

Alluvial Diamonds: A New Resource Curse Theory

Victor A.B. Davies

University of Oxford

Abstract

I develop the micro-foundations of a resource curse process in small-scale alluvial diamond mining in poor countries. I identify a commons problem and gambling for resurrection as sources of labour inefficiency induced by mining institutions. I show that the commons problem lowers aggregate output. Thus, I provide another perspective to the debate on the role of institutions in economic development, focusing on the industrial organization of diamond mining. I also contribute to the literature on the commons problem and gambling for resurrection by showing that they occur in alluvial diamond mining. The labour inefficiencies help explain why Sierra Leone, with liberal access to its diamond mines, is poorer than Namibia and Botswana, with restricted access; and why African countries with alluvial diamonds tend to be conflict-prone.

February 2009

1. Introduction

Many countries rich in natural resources are poorer and more miserable than countries that are less well endowed (Soros 2007). The literature highlights three main processes that can lead to such a resource curse – failure to benefit from natural resource wealth. First is the Dutch disease wherein a real exchange rate appreciation following a resource boom diverts factors of production away from sectors with positive growth externalities (Corden and Neary, 1982; van Wijnbergen, 1984). Second is through political economy channels like rent seeking and corruption (Torvik, 2002); state predation (Lal and Myint, 1996); and political instability, including violent conflict (Collier and Hoeffler, 2004). Third is commodity price volatility (Aizenman and Marion, 1999; Ramey and Ramey, 1995).

In this paper I highlight a fourth resource curse process in artisanal (small-scale) alluvial diamond mining in poor countries: I identify two sources of labour inefficiency induced by mining institutions: a commons problem and gambling for resurrection. Thus, I provide a new perspective to the debate on the role of institutions in economic development, complementing others highlighting the effects on institutions of more generic geographical factors like the disease environment or location in the tropics (Acemoglu, Johnson and Robinson, 2001; and Easterly and Levine, 2003). I also contribute to the literature on the commons problem and gambling for resurrection by showing that they occur in alluvial diamond mining.

The institution that I focus on is the industrial organization of diamond mining, which is determined by a combination of geological and political economy factors. Alluvial diamond deposits are spatially dispersed and could be mined with crude, hand-held implements, in contrast to capital-intensive “point” resources like deep-pit Kimberlite diamond deposits, or other resources that dominate the resource curse literature. The difficulty of enforcing property rights over the expanse over which alluvial diamonds typically occur, and the scope for small-scale mining, tend to attract a myriad of miners, resulting in a degree of open access. Sierra Leone testifies to this difficulty. Sierra Leone started with a monopoly in the 1930s which collapsed during the “diamond rush” of the 1950s when some 75000 miners invaded the concessions (van der Laan, 1965). In response, in 1956, the colonial government bifurcated the mines into an artisanal sector – with conditions approximating open access – and a corporate sector reserved for the former monopolist. However, pressure to liberalize access to the corporate concessions was sustained. In 1967, the opposition was voted to power partly on promises to do so, leading to the eventual universalization of artisanal mining. (Davies 2007). However, open access in alluvial diamond mining is not inevitable. Namibia has been able to restrict access to at most a few corporate producers ever since 1908. Namibia’s diamonds occur mostly in desert regions or offshore, facilitating access restriction, unlike in Sierra Leone whose diamond-bearing regions are inhabited.

I show that failure to effectively restrict access to the mines, as in Sierra Leone, induces a commons problem. In the traditional commons problem, free access to a finite resource ultimately dooms the resource through overexploitation (Hardin, 1968). In alluvial diamond mining, overexploitation leads to excessive employment. Finding a diamond is a matter of chance. As more and more miners search for diamonds, every new miner reduces other miners’ chances of finding a diamond. Thus, with open access, the last miner imposes a cost on all

existing miners, raising private return above social return. Labour allocation, based on private return, becomes socially excessive. I present two models capturing the externality. A “lottery” model captures the lottery context in which the externality occurs. I use it to illustrate both the commons problem and gambling for resurrection numerically. The other, “spatial” model captures the spatial context in which the externality occurs and illustrates the implications for aggregate output.

Uncertainty in diamond mining – and the fact that, ex post, some lucky diggers may be rich and others poor – contrast with the traditional commons problem where uncertainty does not exist and ex post outcomes are the same for everyone. However, the inefficiency characterising the commons problem in diamond mining is unrelated to uncertainty or the ex post dimension. The source of the inefficiency is the externality in individual behaviour, like in the traditional tragedy of the commons.

The second source of inefficiency in artisanal diamond mining that I highlight also sets private returns above social returns, inducing excessive employment of its own. African artisanal diamond miners are generally very poor. They typically work on credit and share the profits with their creditors. In the event of a loss, they do not refund any part of the credit that cannot be recovered from their earnings (Partnership Africa Canada and Global Witness, 2004). I draw on the finance literature to show that this contract form induces “gambling for resurrection” – the tendency for a financially distressed firm to engage in excessive risk taking. The incentive is that the firm gains disproportionately if a risky project succeeds but bears too little of the cost if the project fails: it files for bankruptcy and walks away from its debt (Hart, 2000; Akerloff and Romer, 1993; and White, 2007 and 1989).

The identified labour inefficiencies help explain why Sierra Leone, which ranked bottom on the 1991 UNDP Human Development Index, is much poorer than Namibia and Botswana with restrictions to their diamond deposits that obviate the inefficiencies.¹ Sierra Leone’s per capita income in the 1980s was US\$280 compared with US\$560 in Sub-Saharan Africa, and US\$1500 in Namibia and Botswana. Labour shortages have been reported as a constraint to Sierra Leone’s agriculture (Food and Agriculture Organization, 2005). This suggests a positive marginal product of agricultural labour. That part of Sierra Leone’s artisanal diamond labour force – estimated at over 100,000 in 2004 (Government of Sierra Leone, 2005) – could be excessive, in the face of a positive opportunity cost of labour, suggests that artisanal diamond mining could be immiserizing. Indeed, the regime change from monopoly to open access appears to have been costly to Sierra Leone. In the 1950s, the country turned from a net exporter of rice, the staple food, to a net importer, as farmers abandoned rice fields for the diamond mines (Saylor 1967). The country has remained a net rice importer ever since. Namibia avoided the labour inefficiencies by restricting access to its alluvial deposits ever since 1908, allowing only a few wage-paying producers, obviating both the commons problem and gambling for resurrection. Botswana’s capital-intensive, “point” Kimberlite diamond deposits tend to induce a natural monopoly. Unsurprisingly, the country’s diamonds are mined by a monopolist.

¹ Sierra Leone’s official diamond output peaked at two million carats in the 1960s. However, a large proportion of its diamonds has been smuggled over the years. Thus, the size of total diamond output remains a matter of speculation.

The labour inefficiencies also help explain why African alluvial diamond producers like Sierra Leone, the Democratic Republic of Congo and Angola, have tended to be conflict-prone: Warfare participation, driven by a desire to mine diamonds – as sometimes observed (Abraham 1997) – constitutes an employment choice synonymous with diamond mining. Thus, with open access in diamond mining, warfare participation may be susceptible to the commons problem. With profit sharing, it may also be susceptible to gambling for resurrection. Either effect induces overemployment in warfare. Thus, alluvial diamond mining makes it easier to attain a critical mass of combatants to initiate or sustain warfare.

2 The Two Sources of Labour Inefficiency

2.1 The Commons Problem

I first model the externality due to the commons problem in alluvial diamond mining as a lottery process with the number of diamond finds a probability distribution. The key idea to capture is that any diamond found is one diamond less for others to find. I then model the externality as a spatially constrained production process.

2.1.1 The lottery model

Assume X diamonds are randomly distributed over Y identical plots of land. For simplicity, assume $X < Y$ and each plot contains one or no diamond. Each of L_d miners randomly searches a single plot for diamonds without revealing the outcome. The miners search sequentially, precluding the possibility of two or more miners simultaneously finding the same diamond. Thus, if A finds a diamond this reduces the probability that subsequent searchers will find a diamond. However, if A does not find a diamond, that probability is unchanged. With two miners, the probability that the first miner finds a diamond is X/Y . The probability that he does not find a diamond is $\frac{Y-X}{Y}$ since $Y-X$ plots do not contain any diamond. The probability that the second miner finds a diamond if the first miner has already found one is $\frac{X-1}{Y}$: If the first miner finds a diamond, the number of remaining diamonds decreases to $X - 1$.

Expected return, P^e , is given by the expected diamond finds (expected total return) divided by the number of diamond miners, L_d . Expected diamond finds is the sum of the product of possible diamond finds, N_i , and the respective probability, $prob(N_i)$:

$$P^e = \frac{\text{expected diamond finds}}{L_d} = \frac{\sum_{i=0}^{X-1} N_i \text{prob}(N_i)}{L_d} \quad (1).$$

I assume risk neutrality, abstracting from risk as a source of inefficiency.

Table 1 presents the expected returns for $X=2$, $Y=3$, and $L_d = 1,2,3$. The elements in the outcome set are ordered: (1,0) reads “the first miner finds a diamond and the second miner does not”. Table 1 shows that expected marginal return (expected social return) is less than expected private return. For instance, for $L=3$, expected marginal return is $8/27$ while expected private return is $38/81$.

I have assumed that $X < Y$. However, the relative magnitude of X and Y does not matter. X could exceed Y . By implication, a miner could find multiple diamonds in one period. The key idea to capture in any variant of the above scenario is that any diamond found is one diamond less for others to find.

Table 1: The Commons Problem in the Lottery Model

Number of miners L_d	Number of diamond finds N	Sample space	$prob(N)$	Expected total return (expected diamond finds)	Expected private return	Expected marginal return (expected social return)
1	0	(0)	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	-
	1	(1)	$\frac{2}{3}$			
2	0	(0,0)	$\frac{1}{3} \cdot \frac{1}{3} = \frac{1}{9}$	$\frac{10}{9}$	$\frac{5}{9}$	$\frac{4}{9}$
	1	(0,1) (1,0)	$\frac{1}{3} \cdot \frac{2}{3} + \frac{2}{3} \cdot \frac{1}{3} = \frac{6}{9}$			
	2	(1,1)	$\frac{2}{3} \cdot \frac{1}{3} = \frac{2}{9}$			
3	0	(0,0,0)	$\frac{1}{3} \cdot \frac{1}{3} \cdot \frac{1}{3} = \frac{1}{27}$	$\frac{38}{27}$	$\frac{38}{81}$	$\frac{8}{27}$
	1	(0,0,1) (0,1,0) (1,0,0)	$\frac{1}{3} \cdot \frac{1}{3} \cdot \frac{2}{3} + \frac{1}{3} \cdot \frac{2}{3} \cdot \frac{1}{3} + \frac{2}{3} \cdot \frac{1}{3} \cdot \frac{1}{3} = \frac{14}{27}$			
	2	(1,1,0) (1,0,1) (0,1,1)	$\frac{2}{3} \cdot \frac{1}{3} \cdot \frac{1}{3} + \frac{2}{3} \cdot \frac{1}{3} \cdot \frac{1}{3} + \frac{1}{3} \cdot \frac{2}{3} \cdot \frac{1}{3} = \frac{12}{27}$			

The lottery model is similar in spirit to the Harris-Todaro (1970) model of rural-urban migration. In both models a negative externality sets social return below private return. In Harris-Todaro, migration generates the externality by increasing competition for a fixed number of higher-paying urban jobs, lowering the probability of urban employment. Output is fixed, setting the marginal product of an urban migrant to zero. In my model, marginal product of labour is positive since diamond output increases with employment, which is available to everyone due to open access. Output assumes a probability distribution.

2.1.2 The spatial model

Consider an economy with two sectors, diamond mining and agriculture. The return to agricultural labour, F , is constant. Mining occurs on diamond-bearing land of dimension, B , divided into L_d identical plots and distributed one each among the miners, numbering L_d . Thus,

$$\text{plot size per miner} = \frac{B}{L_d} \quad (2).$$

Private return, P , is given by

$$P = \left(\frac{B}{L_d}\right)^\alpha = B^\alpha L_d^{-\alpha}, \quad 0 < \alpha < 1 \quad (3).$$

$$\text{Total return} = Q_d = P \cdot L_d = B^\alpha L_d^{1-\alpha} \quad (4).$$

$$\text{Marginal return} = \frac{dQ_d}{dL} = (1 - \alpha) B^\alpha L_d^{-\alpha} \quad (5).$$

Under open access, entry into the mines will continue until P equals F , the return to agriculture. Thus, equilibrium is attained when

$$B^\alpha L_d^{-\alpha} = F \quad (6).$$

Equilibrium under a wage-paying monopoly is at the point where diamond marginal return equals F

$$(1 - \alpha) B^\alpha L_d^{-\alpha} = F \quad (7).$$

To compare the equilibrium levels of diamond employment under open access, L_d^{open} , and monopoly, L_d^{mono} , solve for L_d in (6) and (7):

$$L_d^{open} = \frac{B}{F^{1/\alpha}} \quad (8),$$

and

$$L_d^{mono} = (1 - \alpha)^{1/\alpha} \frac{B}{F^{1/\alpha}} \quad (9).$$

Thus, $L_d^{open} > L_d^{mono}$, given that $0 < \alpha < 1$. Whereas monopoly employment is socially optimal (based on marginal return and not private return), open-access employment is socially excessive. The excess is given by:

$$\begin{aligned} \text{excess employment} &= L_d^{open} - L_d^{mono} = \\ &= \left\{ \frac{B}{F^{1/\alpha}} \right\} - \left\{ (1 - \alpha)^{1/\alpha} \frac{B}{F^{1/\alpha}} \right\} = \frac{B}{F^{1/\alpha}} \left[1 - (1 - \alpha)^{1/\alpha} \right] \end{aligned} \quad (10).$$

Substituting (8) into (2) gives

$$\text{open access equilibrium plot size per miner} = \frac{B}{L_d^{open}} = \frac{B}{B/F^{1/\alpha}} = F^{1/\alpha} \quad (11).$$

Substituting (9) into (2) gives

$$\text{optimum plot size per miner} = \frac{B}{L_d^{mono}} = \frac{B}{(1 - \alpha)^{1/\alpha} \frac{B}{F^{1/\alpha}}} = \frac{F^{1/\alpha}}{(1 - \alpha)^{1/\alpha}} \quad (12),$$

which is larger than the open access equilibrium plot size per miner, since $0 < \alpha < 1$. Thus, the commons problem drives the plot size per miner beyond the optimum.

Implications for aggregate output

The commons problem lowers aggregate output, Y , given by

$$Y = Q_d + Q_a \quad (13),$$

where Q_a is agricultural output. To see this, assume a fixed total labour supply L , given by

$$L = L_d + L_a \quad (14),$$

where L_a is agricultural labour. Using (14), agricultural output Q_a , could be written as

$$Q_a = F \cdot L_a = F(L - L_d) \quad (15).$$

Substituting for Q_d from (4) and for Q_a from (15) into (13):

$$Y = Q_d + Q_a = B^\alpha L_d^{1-\alpha} + F(L - L_d) \quad (16).$$

Under open access, equilibrium employment is at the point where the return to agriculture F , equals the private return to diamond mining. Thus, aggregate output, Y^{open} , equals FL .²

Diamond output under monopoly, Q_d^{mono} , is

$$Q_d^{mono} = B^\alpha L_d^{1-\alpha} = B^\alpha \left\{ (1-\alpha)^{1/\alpha} \frac{B}{F^{1/\alpha}} \right\}^{1-\alpha} = B \left\{ \frac{(1-\alpha)}{F} \right\}^{\frac{1}{\alpha}-1}$$

Aggregate output under a diamond monopoly, Y^{mono} , is therefore

$$\begin{aligned} Y^{mono} &= B \left\{ \frac{(1-\alpha)}{F} \right\}^{\frac{1}{\alpha}-1} + F(L - L_d) = B \left\{ \frac{(1-\alpha)}{F} \right\}^{\frac{1}{\alpha}-1} + F \left\{ L - \left((1-\alpha)^{1/\alpha} \frac{B}{F^{1/\alpha}} \right) \right\} \\ &= FL + B \left\{ \frac{(1-\alpha)}{F} \right\}^{\frac{1}{\alpha}-1} - \left\{ F^{1-\frac{1}{\alpha}} (1-\alpha)^{1/\alpha} B \right\} \\ &= FL + BF^{1-\frac{1}{\alpha}} (1-\alpha)^{\frac{1}{\alpha}-1} - BF^{1-\frac{1}{\alpha}} (1-\alpha)^{\frac{1}{\alpha}} \end{aligned} \quad (17).$$

To compare Y^{mono} and Y^{open} , i.e. $\left\{ FL + BF^{1-\frac{1}{\alpha}} (1-\alpha)^{\frac{1}{\alpha}-1} - BF^{1-\frac{1}{\alpha}} (1-\alpha)^{\frac{1}{\alpha}} \right\}$ and FL , respectively, subtract FL from Y^{mono} and Y^{open} . Thus $Y^{mono} > Y^{open}$ if

² To obtain equilibrium diamond output under open access, Q_d^{open} , substitute the equilibrium diamond employment into the diamond production function: $Q_d^{open} = B^\alpha L_d^{1-\alpha} = B^\alpha \left(\frac{B}{F^{1/\alpha}} \right)^{1-\alpha} = BF^{1-\frac{1}{\alpha}}$. Thus, $Y^{open} = BF^{1-\frac{1}{\alpha}} + F(L - L_d) = BF^{1-\frac{1}{\alpha}} + F \left(L - \frac{B}{F^{1/\alpha}} \right) = FL$.

$$BF^{1-\frac{1}{\alpha}}(1-\alpha)^{\frac{1}{\alpha}-1} - BF^{1-\frac{1}{\alpha}}(1-\alpha)^{\frac{1}{\alpha}} > 0 \quad \text{or}$$

$$BF^{1-\frac{1}{\alpha}}(1-\alpha)^{\frac{1}{\alpha}-1} > BF^{1-\frac{1}{\alpha}}(1-\alpha)^{\frac{1}{\alpha}} \quad (18).$$

Multiply both sides of (18) by $\frac{(1-\alpha)^{-1/\alpha}}{BF^{1-\frac{1}{\alpha}}}$ to get

$$Y^{mono} > Y^{open} \text{ if } (1-\alpha)^{-1} > 1 \quad (19).$$

Thus, $Y^{mono} > Y^{open}$, since $0 < \alpha < 1$ as defined in (3).

2.2 Gambling for Resurrection

The lottery and spatial models abstract from the presence of debt in diamond mining and the riskiness of the returns as a source of inefficiency. I now turn to this issue, highlighting the possibility of “gambling for resurrection”, the tendency for excessive risk taking in financial distress. Consider a poor miner who needs a bank loan C , to mine diamonds. The loan will be repaid solely from the miner’s diamond earnings, and, by way of compensation, the bank will receive a share of any eventual profit. There are two possible earnings: $P_r + G$ with probability p or $P_r - G$ with probability $1 - p$. $P_r + G > C > P_r - G$. Therefore, if the miner earns $P_r + G$ he repays the loan in full, keeps a proportion \emptyset , of the profit $P_r + G - C$, and gives the bank the rest of the profit. If the miner earns $P_r - G$, he makes a loss and repays only $P_r - G$, the part of the loan recoverable from his earnings. The bank forfeits $C - (P_r - G)$.

Since his net earnings are zero in the event of a loss, the

$$\text{miner's expected profit} = p(P_r + G - C) \quad (20),$$

and the

$$\text{miner's expected return} = \emptyset p(P_r + G - C) \quad (21).$$

However, shadow expected profit (incorporating the loss in full) is

$$p(P_r + G - C) + (1 - p)(P_r - G - C) \quad (22).$$

Collecting terms,

$$\text{shadow expected profit} = 2pG + P_r - G - C \quad (22a)$$

which is less than the miner’s expected profit, from which his expected return is derived. The wedge between the miner’s expected profit and shadow expected profit is a source of inefficiency, causing the miner to mine when it is economically inefficient to do so. This could

result in “inefficient continuation” wherein a financially distressed firm continues to produce even though it is more economically efficient to file for bankruptcy. Thus, if

$$[p(P_r + G - C) + (1 - p)(P_r - G - C)] < 0 < p(P_r + G - C) \quad (23),$$

the miner will mine even though it is economically inefficient to do so: Shadow expected profit is negative but the miner’s expected profit, and by implication, the miner’s expected return, is positive. Incorporating the agricultural sector in Sub-section 2.1 with fixed return, F , inefficient mining still occurs even with a positive shadow expected profit if

$$[p(P_r + G - C) + (1 - p)(P_r - G - C)] < F < \emptyset p(P_r + G - C) \quad (24).$$

i.e. if the miner’s expected return exceeds the return to agriculture but the shadow expected profit is less than the return to agriculture. In this case, it would be more economically efficient for the miner to farm.

The volatility of the diamond earnings (captured by G) could also induce inefficiency: For $p < 0.5$, shadow expected profit (22a) decreases with G : The derivative of (22a) with respect to G is $2p - 1$, which is negative for $p < 0.5$. On the other hand, miner’s expected profit (20) increases with G : The derivative of (20) with respect to G is p , which is positive since p is positive. Therefore, for $p < 0.5$, the wedge between shadow expected profit and the miner’s expected profit increases with the volatility of diamond earnings. Thus, the incentive to mine increases with the riskiness of the return while the prospect for economically efficient mining decreases with the riskiness of the return.

Generalizing for multiple outcomes, let R_i be the gross earnings less total costs associated with outcome i and π_i the probability of i . Then

$$\text{miner's expected profit} = \sum \pi_i \cdot R_i, \quad \forall R_i > 0 \quad (20a)$$

and

$$\text{shadow expected profit} = \sum \pi_i \cdot R_i, \quad \forall R_i \quad (22b).$$

Table 2 uses the lottery model and the probability statistics in Table 1 and (20a) and (22a) to illustrate gambling for resurrection numerically. I assume unit cost of production C , is $1/3$. Thus, return measures are now net of costs. The table shows that private return with gambling for resurrection exceeds private return with the commons problem alone. For example, with three miners, the respective figures are $4/27$ and $11/81$, while marginal return (social return) is negative, $-1/27$.

Table 2: The Commons Problem and Gambling for Resurrection

Number of miners L_d	Number of diamond finds N	prob(N)	Expected return = $\text{prob}(N) \cdot \{N - (L_d \cdot C)\}$	Expected total returns with commons problem alone	Expected marginal return	Expected private return with commons problem alone	Expected total returns with commons problem and gambling for resurrection	Expected private return with commons problem and gambling for resurrection
1	0	$\frac{1}{3}$	-1/9	1/3		1/3	4/9	4/9
	1	$\frac{2}{3}$	4/9					
2	0	$\frac{1}{9}$	-2/27	4/9	1/9	2/9	14/27	7/27
	1	$\frac{6}{9}$	2/9					
	2	$\frac{2}{9}$	8/27					
3	0	$\frac{1}{27}$	-1/27	11/27	-1/27	11/81	4/9	4/27
	1	$\frac{14}{27}$	0					
	2	$\frac{12}{27}$	4/9					

Figure 1 illustrates the labour inefficiencies due to the commons problem and gambling for resurrection, based on Table 2. Total labour supply is fixed. It is measured on the horizontal axis with the origin of diamond labour on the left corner and agriculture on the right. Optimal employment – at point A, corresponding to L_{d1} units of diamond employment, and the rest, agriculture – is where the expected marginal return to diamond mining and the return to agriculture equalise. However, labour decision is based on comparing expected private return to diamond mining and the return to agriculture. The two equalise in equilibrium, at point B, with L_{d2} units of diamond employment. L3, the private return curve reflecting both gambling for resurrection and the commons problem lies above L2, the private return curve reflecting the commons problem alone. With L3, equilibrium diamond labour is L_{d3} , increasing the diamond overemployment beyond the level induced by the commons problem alone.

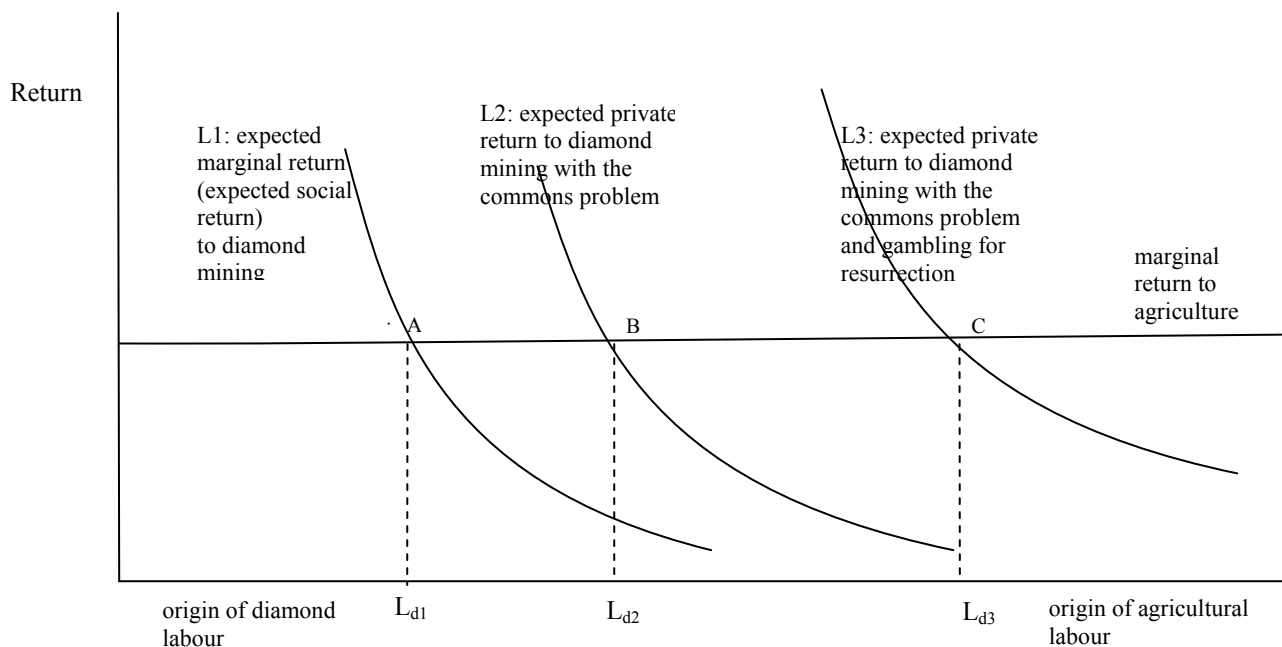


Figure 1: The Commons Problem and Gambling for Resurrection

I have abstracted from attitudes to risk which could either mitigate or exacerbate the labour inefficiencies due to gambling for resurrection. There is some evidence suggesting that miners may be risk loving. Partnership Africa Canada and Global Witness (2004) report estimates of average daily earnings under profit-sharing at between US\$1.24 and US\$1.46 in Sierra Leone, compared with US\$2 under wage payment, but “historically, most diggers (miners) have preferred the casino system (profit-sharing), betting on a share of the winnings”. Economic theory rationalizes such possible risk preference. For instance, a Friedman-Savage (1948) or Markowitz (1952) utility function with concave and convex segments implies that the miner is risk averse for increases in income that keep him within the same income class (small values of G), and risk-loving for large increases in income (large values of G) enabling movement to a higher class. Risk aversion could mitigate the labour inefficiencies. However, risk-averse individuals could also opt for an actuarially unfair gamble like diamond digging, behaving like risk lovers in certain circumstances: when the marginal returns to wealth increase with wealth (Appelbaum and Katz 1981, Stark 1991); when utility is derived from wealth and social status (Katz 1983 and Stark 1991); or if the miner overweights low-probability events like a big diamond find (Tversky and Kahnemann, 1992). One way or the other, my aim is to highlight gambling for resurrection as an institutionally induced source of market failure, independent of the miner’s risk attitude.

Some solutions

Imposing loss and profit sharing, forcing the miner to pay a proportion ϕ , of any eventual loss, the same as his profit share, eliminates the moral hazard of the miner bearing too little of the cost of bankruptcy relative to the upside benefits he stands to gain. His expected return now becomes

$\emptyset(2pG + P_r - G - C)$, i.e. \emptyset times shadow expected profit (15) or (15a). Since the miner's expected return is now a proportion of shadow expected return; inefficient continuation, and the incentive to mine as the riskiness of the return increases, are now eliminated. However, in practice, getting the poor miners to share the loss may be difficult.

A fixed rate of pay eliminates the option to gamble for resurrection by delinking the miner's return from the underlying riskiness of the diamond earnings. Given that a monopoly eliminates the commons problem, a fixed-wage-paying monopoly would eliminate both the commons problem and the option to gamble for resurrection. The miner would now cease to be an entrepreneur and would no longer be responsible for financing diamond mining. However, wage payment may be difficult to introduce, given that the miners have historically preferred profit sharing. Also property-rights enforcement costs, which I assumed away, may be high, rendering a monopoly unfeasible. Enforcing property rights may also be politically difficult. In Sierra Leone, governments have always come under pressure to liberalize access to the mines. The opposition was voted to power in 1967 partly on promises to do so (Smillie *et al* 2000).

In post-war Sierra Leone, donors have launched a credit scheme to support the miners, allowing them to keep all the profits after repaying the credit. While these terms are favourable to the miner relative to profit sharing, they increase the incentive to gamble for resurrection: In the event of a loss, the miner would still walk away from some of his debt. His expected return is now $p(P_r + G - C)$ which is higher than his expected return under profit sharing $\emptyset p(P_r + G - C)$, since he now keeps all the profit. Thus, the upside benefits the miner stands to gain has increased while the downside cost has not changed.

Finally, taxation could correct the market failures by reducing diamond returns. In Figure 1 taxation could shift the relevant expected private return curve inwards to intersect the return to agriculture curve at point A, for optimal labour allocation. However, this assumes away the ease of smuggling diamonds due to their high unit value. In reality, a high tax rate might simply induce smuggling, with low tax revenues and labour allocation close to the zero-tax level.

3. CONCLUSION

I have highlighted a process whereby alluvial diamond mining under open access in poor countries undermines economic development through a commons problem and gambling for resurrection, each inducing overemployment. The solution to the commons problem is to restrict access to the mines, with a monopoly being the limiting case. However, the economic and political costs of enforcing property rights could be prohibitive: In Sierra Leone the opposition secured electoral victory in 1967 partly on promises to liberalise access to the mines. In fact, the difficulty of enforcing property rights is what often induces open access in the first place.

Loss and profit sharing reduces the incentive to gamble for resurrection by eliminating the moral hazard of the miner bearing too little of the cost of bankruptcy relative to the upside benefits of diamond mining. However, that the miners are typically very poor casts doubts on whether they can be forced to share losses. Fixed wage payment eliminates the option to gamble for resurrection. However, wage payment may be a difficult proposition given that the miners have

historically preferred profit sharing. Thus, countries like Sierra Leone may be “doomed” to open access and its possible resource curse. The challenge, in these circumstances, is to devise policies to mitigate the two sources of labour inefficiency. The first step is to appreciate the existence and magnitude of the problem. In Sierra Leone, aid donors have introduced a credit scheme that allows the miners to keep all the mining profit after paying back the credit. I have shown that while the scheme would benefit the miners, it increases the incentive to gamble for resurrection. These dilemmas show that there are no simple solutions. Support to alternative activities such as agriculture, rather than to diamond mining, may well be the best feasible option to minimize the labour inefficiencies.

REFERENCES

- Abraham, A., (1997) “War and Transition to Peace: A Study of State Conspiracy in Perpetuating Armed Conflict”. *Africa Development*, 22, issues 3-4, 101-116.
- Acemoglu D., S. Johnson and J.A. Robinson, (2001). “The Colonial Origins of Comparative Development: An Empirical Investigation”, *American Economic Review*, 91(5), 1369-1401.
- Akerlof, George A., and P. Romer. (1993) “Looting: The Economic Underworld of Bankruptcy for Profit”. *Brookings Papers on Economic Activity*, 2, 1-60,
- Aizenman, J., and N. Marion, (1999) “Volatility and Investment: Interpreting Evidence from Developing Countries” *Economica*, 66, 157-79.
- Appelbaum, E., and E. Katz, (1981) “Market Constraints as a Rationale for the Friedman-Savage Utility Function”. *Journal of Political Economy*, 89,4, 819-825.
- Collier, P., and A. Hoeffler (2004) “Greed and Grievance in Civil War” *Oxford Economic Papers*, 56,4, 563-595.
- Corden, N.M. and J.P. Neary, (1982) “Booming sector and de-industrialization in a small open Economy”, *Economic Journal* 92,825-848.
- Davies, V.A.B. “Sierra Leone’s Economic Growth Performance, 1961-2000” in B. Ndulu *et al* (editors), *The Political Economy of Economic Growth in Africa 1960-2000, volume 2: Country Case Studies*, Cambridge University Press.
- Easterly, W. and R. Levine, (2003) “Tropics, Germs, Crops: How Endowments Influence Economic Development”, *Journal of Monetary Economics*, 50,1, 3-39.
- Food and Agricultural Organization, (2005) “Sierra Leone Food Aid Strategy”. Rome: Food and Agricultural Organization mimeograph.
- Friedman, M., and L.J. Savage (1948) “The Utility Analysis of Choices Involving Risk” *Journal of Political Economy*, 56,4, 279-304.

Government of Sierra Leone (2005) Poverty Reduction Strategy Paper, Freetown: Government of Sierra Leone.

Hardin, G., (1968) "The Tragedy of the Commons", *Science* 162, 3859, 1243-48.

Harris, J.R., and M.P. Todaro (1970) "Migration, Unemployment and Development: A Two-Sector Analysis", *American Economic Review*, 60,1, 126-142.

Hart, O. (2000). Different Approaches to Bankruptcy. NBER Working Paper No. 7921.

Katz, E. (1983) "Wealth, Rank, Risk Aversion and the Friedman-Savage Utility Function" *Australian Economic Papers* 22,41, 487-490.

Lal, D., and H. Myint (1996) *The Political Economy of Poverty, Equity and Growth*, Oxford: Clarendon Press.

Levin, E.A. & Gberie, L. (2006). "Dealing for development? A story of diamond marketing and pricing in Sierra Leone." Diamond Development Initiative mimeo.

Markowitz, H. (1952) "The Utility of Wealth", *Journal of Political Economy*, 60,2, 151-158.

Partnership Africa Canada and Global Witness, (2004) "Rich Man, Poor Man; Development Diamonds and Poverty Diamonds: The Potential for Change in the Artisanal Alluvial Diamond Fields of Africa", Global Witness report, October.

Ramey, G., and V.A. Ramey (1995) "Cross-Country Evidence on the Link between Volatility and Growth", *American Economic Review*, 85, 1138-1151.

Saylor R. G. (1967) *The Economic System of Sierra Leone* (Durham, N.C. Duke University Press).

Smillie, I., L. Gberie, and R. Hazleton (2000) *The Heart of the Matter: Sierra Leone Diamonds and Human Security*. Ottawa: Partnership Africa Canada.

Stark, O. (1991) *The Migration of Labour*. Oxford, UK: Blackwells.

Torvik, R., (2002) "Natural Resources, Rent Seeking and Welfare" *Journal of Development Economics*, 67, 455-470.

Tversky, A. and D. Kahneman (1992) "Advances in Prospect Theory: Cumulative Representation of Uncertainty" *Journal of Risk and Uncertainty*, 5(4): 297-323.

van der Laan, H.L. (1965) *The Sierra Leone Diamonds*. Oxford, UK: Oxford University Press.

van Wijnbergen, S. (1984) "The Dutch Disease: A Disease After All" *Economic Journal* 94, 41-55.

White, M (1989) “The Corporate Bankruptcy Decision”. *Journal of Economic Perspectives*, 3(2), 129-151.

White, M., (2007), “Bankruptcy Law” in Handbook of Law and Economics, edited by A.M. Polinsky and Steven Shavell.