Recovering *Ex situ* Gemstones in African Countries: The Economic Man Versus the Police Man[1]

by
Voxi Heinrich Amavilah
Mineral Economics Program
Department of Mining and Geological Engineering
The University of Arizona
Tucson, AZ 85721, USA

and

Ore Body Engineering, Ltd
P.O.Box 3573
Tucson, AZ 85719, USA

All Correspondence to:
VHS Amavilah
3425 West Golden Lane
Phoenix, AZ 85051, USA

[1]An earlier version of this paper was submitted to the Permanent Secretariat of the Ministry of Mines and Energy of the Republic of Namibia in July 1992. This version has been revised and expanded. I am grateful to my wife Tamara Bishop-Amavilah for editing and word-processing this paper as a surprise birthday gift. All all mistakes remain mine alone.

Abstract

The illicit dealing in gemstones is a fast growing activity in African countries which produce these minerals. Zaire and Angola are two extreme examples but by no means exceptions. The preferred policy efforts to controlling the flow of illicit trade in gems have been legislative actions -- the police man. However, the police man has invariably failed to do the intended job. As an alternative this analysis argues for an economic approach -- the economic man. It suggests how good old economic principles may be used to price out of the market and recover *ex situ* gems from illicit traders with only little modifications for local conditions. The conclusion is that even under a limited liberalization regime the economic man tends to be more efficient and effective than the police man.

1. Objective and Organization

The objective of this theoretical analysis is to direct critical thinking toward an economic means of reducing illicit gemstone activities in African countries. Section 2 gives a background perspective on the problem stated in Section 3. In this section too the dimension of the problem in four African countries is sketched. Section 3 outlines the importance of the problem, and the potential benefits from its solution are justified. A solution is proposed in Section 4 followed by concluding remarks in Section 5.

In any case attention is drawn to the proposition that economic theory offers the best means to recovering *ex-situ* (out of the ground) gemstones from those already holding them illegally. It is argued that the economic man is more efficient and effective than the policeman. Having said that, we caution, however, that the superiority of the economic man over the police man cannot and should not be construed as promotion for an illegal activity; rather it is a suggestion that any attempt to improve upon the willingness of illicit gemstone dealers to declare their loot *must simultaneously and in credible ways take into account the self-interests of those dealers*. This may be unfortunate and undesirable but nonetheless inevitable.

2. Perspective

The illicit dealing (mining and trading) in gemstones (diamonds and emeralds mainly) is a fast growing activity in African countries which produce these minerals. This is not

unexpected, as these gemstones have huge unit values and low volume, as well as low transport costs. Of concern is the dimension of the problem revealed by the fact that among the major diamond producing African countries, only Botswana and South Africa have not publicly admitted having this problem. Elsewhere there is sufficient evidence that "more than 50% of the artisanal and small-[scale] mining production of gemstones (diamonds, emeralds, etc.) and gold are traded illegally, causing significant direct and potential economic losses to affected countries (Kambani, 1995 p.107). Here are a few examples.

In Zaire up to US$400 million of diamonds and gold are exported illegally (Kambani, 1995; Jennings, 1993). The Zairean government initially set up local diamond buying offices such as Mbujimaji in order to reduce the activity. Whatever the verdict of the initial response, it is widely known that by 1994 five million carats of diamonds per annum were leaving the country through illicit trade. If true that the government of Zaire has now revoked the legal status of small-scale diamond miners except those operating around the property of the diamond mining firm Miba (**A**frican **R**esearch **B**ulletin (ARB), 1994), it is the case that the illicit trade in gemstones in that country can be expected to rise. By controlling the quantity of illicit gemstones, the policy essentially raises its corresponding black market price. Higher prices would then induce further entry into the illicit activity.

As a second example the Reserved Mineral Corporation (RMC) of

Zambia was created in c.1980 to counter illegal dealing in emeralds by purchasing emeralds from illicit miners and others under an amnesty. Incipiently RMC seemed like it was going to succeed where others had failed. But as with most parastatals bureaucratic tendencies crept in; a marketing function was added to the company's original mission, and "things fell apart". By 1983 the US$14.7 million joint venture between RMC and the International Development and Construction Corporation of Saudi Arabia (IDCO) had unraveled.

A new venture between Brazil and Zambia resulted in the Zambia Emeralds Industries, Ltd. (ZEIL). But ZEIL faced problems from the very start, problems that were compounded by the weak economy and the transition from the Kaunda dictatorship to the slightly more liberal new regime. One important event was a break-in at the ZEIL offices in which a substantial amount of emeralds was stolen (ARB, op. cit). The monetary value of the loss remains unclear; clear is that in 1988 the licit emerald exports value from Zambia was only US$8.0 million while US$180 million worth of illicit emeralds exports entered Israel alone in that same year (ARB, op. cit.).

Although 100 to 200 small miners are licenced in Zambia, not all have full title and/or leasehold title to the properties they work. The extant revocable licence scheme has induced competitive rent seeking behavior which has constrained long-run investment decisions in the country's emeralds industry. Thus in 1990 the volume of illicit emeralds exports from Zambia was estimaterd by

Kambani (1995), Bull (1993), and Ward (1990) at beween US$110 million to US$310 million.

The illicit diamond activity has been the worst in Angola. During the 1983/84 fiscal year Diamang/Endiama lost over 20% of its diamond production to illicit trading. Twenty percent represented roughly US$140 million of high grade diamonds. By 1991 smugglers were exporting as much as US$20 million worth of diamonds from the Lunda Norte and Sul region alone. The current flow of illicit diamond trade in Angola is estimated at US$0.45 billion per year (ARB, 1994).

Zaire, Zambia and Angola are the worst-case examples of illicit gemstone dealing, but the problem is by no means peculiar to these three countries. In the past the Namibian diamond producer, the Consolidated Diamond Mines, Ltd (CDM), adopted a "keep quiet" attitude toward illegal diamond smuggling. Recently the company acknowledged the problem (ARB, 1992). Even more revealing is that De Beers' consent to Namibian government equity participation may well have been motivated by the company's desire to have the policeman on its side in the fight against the illicit diamond trade which court-cases have shown is growing rapidly (see *The Namibian*, 1992-1993).

3. The problem

The illicit gemstone trade affects production and investment behavior, government tax revenue, and foreign exchange earnings (see Kambani, 1995 for a diagramatic exposition). There is thus legitimate concern about this problem and especially about whether

economic theory has something else better to offer in the way of recovering gems than legislative directives which are currently used to manage illicit trade in gems.

The debate over the original sources of *ex situ* gem reserves and the manner in which these gems were obtained is not a relevant point to this analysis. The relevant point is how to recover such reserves. This is why the proposition that the economic man is a more efficient and effective tool for recovering stolen gems than the policeman is important. A major assumption of this proposition is that *illegal dealers are rational*. Any attempt at recovering stolen gems from them that does not consider their self-interests is bound to meet limited success. That is one issue. A related issue is that prohibition of any illegal possession of gems may be effective in controlling future theft, but serious debate can surely be engaged as to the precise manner by which that can be carried out. What is clear is that the effect of prohibition on the recovery of gems already stolen is practically NIL. The implication here is that the effect of legislative actions on the underground gem economy will remain limited for the foreseeable future thereby elevating further the need for clear thinking.

Hence, two options are open to the affected countries. The first is to continue with the *status quo*. An alternative option is to resort to economic principles. The implication of the latter option is that a bitter pill would have to be swallowed, perhaps more than once. Because the causes of illicit trading in gems (see Kambani, 1995, pp.108-110) are such that a liberal institutional

setting is required for an optimal solution to this problem, an economic approach will work only in a setting that approximates the free market. The bitter pill that must be swallowed in this instance is that the proper working of a market requires the voluntary coming together of illegal dealers and the government to exchange for mutual gain -- something the policeman cannot do well.

Two arguments against the economic approach can be anticipated. Politicians may argue that an economic approach is tantamount to rewarding gem thieves which then means encouraging further theft. With respect to the latter an economic approach to illicit gem trade neither requires the abolition of current laws nor relaxation of extant security schemes. The argument about rewarding theft is fundamentally flawed. It is known that DeBeers itself has frequently bought up diamonds entering the market illegally. This is no act of disinterestedness or altruism on the part of DeBeers; it is an act in self-interest: to support diamond prices - - a simple law of supply and demand. By the same token, it is in the best interests of affected gemstone producers to maintain a healthy diamond market upon which they so heavily depend for revenue. It seems reasonable to argue that African countries have double to lose from continued illicit gemstone dealings (1) by letting the valuable assets (wealth) produced by illicit gem trade within their borders remain unutilized, and (2) by allowing the supply of illicit gems to influence free market gem prices.

A second argument to be anticipated is the notion that liberalizing domestic gemstone industries will depress free market prices in the long-run. This notion is correct but only in the sense that free and black market prices are related. However, it does not tell us anything about the winners and losers from reduced prices that **may** follow. With respect to extant illicit *ex situ* gems this argument is like a tail wagging a dog. If every gem producer was able to minimize the flow of illicit gems into the market the opposite is equally likely to happen. That is obvious; it would also be possible in the case of diamonds for the Central Selling Organization (CSO) to pay different prices for homogeneous gems assuming that the free market gem price (P^m) is the sum of marginal production cost (MC), transport and insurance costs (TC), credits for keeping the market price stable (premium for stemming illicit product entry into the gem market ρ and the gem quality premium (ρ_q): $P = MC + TC + \rho_s + \rho_q > MC + TC - \rho_s + \rho_q$.

There is sufficient evidence that a liberal institutional attitude toward illicit gemstone activities has improved the declaration problem in a number of countries (Kambani, 1995; Traore, 1993). Even better evidenced are the positive effects of appropriate monetary and fiscal policies on the performance and recovery rate of gems from illicit dealers (Gocht, et. al., 1988). Little explored is the pricing system that is central to the recovery of stolen gemstones in African countries as elsewhere. This is an importance problem. In a free-market system market scanners discover gem prices and relay price information to market

observers who then determine prices from demand and supply configurations as revealed by markets. It is, however, very unlikely given the current status of *markets* and political orientations of African governments to expect the total liberalization of the now illicit gemstone trade to come about soon. Part of the difficulty appears to be that these governments are unaware or unconvinced of the appropriateness of economic approaches to the problem. This exercise works out very simple pricing rules which must be of interest to policy-makers!

4.0. Pricing Stolen Gems

The central measure of the value of any economic good, including gems, is its price. Thus the gemstone declaration problem is a problem about the necessary and sufficient price for the exchange between legal and illegal dealers: What that price must be, what its implications are likely to be for the participants, and the extent to which it affects the specific-to-general- welfare of concerned agents.

The here proposal is that the purchase (offer) price be negotiated between each illicit gem seller and licit buyers (including, but not advisably, government buyers) on the basis of the free-market price of quality-equivalent stones. As long as negotiation (transaction) cost are sufficiently low, and if bargaining is possible, negotiation in that case as Coase (1960) has taught economists leads to efficiency (optimal price) irrespective of the manner by which gems were initially acquired (the structure of property rights). Such a price (P) must be

equal to or higher than the black market price (P_b) but *strictly* equal to or lower than the free market price (P_m), i.e. $P_b \leq P < P_m$. Government's role then is confined only to assessing an income tax at a rate τ or an ad valoram tax at a rate ' on sales of taxable magnitude consistent with the extant taxation regime of each country. Its (government's) success will then depend upon the efficieny and optimality of the taxation regime and not on how illicit gems are priced. In any event the efficiency outcome of price negotiation will not be disturbed by a "good" tax.

Let the negotiated price, P, be,

$$P_b \leq P = (1-\phi)P_m < P_m \qquad \mathbf{1}$$

where P is the price negotiated by the illicit trader and licit buyer, P_m is the free market gem price, P_b is the on-going (known or unknown) black market price for the gem, and $\varphi \in \{0,1\}$ is a negotiable netback coefficient. Since P_m is exogeneous to the negotiation process, the key negotiation point is to find φ that makes P necessary and sufficient to the trading agents (an optimal outcome) see e.g.Debreu (1987). Negotiation over P is really negotiation over φ. How high or low φ is will depend upon the bargaining power and skills of traders. Whatever the outcome might be is a matter of distributive equity and not of efficiency.

4.1. Gem Pricing Under Competition

Assume many illegal gem sellers and many buyers (government participation is allowed but not required). Further assume zero external trade such that the quantity the i^{th} illegal gem seller

$$P_i = (1-\phi)P_{i-1} - \theta[(1-\phi)P_{i-1}] \qquad \mathbf{2}$$

will sell at P is x_i and the appropriate tax rate applicable to the sale of x_i is θ, designated as τ for income tax and/or ' for an ad valoreum tax. The i^{th} seller's revenue (R_i) will be,
The illicit seller will pick from his hidden reserve (*ex situ*) that x_i for which the negotiated P is acceptable (necessary). At that price the amount the gem thief selects to sell maximizes R_i iff,

$$dR_i / dx_i = (1-\phi)P_m - \theta[(1-\phi)P_m] = 0 \qquad \textbf{3}$$

Eq. (3) is the usual price-equal-marginal cost rule. The only qualification to be observed is that marginal cost in this case is marginal tax cost plus marginal theft penalty since the gem thief has no explicit production cost. That is, the price the i^{th} thief receives for his i^{th} marginal gem equals the direct marginal tax cost plus indirect marginal theft cost. Whether the illicit gem seller sells at that price or not depends on the optimality of φ and on what the difference between the free-market and the black market price (P_b) is taking into account the tax rate. If the difference between P_b and P is smaller than the tax cost, the dealer will tend to the black market if also the risk premium (ρ_r) of being caught is lower than the tax cost since $P_b = P_m - \rho_r$. With $\rho_r = \theta(1-\varphi)$ the seller is indifferent between the black market and the negotiated scheme. How close P_b is to P depends upon how close ρ_r is to $\theta\varphi$. What is clear is that the seller will weigh his net revenue based on knowledge of pre-negotiation and post-negotiation decision rules, that is, considering R_i (x_i, P,

P_b).

So far focus has been on the i^{th} thief's gains. To view the benefits due to the buyer let C_i be the real cost to the buyer per individual purchase including all risks. Net gains (R_p) to the buyer(s) will be total revenue from the sale of x_i at the free market price plus tax revenue from the purchase of x_i at $P < P_m$ minus the purchase cost on x_i at P, minus all other costs, i.e.

$$R_p = P_m x_i + (1-\phi) P_m x_i + \theta[(1-\phi) P_m x_i] - (1-\phi) P_m x_i - C_i x_i \qquad \textbf{4}$$

Define total cost to buyer(s) as $_x_i \equiv C_i x_i + (1-\varphi) P_m x_i \ni R_p = P_m x_i = (1-\varphi) P_m x_i = \theta[(1-\varphi) P_m x_i] - __i x_i$. The first order conditions follow as,

$$dR_p / dx_i = P_m + (1-\phi) P_m + \theta[(1-\phi) P_m] - \tilde{c}_i = 0 \qquad \textbf{5}$$

If the buyer is government all of (5) belongs to government. If, however, the buyer is a private agent, it gains $P_m + (1-\varphi)P - __i$ and government receives $\theta[(1-\varphi)P_m] - __i$. Here we consider a tax only on stolen stones. But normally licit buyers also face a tax. In that case government revenue is $\theta P_m + \theta[(1-\varphi)P_m] - __i$. The implication of this must be obvious and that is that government is better off if it does not participate in buying gems from thieves but permits private agents to do so because $\theta[(1-\varphi)P_m] < \theta P_m + \theta[(1-\varphi)P_m] \Rightarrow$ government does not tax itself, and so $\theta P_m = 0$. To determine P^* and φ^* which conditions the pricing system, set (3) = (5) and solve simultaneously for P^* and φ^*. That is $dR_i/dx_i = dR_p/dx_i = (1-\varphi)P_m - \theta[(1-\varphi)P_m] = P_m + (1-\varphi)P_m + \theta\{(1-\varphi)P_m] - __i$. Using (1), $P^* = (P_m - __i)/2\theta$. Similarly, φ^* can be found to be,

$$\phi^{*} = (1 + 2\theta - \tilde{c}_i)/2\theta \quad \in [0,1] \qquad \textbf{6}$$

since $\theta \in [0,1]$ and $__i > 0$. A logical proposition resulting from (6) is that the long-run behavior of φ^* is the conditioner of the behavior of sellers and buyers of gems. Its arbitrary theorems are: If $\varphi^* = 0$, $P = P_m$ and the illegal activity is totally eliminated and the market clears; if $\varphi^* = 1$, $P = 0$, $P_b > 0$ and all illicit gems either remain stashed away or they enter the black market. The implication is that a government program that offers a negotiated price lower than the black market price will beyond will almost certainly fail to recover illicit gems. That is, $\forall [P_b \leq P < P_m]\ \exists [0 < \varphi^* \leq 1]$.

The foregoing analysis can be generalized quite easily. Using (1) and assuming that for n > 1 individual purchases $X = \Sigma^n_i x_i$, sellers' total revenue is the sum of quantities each seller is willing to sell at the negotiated price. Total program gains (TRp) become,

$$TR_p = P_m X + PX + \theta PX - PX - C_p X = (p_m - \theta - c_p)X \qquad \textbf{7}$$

where $C_p = \sum^n_{i_i} x_i$. Eq. (7) is maximum at $P_m + \psi P + \theta P - P - C_p = 0$ $\Rightarrow P_m + P(\psi + \theta - 1) - C_p = 0$, where $\psi = 1 - \varphi$. Note that this solution is similar but not identical to (5) because (7) is evaluated at $\sum^n_i x_i > x_i$.

Now assuming a normal probability distribution of gems among illicit traders, the desired cut-off quantity of gemstones that must be purchased for the negotiated market to be sustainable (X^*)

is

$$X^{*} = E(X) + \beta var(x_i) = \sum_{i}^{N} Xf(x)dx + \beta[\in (X) - \mu]^2 \qquad \textbf{8}$$

where $\mu = E(X) = f(P, P_b, x_i)$ are conditional expectations of quantities individuals are willing to sell at the negotiated price, $var(X_T) = q(P, P_b, P_m, Z)$ is the variabilities in the unknown total *ex situ* stock, X_T, where X_T is determined by the negotiated price, black market price, free market price and other demand/supply determinants (Z), cpmpare to Braverman, et. al, (1992), and Newberry and Stiglitz (1981). Thus, the target net income will be $TR^{*}_{p} = X^{*}[P_m + P(\psi + \theta - 1) - C_p]$.

Given TR^{*}_{p} and TR_p the social impact of a negotiated market upon the country's consumption, savings, gross domestic product, and investment can easily be assessed. How such an assessment may procede is a separate proposal from this study.

4.2. Pricing Homogeneous Gems under Monopolistic Competition

The previous discussion has banned the influence of international gemstone markets upon the negotiated domestic market. The only reference made to the international trade in gems was through the free market price upon which the negotiated price is fractional. When these assumptions are relaxed competition as perceived in Section 4.1 above is altered. And indeed gemstone markets are specialized markets and the free market price may itself be a negotiated or contract price. This is certainly true of the gem diamonds market which is to a large

extent controlled by De Beers' CSO. Instead of being horizontal the world demand for gem diamonds is downward sloping (perhaps steeply and in some narrow confines of high grade and high income groups it may be upward sloping -- a Veblen good versus a Giffen good). If so, upon which the negotiated price is based, facing the j^{th} legal seller would depend upon j's output and the sum of outputs of other sellers in the market (oligopoly). Let that inverse demand be,

$$P_{m,j} = A_j - \alpha_j x_j - \sum_{j_i}^{n} \beta_{ji} x_i, i_j = 1,2,...,n \qquad \textbf{9}$$

Since $dP_{m,j}/dx_i = -\beta_{ji} < 0$, by assumption sellers face identical world demand $\ni \beta_{ji} = \beta$. Supposing further that production costs $c_j(x_j) \neq c_i(x_i) > 0$, the world demand facing a representative seller j is thus,

$$P_{m,j} = A - \alpha x_j - \beta \sum_{i_j}^{n} x_i \qquad \textbf{10}$$

Eq. (10) evidently suggests that the demand facing the representative seller of stolen gems bought at a negotiated price is,

$$P_b \leq P_j = (1 - \phi)[A - \alpha x_j - \beta \sum_{i_j}^{n} x_i] \qquad \textbf{11}$$

The implication of (11) is that the j^{th} seller of stolen gems under-prices the licit gem miner (dealer) in the same market or his profits will be higher since $P_{m,j} > P_j \geq P_b$. To appreciate the argument let $C_j(x_j) > 0$ be the cost to a trader who sells to buyers

at the free market price in (9) or (10) only stolen gems purchased at a negotiated price , i.e. the cost to j is the sum he paid for the gems $(1-\varphi)P_m \cdot x_j = C_j x_j$. It follows that his net revenues will be,

$$R_j = P_{m,j}\, x_j - (1-\phi)\, P_m\, x_j \qquad \textbf{12}$$

After substituting for $P_{m,j}$ we get,

$$R_j = [A - \alpha x_j - \beta \sum_{i_j}^{n} x_i]\, x_i - (1-\phi)[A - \alpha x_j - \beta \sum_{i_j} x_i]\, x_j \qquad \textbf{13}$$

Expansion of (13) above equation yields,

$$R_j = [A - \alpha x_j - \beta \sum_{i_j}^{n} x_i]\, x_j - x_j [A - \alpha x_j - \beta \sum_{i_j}^{n} x_i - \phi A + \phi\alpha x_j + \phi\beta \sum_{i_j}^{n} x_i] \qquad \textbf{14}$$

Applying an income tax θ on (12) for illustrative purposes we obtain,

$$r_j = -\theta [\phi A\, x_j - \phi\alpha\, x_j^2 - \phi\beta \sum_{i_j}^{n} x_i\, x_j] \qquad \textbf{15}$$

Taking the partial derivatives of the bracketed part of (15) with respect to x_j, we find,

$$\frac{\partial r_j}{\partial x_j} = -\theta [\phi A - 2\phi\alpha x_j + \phi\beta \sum_{i_j}^{n} x_i] > -\theta [A + 2\alpha x_j - \beta \sum_{i_J}^{n} x_i - c_i \qquad \textbf{16}$$

The LHS (left-hand side) of (16) is greater than the RHS (right-hand side) which would have obtained if the seller sold at P_m but produced at some cost $C_i(x_j) > 0$. The reader can work out the

implications of an ad valoram tax. In either case sellers, buyers and government all benefit from a quasi-competitive market allowance in which agents within legal frameworks enter exchange of illicit gemstones on voluntary and free terms.

In addition, gemstone homogeneity implies that the quality of the i^{th} stone is the same as that of the j^{th} stone. Under this assumption the demand for stolen gems will be conditioned by the industry's effective demand such that $P_{m,j} = [A - (\alpha + (n-1))\beta]x_j$. Hence given j's costs $C_j x_j$, the resulting profit will be $r_j = P_{m,j}x_j - P_j x_j = \{[A - (\alpha + (n-1))\beta]x_j\}x_j - (1-\varphi)\{[A - (\alpha + (n-1))\beta]x_j\}x_j \Rightarrow [Ax_j - (\alpha + (n-1))\beta x^2_j] - (1 - \varphi)[Ax_j - (\alpha + (n-1))\beta x^2_j \Rightarrow 2[A - (\alpha + (n-1)\beta]x_j - (1 - \varphi)2[A - (\alpha + (n-1))]\, x_j = 0$ at the maximum point.

Using (4) to (8) in the framework of (9) to (13) it becomes easy to evaluate the benefits and costs of an economic approach to the problem of illicit gemstone trade. It is clear in the case in which government is the sole buyer that the illegal gem trade will continue unabated unless the price offered is above the black market price. In the final section below the case involving horizontal gem differentiation under imperfect competition is sketched following the models of Dixit (1979; 1977) and Beath and Katsoulacos (1991).

4.3. Pricing Horizontally Differentiated Gems under Imperfect Competition

Assume that buyers purchase stolen gems locally at differentiated prices P_i according to gem quality (q_i) and sell

them in the free market also at differentiated prices $P_{i,m}$. In reality international sales of gems involve both stolen and "legal" gems but we ignore reality a bit. Assume instead that only stolen gems are sold or they are sold separately from licit ones. In that case the inverse demand for quality-differentiated gems is,

$$P_i = P(x_i, q_i) = P(x'_i) \qquad \textbf{17}$$

where $x'_i = x_i q_i$, for $\partial P(x'_i)/\partial x_i < 0$ and $\partial P(x'_i)/\partial q_i > 0$. What matters is the quality-adjusted gem (quantity), $x'_i - q_i x_i$, . In that case the gross pay-off to market agents (σ) from sales of x'_i is,

$$\sigma(x'_i) = \int_0^{x'_i} x'_i(\sigma, x_i)\, d\sigma \qquad \textbf{18}$$

i.e. the area under the demand curve. Therefore, net (18) will be $\sigma(x'_i) - x_i P(x'_i)$. Since production costs are increasing more in q_i than in x_i, that is $\partial C(x'_i)/\partial x_i \cdot 1/x_i < \partial C(x'_i)/\partial q_i \cdot 1/q_i$, then the gain from market exchange in this instance will be $R_p(x'_i, P_i) = x_i P(x'_i) - C(x'_i)$. This suggests that total gain (TR_p) is $TR_p(x'_i, P_i) = \sigma(x'_i) + R_p(x'_i, P_i) = \sigma(x'_i) - C(x'_i)$ which gives $dTR_p/dq_i = \sigma_q(x'_i) - C_q(x'_i)$ and $dTR_p/dx_i = P_x(x'_i) - C_x(x'_i)$, where $\pi(x'_i) = F(x_i, q_i) = f(x_i * q_i)$. This means that the quality-adjusted revenue, R_p is ,

$$R_p = P_{i,m}(x'_i)x'_i + \psi P_i(x'_i)x'_i + \theta P_i(x'_i)x'_i - P(x'_i)x'_i - C(x'_i)x'_i \qquad \textbf{19}$$

The first order conditions for profit maximization with respect to q_i and x_i are straightforward. The difficulty is the implication

that quality and quantity are separable. Differentiation by the chain rule only complicates understanding. Thus the general form (19) is only indicative and simpler since its first order condition can be shown to be $dR_p/dx_i = P_{i,m}(x'_i)+\psi P_i(x'_i)+\theta P_i(x'_i)-P_i(x'_i)-C(x'_i) = 0$. This means $P_{i,m}(x'_i)+\psi P_i(x'_i) = P_i(x'_i)+C(x'_i) \Rightarrow P_{i,m}(x'_i)+\psi P_i(x'_i) = _(x'_i)$, where $_(x'_i) = C(x'_i) + P_i(x'_i)$ as designated above.

Under the assumption of differentiated gems (9) becomes,

$$P_{i,m,j}(x'_j) = A - \alpha x'_j - \beta \sum_{i _ j}^{n} x'_i \qquad \textbf{20}$$

Defining $X'_i \equiv \sum^{n}_{i \neq j} x'_i$, it follows that $P_i(x'_i) = (1-\varphi)P_{i,m,j}(x'_j)$ and after-tax (income) profit will simply be $r_j = P_{i,m,j}(\cdot)x'_j - P_{i,m,j}(1-\varphi)x'_j = \{[A-\alpha x'_j-\beta x'_i]x'_j-(1-\varphi)[A-\alpha x'_j-\beta x'_i]x'_j\}\theta$ -- QED (13) above. The reader can work out the relationships with regard to the industry in the context of horizontal product differentiation discussed in this section.

5. Conclusions

The problem of illicit gemstone mining and trading is growing rapidly in African countries. Attempts in Zaire, Zambia and Angola to solve this problem by legislative actions have had limited success. With respect to recovering *ex situ* gemstones already in the hands of illicit dealers prohibition has totally failed. Therefore, affected countries have two options open to them. The first option is to continue with the *status quo*. The implication of this option is that affected countries must lower

their expectations for ever solving the problem. An alternative option is to liberalize the illicit activity. Full liberalization will solve the problem completely, but even moderate liberalization will allow market-like solutions to emerge.

This analysis has assumed that market-like arrangements exist or can be induced. It then derived three alternative pricing rules relevant to gem markets. In each case the outcome of these pricing rules is efficient. Each efficient outcome represents a potential gain to all agents involved. Hence it is concluded that the economic man is indeed more effective than the policeman!

References

Africa Research Bulletin, Various, (1983-1995).

Beath, John and Yannis Katsoulacos (1991) *The Economic Theory of Product Differentiation*, Cambridge: Cambridge University Press, Chapters 3,5,7 and 9.

Braverman, Avishay, et. al., (1992) *Commodity Price Stabilization and Policy Reform: An approach to the Evaluation of Brazilian Price Band Proposals,* World Bank Regional and Sectoral Studies, The World Bank, Washington, D.C.

DeBreu, Gerald (1987) *The Theory of Value*, A Cowles Foundation Monograph 17, New Haven and London: Yale University Press (rpt), Chapter 3.

Dixit, A.K. (1979) 'Quality and Quantity Competition', *Review of Economic Studies*, 44: 589-99.

Dixit, A.K. and J.E. Stightz (1977) 'Monopolistic Competition and Optimum Product Diversity', *American Economic Review*, 67: 297-308.

Gocht, W>R>, H. Zantop and R.G. Eggert (1988) *International Mineral Economics: Mineral Exploration, Mine Valuation, Mineral Markets, International Mineral Policies*, New York: Spring-Verlag, Part II and III.

Henderson, James M. and Richard E. Quandt (1980) *Microeconomic Theory: A Mathematical Approach*, 3rd Ed., London: McGraw-Hill.

Jennings, N.S. (1993) 'Small-Scale Mining in Developing Countries: Addressing Labour and Social Issues', in *U.N. Interregional Services on Guidelines for Development of Small and Medium Scale Mining*, Harare, Zimbabwe: United

Nations, 15–19 February.

Kambani, Stephens M. (1995) 'The Illegal Trading of High Unit Value Minerals in Developing Countries', *Natural Resources Forum*, 19(2): 107–112.

Newberry, D., and J. Stiglitz (1981) *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*, Oxford: Clarendon Press.

Traore, P.A. (1994) 'Constraints on Small–Scale Mining in Africa', *Natural Resources Forum*, 18(3): 207–212.