxation, they are mostly equivalent in practice, since the difficulty of diamond valuation implies that royalties are often best collected on the official export value.[11] Moreover, since virtually all production is exported, the distinction between diamond production and diamond exports is negligible. Tax rates, however, do vary considerably between countries: from 0.75 percent in the D.R.C. (applied to artisanal miners) to 10 percent in Botswana Namibia (Table 3). These differences in tax rates gives rise to large differences in fiscal revenue from diamonds, which are discussed in the next section.

IV. Incentives for Tax Evasion

For SSA countries that rely on artisanal diamond mining from alluvial deposits, government revenue from diamonds tends to be low.[12] For example, Table 3 shows that diamond sector revenue amounted to 3.7 percent of the estimated value of production in the Central African Republic; to about 1.2 percent in Guinea; and to a mere 0.75 percent in Sierra Leone.

One of the main reasons for the low fiscal revenue from alluvial diamond mining is the fact that tax evasion is relatively easy, implying that tax rates need to be set at sufficiently low rates. An indication that significant tax evasion takes place is the fact that large differences exist, in several countries, between expert estimates of diamond production (based on recorded diamond imports) and officially recorded diamond exports.[13] These discrepancies between import and export-based data exist for all diamond exporting countries, but are especially common and large in countries with mostly artisanal production out of alluvial deposits.

Tax evasion can take place either by underreporting the export value of diamonds, or by smuggling diamonds abroad. Incentives to evade taxes by means of undervaluation arise from two main sources. First, diamond valuation is more difficult than the valuation of most other minerals, which makes it difficult to detect undervaluation. Second, the salaries of

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[11] Royalties, which can be regarded as factor payments for the right to extract nonrenewable resources, can be based on either the volume or value of production. In practice, large differences in prices per weight make the case for royalties to be based on production value.

[12] Even when alluvial deposits are mined by corporations, profit-to-revenue ratios of less than 50 percent in alluvial mining inevitably generate lower tax revenue from the sector.

[13] However, not the entire difference between import-based and export-based estimates can be attributed to tax evasion, since the country of origin is not always truthfully reported at the point of import. In particular, it is likely that "conflict diamonds" from countries such as Angola and the Democratic Republic of the Congo have been "laundered" through other countries, such as the Central African Republic (Dietrich, 2003; Doyle, 2003). This could explain why the volume of imported C.A.R. diamonds was much higher than reported C.A.R. diamond exports, particularly between 1998 and 2000 (IMF, 2003).

Table 3. Diamond Sector Taxation in Selected Sub-Saharan African Countries

Country	Corporate Production (In percent of total)	Current Fiscal Regime	Fiscal Revenue (In percent of estimated value of production) [1]	Fiscal Revenue (In percent of total fiscal revenue) [2]
C.A.R.	0	Export levy of 6 percent	3.7	4.0
Liberia	0	Export levy of 4 percent Turnover tax of 4 percent	...	...
Sierra Leone	0	Export levy of 2.5 percent or Royalty of 5 percent	< 0.8	< 0.6
Guinea	21	Export levy of 3 percent Government share of 15 percent in new companies	1.2	0.4
D.R.C.	30	Export levy: 0.75 percent for artisanal miners 3 percent for mining companies	...	...
Angola	50	Industrial income tax of 35 percent Royalty of 5 percent Export levy of 3.5 percent	...	...
Botswana	100	Royalty of 10 percent Corporate income tax of 25 percent	74.8	74.1
Namibia	100	Export levy of 10 percent Corporate income tax of 55 percent	23.1	7.4
South Africa	100	Royalty of 8 percent Corporate income tax of 30 percent	>10.0	<5.0

[1] For 2001 for the C.A.R. and for 2000 for all other countries.
[2] For 2000 for Sierra Leone and for 2001 for all other countries.

Sources: Country authorities; IMF staff estimates, and Terraconsult, 2002.

official valuators tend to be low compared with the size of the profit to be shared. Official valuators are thus prone to accepting offers for underreporting the export value of diamonds in exchange for part of the export tax savings. According to the Diamond High Council (HRD) in Antwerp, undervaluation has been particularly a problem in the Central African Republic and the D.R.C.[14]

Incentives to evade taxes by means of smuggling are higher for diamonds than for other commodities, because of lower risk and higher payoffs. The risk associated with the smuggling of diamonds is lower because (1) diamonds are small, which makes them easy to

[14] For more on undervaluation in the C.A.R., see IMF (2003).

carry and easy to conceal; (2) the origin of diamonds cannot be easily determined, especially when diamonds from different areas are mixed (Goreux, 2001, p. 9); and (3) diamond-mining areas are often large, insecure, and difficult to control. The payoffs from smuggling are also higher for diamonds than for other commodities, because diamonds have one of the highest values per unit of weight, so that even at a low tax rate, the expected benefits from smuggling a diamond can be considerable.

An additional reason why payoffs from diamond smuggling may be high is that exporters' domestic purchasing prices (i.e., the prices at which export companies buy their diamonds in the exporting country) can be significantly below international market prices. This occurs when competition between diamond buyers is limited by explicit barriers to entry[15] or implicit contracting between diamond sellers and buyers. Implicit contracting typically arises because artisanal diamond miners have highly irregular earnings (they can go for weeks or months without finding a diamond), and are therefore in need of financing to "insure" themselves against bad times. Since diamond miners are typically unable to borrow through the conventional banking system, their financing needs are often met by diamond traders, who provide them with advance payments (either in kind and in cash) in return for the exclusive right to buy their diamonds. Diamond traders, in turn, often have similar implicit contracts with export companies. These implicit contracts limit competition, and allow export companies to purchase at prices below the international market price, which constitutes an important incentive to smuggle.[16]

V. A Model of Diamond Smuggling and Optimal Taxation

In this section, we develop a model of diamond smuggling and optimal taxation. We assume that governments choose the diamond tax rate and the enforcement rate (i.e., the rate at which diamond smugglers are caught) so as to maximize total revenue from diamonds, while taking into account the effect that tax rates and enforcement rates have on the rate at which diamonds are smuggled.[17] It is shown that the optimal tax rate is lower for countries where diamond sectors are less corporate and more artisanal in nature, while both the optimal tax rate and the optimal enforcement rate are higher in countries with a higher degree of competition between diamond buyers (resulting in a smaller difference between domestic and world diamond prices). The government is assumed to maximize revenue over short time

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[15] This is particularly the case in the Central African Republic, where diamond export companies wishing to set up a purchasing bureau face significant start-up costs: (1) a license fee of CFAF 5 million (US$8,000); (2) a guarantee of CFAF 100 million (US$160,000) to be deposited in a trust fund (*fonds de garantie*) for 5 years; and (3) an additional deposit of CFAF 100 million (US$160,000) in a reserve fund to guarantee their solvency (IMF, 2003).

[16] For more on this issue, see IMF (2003).

[17] The model does not take into account the choice to evade taxes by means of undervaluing diamonds, the opportunities for which are expected to decline significantly with recent international regulation adopted under the Kimberley Process.

horizons, and therefore takes output and prices as given. However, as will be argued in the next section, total revenue can be increased in the longer run by raising total output (through increases in productivity or exploration of new areas) and by stimulating competition between diamond buyers, which would lower the difference between domestic and world market prices.

A. Diamond Sellers

Diamond sellers can be either individual miners or traders (in the case of artisanal mining) or companies (in the case of corporate mining). As noted in the previous section, a diamond seller's incentives to smuggle derive from two sources: (1) the tax rate t; and (2) the extent to which the official domestic price p falls below the world market price p^*, which depends on the degree of competition between diamond buyers.[18]

The risk associated with smuggling depends on the enforcement rate e, which we interpret as the probability that a diamond smuggler is caught. We assume that, if smugglers get caught, the diamonds will be confiscated by the government.[19]

For simplicity, we assume that all diamonds are of equal weight, which is normalized to one carat, so that the prices per diamond equal the per carat prices p and p^*. Let the payoff from smuggling a diamond be denoted by u_0, and the payoff from legally exporting a diamond by u_1. We can then write:

Payoff from smuggling: $u_0 = (1-e)p^*$

Payoff from not smuggling: $u_1 = (1-t)p$

That is, a smuggler is able to obtain the world market price p^* with probability $(1-e)$, but has probability e of being caught, in which case the payoff is zero. An honest diamond seller receives the domestic price p and pays a tax rate t, so the after-tax payoff is $(1-t)p$. Note that these payoffs are gross payoffs, in the sense that they do not account for the seller's costs of obtaining the diamonds, which include the price paid for the diamonds as well as possible in-kind payments made to artisanal miners. However, these costs are the same regardless of whether or not a seller decides to smuggle, and therefore do not affect the relative payoffs, which is what we are interested in.

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[18] The world market price p^* should be interpreted as the price that diamond sellers would be able to obtain if they were able to sell their diamonds at the international market. This is not necessarily a perfectly competitive price, to the extent that competition at the international level is also not fully competitive. However, since domestic barriers to entry imply that there is even less competition at the domestic level, it seems likely that $p^*>p$.

[19] In addition, there may be other penalties for smuggling that impose costs on smugglers, such as imprisonment, which are not built into the model.

Let $x \equiv u_1 - u_0 = (1-t)p - (1-e)p^*$ denote the relative payoff from not smuggling, and let $y = f(x)$ denote the probability that a diamond seller legally exports diamonds, with $y' \equiv f'(x) \geq 0$. If all diamond traders are homogeneous and have the same payoff function, this gives:

$$y = \begin{cases} 0 & \text{if } x < 0 \\ \in [0,1] & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases}.$$

That is, for $x<0$, all diamonds are smuggled, while for $x>0$, no diamonds are smuggled. Clearly, this "corner solution" does not seem realistic. In order to obtain more realistic behavior, we have to account for heterogeneity among sellers. This can be done by rewriting the individual utilities of smuggling and not smuggling as:

$$u_{0,i} = (1-e)\,p^* + \lambda\varepsilon_{0,i}$$
$$u_{1,i} = (1-t)p + \lambda\varepsilon_{1,i},$$

where $\varepsilon_{0,i}$ and $\varepsilon_{1,i}$ are unobserved variables affecting trader i's preferences for smuggling and not smuggling, respectively.[20] The parameter λ measures the extent to which sellers' preferences are affected by idiosyncratic differences. Alternatively, λ can be interpreted as a measure of the strength of heterogeneity, since the amount of heterogeneity increases with λ.

The probability that seller i will not smuggle diamonds can now be denoted as:

$$\begin{aligned} y_i &= \Pr\{u_{0,i} < u_{1,i}\} \\ &= \Pr\{(1-e)\,p^* + \lambda\varepsilon_{0,i} < (1-t)p + \lambda\varepsilon_{1,i}\} \\ &= \Pr\{\varepsilon_{1,i} - \varepsilon_{0,i} > -\beta x\}, \end{aligned}$$

where $\beta = \dfrac{1}{\lambda}$.

A common assumption in the discrete choice literature is that $\varepsilon_{0,i}$ *and* $\varepsilon_{1,i}$ are i.i.d. across i and t, and are extreme-value distributed, so that $\varepsilon_{1,i} - \varepsilon_{0,i}$ is logistically distributed. This gives as the average proportion of "honest" sellers:

$$y = f(x) = \left(1 + \exp\{-\beta x\}\right)^{-1}.$$

This functional form satisfies $y' \equiv f'(x) > 0$, and exhibits realistic limiting behavior:

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[20] Such unobserved variables could include, for example, moral values, experience, or connections.

$$\lim_{\beta\to\infty} y = \begin{cases} 0 & \text{if } x < 0 \\ 0.5 & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases}.$$

Moreover, $f(x)$ has the useful property that $y' = \beta y(1-y)$.

B. Government

The government chooses a combination of a tax rate t and an enforcement rate e so as to maximize tax revenue $R(e,t)$, while taking the behavior of diamond sellers as given. This gives the following maximization problem:

$$(0.1) \qquad \max_{e,t} \; R(s,t) = p^* q\left(ty + e(1-y)\right) - c(e,q)$$
$$\text{s.t.} \quad y = \left(1+\exp\{-\beta x\}\right)^{-1},$$

where q is the country's total annual output of diamonds, which is treated as fixed,[21] and $c(e,q)$ is the cost of establishing a certain enforcement rate e given annual output q. The fraction $e(1-y)$ of confiscated smuggled diamonds is assumed to be sold by the government at the international price p^* which, henceforth, will be normalized to unity (i.e., $p^*=1$).

The cost of maintaining a given enforcement rate, $c(e,q)$, depends not only on the volume of diamonds, but also on the number of diamond sellers that need to be monitored. The number of sellers is determined by the industrial organization of the sector, which in turn is a function of the nature of diamond deposits.[22] In particular, the number of sellers is large when diamond mining is predominantly artisanal, but declines under corporate diamond mining due to economies of scale.

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[21] The annual output of diamonds (q) is determined by the total volume of deposits in the country, which is fixed, as well as by geological properties, such as the speed of erosion, which determines how many new deposits can be mined every year.

[22] As noted before, the share of corporate mining is closely related to the nature of diamond deposits, with a low corporate mining share suggesting alluvial deposits, and a high corporate mining share suggesting kimberlite deposits. A notable exception to this is Namibia, which has a high corporate mining share while its diamond deposits are mostly of a marine alluvial nature. However, the exploration of these particular alluvial deposits requires specialized offshore mining equipment that can only be provided by large corporations. While the share of corporate mining operations is also related to the overall security level in mining regions and the country as a whole, security in turn is also a function of the density of deposits.

In order to capture this idea, we assume that $c(e,q) = qkc(e)$, where $c(e)$ is the average enforcement cost of inspecting a diamond seller, and k represents the share of corporate mining, which we interpret as a proxy for the number of sellers per diamond. Thus, the enforcement cost of inspecting a given amount of diamonds is lower in countries with a larger share of corporate mining k, since the amount of diamonds per seller is higher in these countries (i.e., the number of sellers per diamonds is lower).

Finally, we assume that $c'(e)>0$ and $c''(e) > 0$, i.e., the cost of inspecting one diamond seller is increasing in the desired enforcement rate (i.e., the desired probability of detecting a smuggler), and the marginal cost of an increase in e is itself increasing in e. This captures the notion that, the higher the enforcement rate a government aims to establish, the more prohibitive the cost becomes, i.e., it would be very costly to eliminate all smuggling by maintaining an enforcement rate of 100 percent.

C. Model Solution and Implications

The first-order conditions to the government's problem are:

$$(0.2) \quad \frac{\partial R}{\partial t} = q(y + (t-e)y'p) = 0$$

$$(t-e)y'p = y$$

$$(0.3) \quad \frac{\partial R}{\partial e} = q((t-e)y' - y + 1) = qkc'(e)$$

$$(t-e)y' + 1 - y = kc'(e)$$

Substituting (0.2) into (0.3) twice, and using the fact that $y' = f'(x) = \beta y(1-y)$, we obtain a relationship between t and e that holds for any solution to the government revenue maximization problem:

$$(0.4) \quad t = e + \left(\beta p \left[1 - \left(\frac{p}{1-p} \right) \left(kc'(e) - 1 \right) \right] \right)^{-1},$$

which satisfies $\frac{\delta t}{\delta e} > 0, \frac{\delta t}{\delta p} < 0, \frac{\delta t}{\delta k} > 0.$

Using the fact that $\ln\left(\frac{y}{1-y}\right) = \beta x$, we can derive a second relationship between t and e:

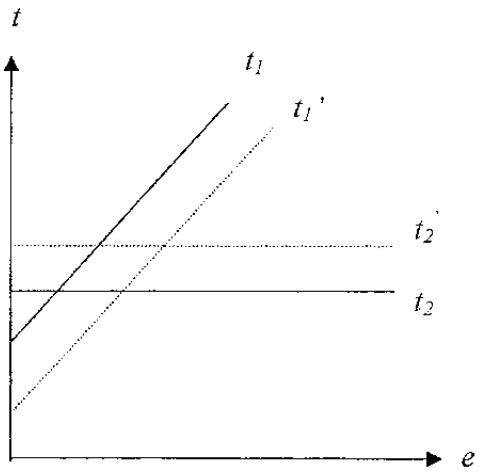
$$(0.5) \quad t = 1 - \frac{1-e}{p} + \frac{1}{\beta p} \ln\left(\frac{kc'(e) - 1}{(1-p)p^{-1} - kc'(e)} \right),$$

which satisfies $\frac{\delta t}{\delta e} = 0, \frac{\delta t}{\delta p} > 0, \frac{\delta t}{\delta k} > 0.$

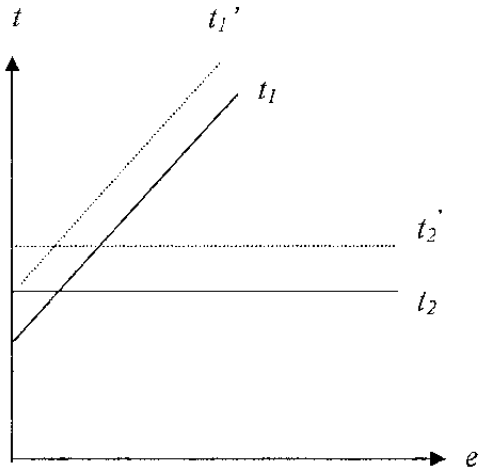
Although equations (0.4) and (0.5) are two equations in two unknowns, it is impossible to derive an analytical expression for t and e in terms of the exogenous variables (p, k, and β). However, we can derive the solution graphically, as illustrated in Figure 2 below, where the two relationships (0.4) and (0.5) are represented as curves denoted by t_1 and t_2, respectively. While the curves need not necessarily be linear, they intersect only once, hence the solution to the model is unique.

Figure 2. Model Solution and Comparative Statics

(a) Effect of an increase in p



(b) Effect of an increase in k



As Figure 2(a) illustrates, an increase in the domestic price level p (i.e., an increase in competition between buyers at the domestic market) leads to a downward shift of curve t_1 and an upward shift of curve t_2, thus implying both a higher optimal tax rate and a higher optimal enforcement rate. Similarly, Figure 2(b) shows that an increase in the share of corporate mining k leads to an upward shift of both t_1 and t_2, generating a higher optimal tax rate but an ambiguous effect on the enforcement rate.

The results of the model, as summarized in Table 4, imply that countries with more competition between diamond buyers (higher p) or a larger share of corporate mining (higher k) have a higher optimal tax rate. Countries that allow for more competition also have higher optimal enforcement rates. Moreover, the optimal tax and enforcement rates do not depend on the level of annual diamond output.

Table 4. Summary of the Model

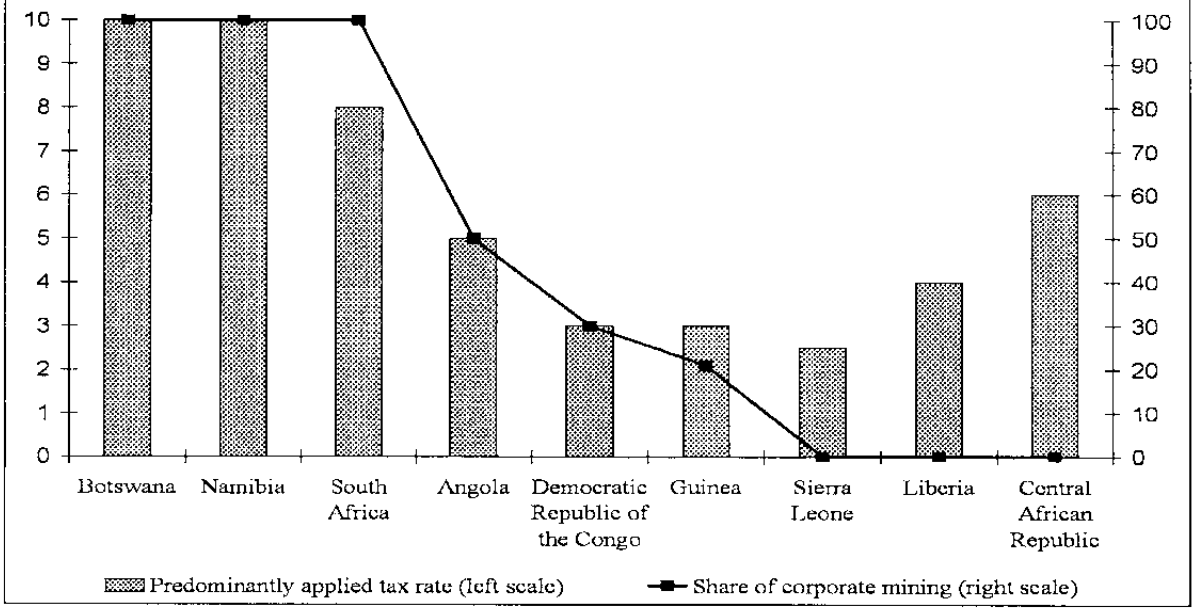
	optimal enforcement rate (e)	*optimal tax rate (t)*
domestic price (p)	+	+
% corporate mining (k)	?	+

While data on p or e is unavailable, we can test the prediction that countries with larger corporate mining sectors have higher tax rates. Figure 3 plots the shares of corporate mining and the predominantly applied tax rates, based on the data in Table 2. These data generally confirm our prediction that tax rates decline with the share of corporate mining. On one side of the spectrum, countries with exclusively corporate mining operations, such as Botswana and Namibia, have royalties or export levies of 10 percent (in addition to corporate income taxation and state equity holdings). On the other side, countries with a low or zero share of corporate artisanal mining, such as the D.R.C., Guinea, Liberia and Sierra Leone, have export levies of about 3 percent.

With a lack of corporate mining and a tax rate of 6 percent, the Central African Republic seems to be an outlier in Figure 3. However, caution should be applied in concluding that this rate is, therefore, too high. First, the C.A.R. authorities have been reluctant to reduce the tax rate, pointing to previous experiences with tax cuts leading to lower fiscal revenue. For example, following the most recent tax cut from 7½ to 6 percent in 1998, reported volumes of C.A.R. diamond exports actually decreased.[23] Second, it should be noted that 3 percent of the total value of C.A.R. diamond exports (i.e., half of all tax revenue from diamonds) is earmarked for projects aimed at improving the valuation process and at strengthening the control of mining areas (see footnote 15). However, it is still possible that a lower tax rate combined with less spending on enforcement may in fact reduce smuggling and increase tax revenue. A more detailed study on the C.A.R. diamond sector would need to be carried out in order to substantiate this claim.

[23] IMF (2003).

Figure 3. Corporate Mining Shares and Tax Rates in Selected SSA Countries
(in percent)



Sources: Country authorities; and Terraconsult, 2002.

VI. Increasing Long-Term Revenue from Diamond Mining

The implications of our model may appear somewhat pessimistic, as they seem to suggest that the potential for raising fiscal revenue from diamonds is limited by the industrial organization of the sector, which in turn is largely determined by the nature of diamond deposits. However, the model assumed that governments maximize revenues over the short run, and therefore treat domestic prices (p) and total annual output (q) as given. Governments with longer time horizons can, in fact, increase the taxable base by taking measures that will raise domestic prices or annual output. In addition, revenue can be increased by attracting investment in value-adding downstream operations and by reducing the costs of establishing a given enforcement rate.

By encouraging competition—which would align domestic with world market prices—, governments can increase the taxable base directly as well as indirectly, since it also reduces incentives for smuggling. In order to prevent domestic diamond prices from falling too far below world market prices, governments could consider reducing license fees and lowering the required start-up costs for diamond exporters (such as those listed in footnote 15).While some of these barriers to entry may be effective in keeping out illegitimate diamond export companies, too many restrictions will keep out legal competitors and give rise to corruption.

Alternatively, or as an additional measure, governments could organize diamond exchanges in which traders and miners can sell their diamonds directly to competing international

diamond buyers, thus allowing them to obtain a higher price.[24] The pricing power of export companies can also be reduced by providing diamond miners and traders with alternative sources of financing, in particular through microfinance institutions. In addition to being a source of credit, microfinance institutions could also be used as a location for depositing currency as well as diamonds.

In order to increase annual diamond production, governments could aim at increasing the productivity of diamond mining and encouraging the exploration of new mining areas. While borrowing constraints make it difficult for artisanal miners to invest in productivity-enhancing equipment, cooperatives of miners would be able to pool risks and borrow the necessary funds to purchase equipment, such as motor pumps or excavators. Stimulating mining cooperatives, therefore, could help to increase the productivity of artisanal diamond mining.[25] In addition, total output itself could potentially be increased by improvements in the legal, institutional, and fiscal framework aimed at stimulating investment in the exploration of hitherto unexplored mining areas.

An alternative way to increase the economic benefits from diamond mining in the longer run is to attract investment in value-adding downstream operations. Currently, most SSA diamonds are exported in rough form and are cut and polished abroad. As a result, the main share of potential value added accrues in diamond trading centers abroad. If SSA countries were to export polished, rather than rough diamonds, they could almost double the value added within the country.[26]

However, there are several reasons why SSA countries have not been able to attract investment in local diamond-cutting facilities. Most diamond processing nowadays is done in low-wage countries like China and India, and it is difficult for SSA countries to compete with these countries in terms of labor cost (for skilled workers), infrastructure, and security. The latter point is particularly important since (1) polishing companies typically need to operate on a large scale to be profitable, and therefore need to maintain a large inventory of rough

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[24] The C.A.R. government recently established such a diamond exchange in Bangui (*Bourse Internationale du Diamant de Bangui*, or BIDB), in partnership with the British services group Gemkin. After a difficult start-up period, the BIDB accounted for about 30 percent of total exports in November and December 2001 (Machulka, 2002; and IMF, 2003).

[25] In the C.A.R., the number of such mining cooperatives has risen in recent years from 5 to 150, and the C.A.R. Mining Sector Development Project aims at organizing an additional 1,000 cooperatives. See Mwamba (2002, p. 41); IMF, 2003.

[26] As Goreux (2001) shows, a country that exports rough diamonds obtains only about one-eighth of all value added. The value of rough diamonds approximately doubles once they have been polished; it doubles again when they have been manufactured into jewelry; and it doubles once more in the process of marketing the jewelry at the retail level.

diamonds, which is risky;[27] and (2) smuggling polished diamonds is even more lucrative than smuggling rough diamonds.

Another problem is that it may be difficult for a polishing company to obtain sufficient rough material, because most existing export companies already have their own polishing facilities abroad.[28] Moreover, it is generally not economical for a polisher to use all rough diamonds found in a given area, which can be of various sizes and qualities. In practice, most diamond polishers specialize in a certain type of diamonds (e.g., only stones with a diameter of 5 to 6 millimeters), so as to meet the demand of particular jewelry manufacturers. To the extent that they cannot obtain sufficient rough material of a given type in a given SSA country, they will prefer to buy instead at diamond trading centers like Antwerp.

A final and perhaps more feasible way for governments to increase revenue from diamonds is to reduce enforcement costs (represented by *c(e)* in the model). In this context, the recent adoption of self-regulatory procedures by the World Diamond Congress may be helpful. In an effort to ban conflict diamonds from international trade (Kimberley Process), the World Diamond Congress agreed in November 2002 on a declaration establishing a self-regulatory framework through a certification system that became effective on January 1, 2003. Certificates are to be issued by a national agency to be designated by each country and will specify the weight and value of the diamonds, together with some additional information. Diamond-importing countries are then required to ensure that the imported diamonds actually match the declaration in the certificate.[29] Finally, the Kimberley Process declaration calls for

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[27] This problem could possibly be reduced by setting up several small diamond-cutting cooperatives, rather than a single cutting facility. Such cooperatives could consist of perhaps no more than five to ten workers, who would purchase small parcels of rough diamonds directly from (cooperatives of) artisans, while leaving the marketing of the cut diamonds to the experienced export companies. As Even-Zohar (1985) points out, small cooperatives have an advantage over large firms because they have little overhead and a faster turnover time, as a result of which they are able to respond more quickly to changes in supply or demand.

[28] In the past, this problem was solved by requiring purchasing bureaus to sell 5 percent of their export volume to the national diamond-cutting facility.

[29] To fulfill this requirement, several alluvial diamond exporting countries are currently in the process of installing independent diamond valuators. For example, in March 2002 the C.A.R. government signed a four-year contract with the Antwerp-based firm Independent Diamond Valuators Ltd. (IDV), which now provides counter-expertise on C.A.R. official exports. IDV also obtained a valuation contract with the D.R.C. government in 2001, but this contract was broken by the D.R.C. government, leading to litigation (Dietrich, 2002, p. 23; and Dietrich 2003, pp. 3-4). This principle of "double evaluation" will be accompanied by an electronic tracking system that requires valuators in Antwerp to immediately transmit their valuations electronically to the authorities of the exporting country. The Diamond High Council (HRD) in Antwerp has already designed and installed such tracking systems for Angola, Sierra Leone, and the Central African Republic (USAID, 2000 and 2001; and Dietrich, 2003).

the registration and licensing of all diamond miners and diggers, as well as professional diamond buyers, traders, agents, and couriers. These measures, if implemented properly by all diamond-exporting countries, should make undervaluation of diamonds nearly impossible, and will significantly reduce the incentives to smuggle. At the present stage, any assessment of the implementation of this self-regulatory regime seems premature.

VI. Conclusion

This paper provided an overview of diamond mining in SSA countries, and explored possibilities to raise fiscal revenue from the diamond sector in those countries with predominantly alluvial deposits. Our analysis suggests that the appropriate tax regime for a diamond-exporting country depends to an important extent on the nature of its diamond deposits. Countries with kimberlite deposits (including Botswana and South Africa) tend to have a large share of corporate diamond mining, and therefore can have tax regimes that rely largely on corporate income taxes. Government revenue from these taxes is generally substantial. In countries with alluvial deposits (including Angola, the C.A.R., the D.R.C., Sierra Leone, and Liberia), most diamond mining is done by artisanal miners who work in large mining areas that cannot be fenced off. Since the earnings of artisans are extremely difficult and costly to verify, export-based taxes are preferred over income-based taxes in these countries, but fiscal revenue remains low due to strong incentives for tax evasion.

In a theoretical model, we showed that optimal diamond tax rates are higher for countries with a larger share of corporate diamond production. Empirical evidence from SSA countries largely matches this prediction, suggesting that potential fiscal revenue from diamonds is dependent on the industrial organization of the sector, which in turn depends largely on the nature of diamond deposits. In addition, the model suggests that more competition between diamond buyers implies a higher optimal tax rate as well as a higher optimal enforcement rate.

While annual output and the domestic price level are fixed in the short run, they can be influenced in the long run with the aim to increase revenue from the diamond sector. On the one hand, annual diamond output can be raised by increasing productivity and exploring new mining areas. On the other hand, domestic prices paid by intermediaries can be made more competitive by reducing the barriers to entry for export companies. This will not only decrease incentives for smuggling, but will also increase the taxable base. In addition, government revenue from alluvial diamond deposits could be increased by reforming the organization of the sector, in order to retain a greater share of the value added in the country. Finally, the recent establishment of self-regulatory procedures under the Kimberley Process, if implemented properly, could significantly reduce tax evasion.

Table 1. Sub-Saharan African Production of Natural Diamonds in 2001

Country	Mines	Tonnes (in '000)	Carats (in '000)	US$ per carat	Production Value (in US$ '000)	Operator
South Africa	Total		11,301	101	1,144,655	
	Venetia	4,802	4,977	85	423,045	De Beers
	Premier	3,102	1,637	75	122,775	De Beers
	Koffiefontein	2,299	145	225	32,625	De Beers
	Kimberley	3,766	550	110	60,500	De Beers
	Namaqualand	6,083	808	180	145,440	De Beers
	Finsch	4,768	2,465	70	172,550	De Beers
	The Oaks	203	124	180	22,320	De Beers
	Baken	5,838	65	400	26,000	Transhex
	Others		230	280	64,400	Various
	Independent diggers		300	250	75,000	Various
Botswana	Total	28,324	26,416	83	2,193,870	
	Orapa	15,779	13,056	50	652,800	Debswana (De Beers)
	Lethlakane	3,625	1,021	180	183,780	Debswana (De Beers)
	Jwaneng	8,920	12,339	110	1,357,290	Debswana (De Beers)
Namibia	Total		1,502	215	322,340	
	Namdeb	21,867	1,385	220	304,700	Namdeb (De Beers)
	Namco		90	151	13,590	Namco
	Diamond Fields		27	150	4,050	DFI/Transhex
Angola	Total		5,871	137	803,145	
	Catoca	3,160	2,693	65	175,045	Alrosa/Odebrecht/Endiama
	Luzamba	725	418	210	87,900	SDM (Odebrecht/Endiama)
	Smaller operators		760	237	180,200	Joint Ventures with Endiama
	Artisans		2,000	180	360,000	Various
Democratic Republic of the Congo	Total		19,537	25	496,310	
	Mbuyi-Maji		5,800	14	81,200	MIBA
	Small operators/Artisans		13,837	30	415,110	Various
Central African Republic	Total		614	150	92,100	
	Small operators/Artisans		614	150	92,100	Various
Ghana	Total		450	25	11,250	
	Small operators/Artisans		450	25	11,250	Various
Tanzania	Total	2,867	191	145	27,695	
	Williamson	2,867	191	145	27,695	De Beers/State of Tanzania
Cote d'Ivoire	Total		145	120	17,400	
	Artisans		145	120	17,400	Various
Liberia	Total		155	150	23,250	
	Artisans		155	150	23,250	Various
Sierra Leone	Total		375	180	67,500	
	Artisans		375	180	67,500	Various
Guinea	Total		754	170	128,180	
	Small operators/Artisans		754	170	128,180	Various
Lesotho	Total		20	190	3,800	
	Small operators/Artisans		20	190	3,800	Various
SSA Countries	Total		67,431	79	5,331,495	

Source: Terraconsult (2002).

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