FISCAL POLICY AND DEVELOPMENT ALTERNATIVES FOR THE ANGOLAN DIAMOND INDUSTRY

by
Roger D. Scott

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Signed: Roger D. Scott

Roger D. Scott

Approved: Roderick G. Eggert

Dr. Roderick. G. Eggert
Thesis Advisor

Golden, Colorado

Date 10 Sept. 1990

John E. Tilton

Dr. John E. Tilton
Professor and Head
Mineral Economics Department

ABSTRACT

Angolan diamond production from alluvial sources is apparently set into a pattern of long-term decline. The industry needs to develop hard-rock diamond mines if it is to regain its former status as a significant diamond producer. The feasibility of such development and the means by which it may be achieved is the subject of this thesis.

Current Angolan policy towards foreign investment is reviewed. It is concluded that while recent statements of policy indicate an attractive environment for foreign investment, significant practical barriers remain, namely, a fixed and overvalued exchange rate and lack of specific fiscal legislation covering mining agreements.

A capital and operating cost model for a hard-rock diamond mine is developed based on the USBM Cost Estimating System. This model is found to perform satisfactorily when tested against an Australian deposit for which costs have been published. The model is then used to estimate cost for two Angolan prospects: a small kimberlite deposit requiring moderate capital investment and a large-scale major investment.

Financial simulation of the small-scale development indicates it is not viable even when financed by cheap development funds. Contributory reasons are low value ore,

short mine life, and lack of economies of scale. Financial modeling of the large-scale option shows it to be uneconomic under the existing fiscal legislation in Angola, Tanzania, and Botswana owing to the use of fixed rate taxation. The deposit is marginally economic under Ghanaian taxation which employs variable-rate tax instruments. Such a system of taxation is clearly required in Angola.

The marginal nature of the Angolan kimberlite prospects makes debt leveraged funding of projects attractive. Leverage gives large companies (with low risk premia on debt) an advantage over junior mining companies and suggests that De Beers is the most likely development vehicle for Angolan hard-rock diamond deposits.

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Chapter 1

INTRODUCTION

Diamonds are a commodity with which Africa is disproportionately well endowed compared with the rest of the world. Of the forty-one countries on the African continent, thirteen have exploited diamond deposits this century. The degree to which this endowment has contributed to development has varied from country to country. At one extreme, Botswana (with an average annual real GDP growth of 12.9% since 1971) owes its good fortune to the foreign exchange earnings derived from three diamond mines. At the other extreme, Tanzania appears to have derived little benefit from the exploitation of the world's largest diamond pipe. The object of this thesis is to assess the economic potential of hard-rock diamond deposits in Angola. With five known but undeveloped diamondiferous kimberlites, Angola is often cited in the mining press as having the potential of another Botswana. This study will attempt to determine whether that reputation has any substance.

For five hundred years Angola was a Portuguese colony and was one of the last countries in Africa to achieve independence when the Portuguese abruptly withdrew in 1975 as the result of a military coup in Portugal. This precipitous departure left a power vacuum which the proxies of the superpowers hastened to fill. The result of this has been that since 1975 the country has remained locked in a civil war that has brought economic development to a standstill. The best that can be said is that the level of infrastructure has remained frozen at 1975 levels (good by African standards). Angola has a healthy oil industry (geographically separated from areas of conflict) that has grown from a production of 159,000 barrels per day in 1975 to 450,000 in 1989. But the economy as a whole has stagnated in the post-colonial period, and living standards of individuals have declined sharply. Two factors are responsible. First, the bulk of the oil revenues have been consumed by the military budget. Second, the conflict has paralyzed the internal transport system, crippling the agricultural and mining sectors in the process. Both factors have largely offset the gains achieved in the oil industry.

Until the end of the 1980s the Angolan conflict appeared to be locked into an equilibrium of violence. Oil revenues and Soviet bloc military help ensured the government's ability to carry on fighting while South African and American support of guerrilla movements opposed to the government guaranteed the continuation of debilitating guerrilla war. This equilibrium now seems set to change. The independence of Namibia and South African preoccupation with domestic political matters has weakened the position of the guerrillas. Similarly, the withdrawal of Cuban troops and turmoil in the Soviet Union has deprived the Angolan government of much of its military support. Against this background it seems a reasonable bet that some form of negotiated settlement will be achieved in the medium term and that economic development will once again become feasible in Angola. Given this, oil and diamonds are certain to loom large in the list of candidates for engines of economic growth.

This study will examine the future economic prospects of the Angolan diamond industry and will focus in particular on the viability of known deposits, on the organizational variants by which they could be exploited, and on the impact of various forms of fiscal legislation on individual prospects. The viability of known prospects will be assessed by building a capital and operating cost model of a hard-rock diamond mine based on the USBM Cost Estimation System (USBM 1987) in which the Argyle Mine in Australia will serve both as a technical model and as a check on the accuracy of the cost model. This model will then be adapted to reflect the differing characteristics of the Angolan prospects that arise from geological differences and from different costs of the factors of production between countries.

Chapter 2

ECONOMIC AND ORGANIZATIONAL ASPECTS OF ANGOLAN DIAMOND RESOURCES

There are two aspects to the economic potential of diamonds in Angola. One is the short-term to medium-term economic potential of known resources and the other is the long-term mineral potential of the remainder of the country. These two economic objectives are also characterized by distinctly different levels of risk due to geographic factors in addition to normal (knowledge related) geological risk.

A line drawn across Angola from northeast to southwest (fig. 2.1) serves to divide the country into two categories as far as diamondiferous character and levels of infrastructure are concerned. The northwest sector has been thoroughly prospected, has demonstrable undeveloped diamond potential, and probably contains few surprises in the way of additional discoveries. The northwest is also well endowed with the necessary infrastructure.

The southeast sector of Angola has favorable geology, is essentially unprospected, and has a minimal level of infrastructure. It has considerable potential for major discoveries but (compared to the northwest) the level of

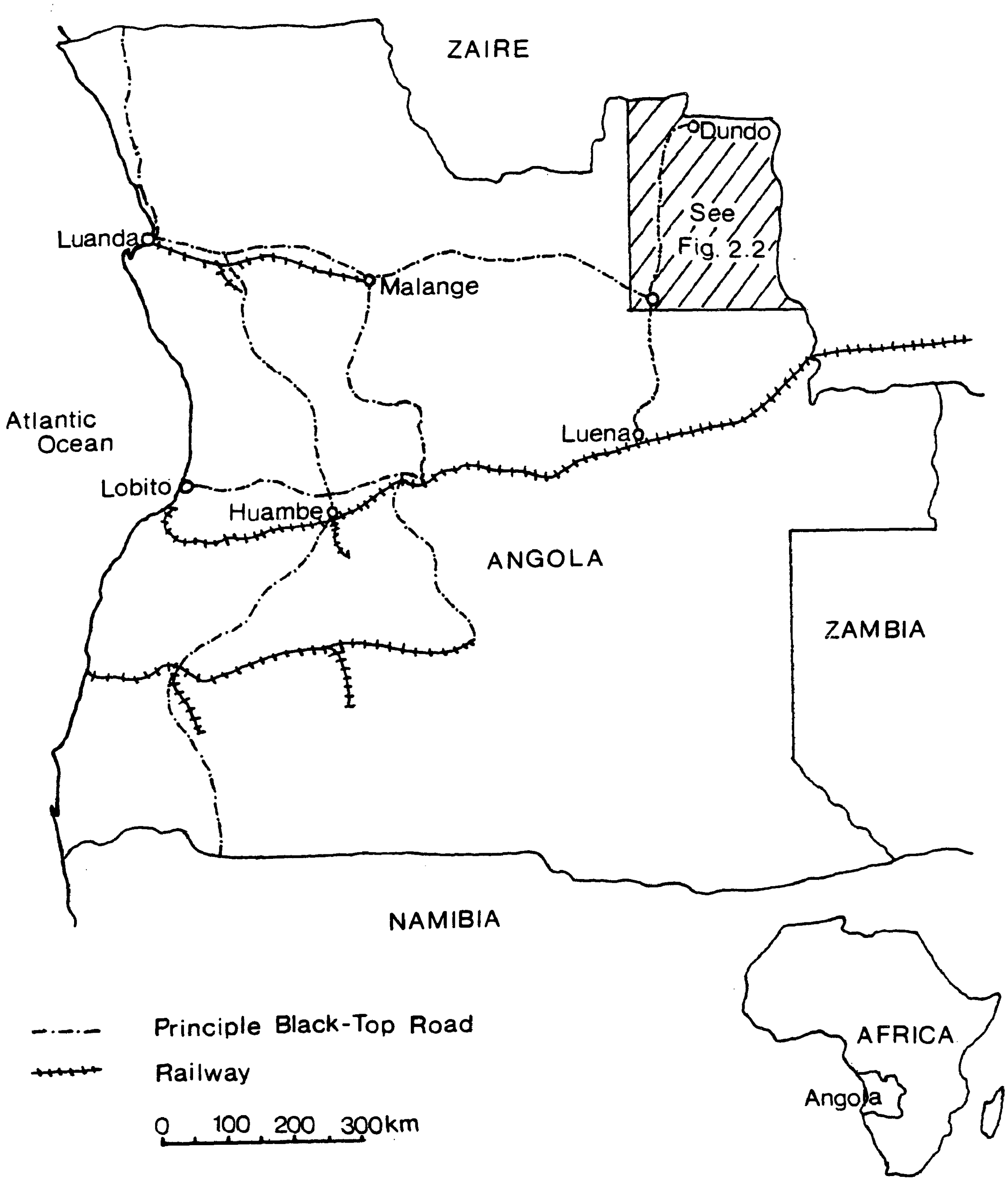

Figure 2.1 Angola Location and Infrastructure Map

Source: Jourdan, P. 1986. Raw Materials Report. 5 (no.1): 21-24.

risk is high given the level of geologic knowledge and the likely cost of development.

The diamond prospects that are the most likely targets for short to medium-term development (and which are the focus of this study) are located in the northwest sector. The same prospects are also likely to influence the final form of Angolan fiscal legislation which is currently under review. The danger exists that "bonanza psychology", encouraged by real or perceived notions of the known prospects, may lead to an onerous fiscal regime which discourages high risk exploration in the southeast. Angola's long-term potential may thus be sacrificed on the alter of medium-term expediency. The bulk of this study is concerned with placing a value on known resources and designing an appropriate fiscal policy, the likely impact of the policy on exploration activity will be returned to in the last chapter.

2.1 Economic Geology

Angola's known diamond resources occur in the northeast part of the country (fig. 2.2) where alluvial deposits have been commercially exploited along five northflowing rivers since 1917 (Helmore 1984).

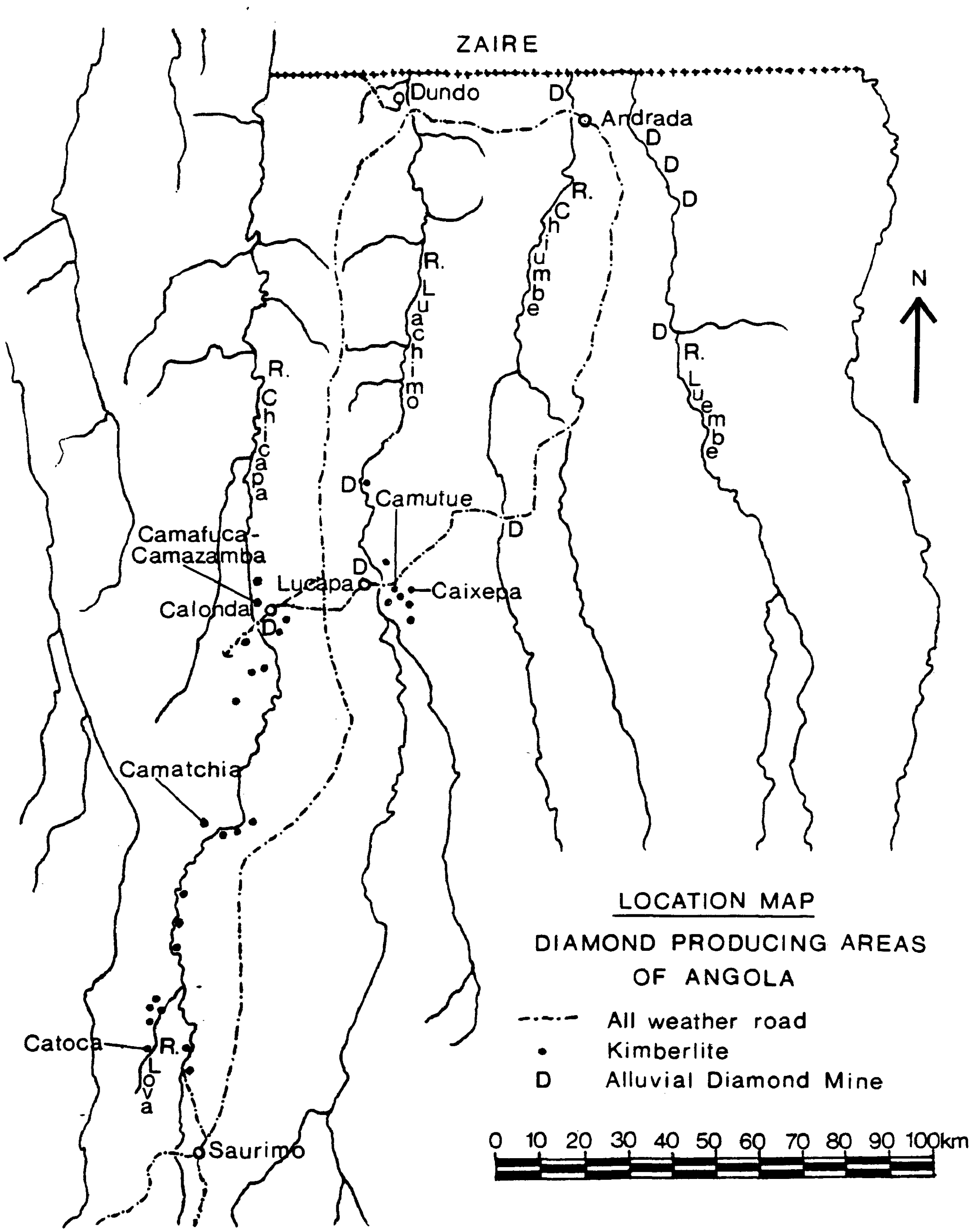

Figure 2.2 Diamond Area Locality Map

Source: Geological Survey of Angola

Four of these rivers (the Chicapa, Luachimo, Chiumbe, and Luembe) are located in the extreme northeast of the country while the fifth (the Cuango) is some 250 kilometers further to the west. Within this area there are three distinct types of diamond deposits, each of which has differing economics. To appreciate this it may be helpful to briefly describe the geological character of the area.

Some 130 million years ago Angola was subjected to a phase of rift faulting related to the formation of the Atlantic Ocean. A extensive series of northeast trending fractures developed across the country along which a host of volcanic centers were intruded. Amongst these intrusives are kimberlites (probably several hundred) of which about 1% contain, at least, subeconomic quantities of diamonds. The river systems of the time were also controlled by the same system of northeast trending fault troughs that had influenced kimberlite emplacement. The net result was the erosion of the upper parts of the kimberlite pipes and dispersion of their diamond content along the river systems. These fossil alluvial deposits are now known as the Calonda Formation. In the diamond areas the Calonda has been subsequently covered by about a hundred meters of younger sandy deposits.

Modern rivers that flow north have cut wide, flat-bottomed but steep sided valleys down through this geological layer cake. In the process the rivers have picked up diamonds where they intersect the old lines of kimberlite emplacement and the courses of the old Calonda rivers. This geological history has bequeathed three classes of diamond deposits to the region, all of which have contributed to past production to a greater or lesser extent.

Modern alluvial deposits related to the present river system have been the predominant historical source of diamonds owing to great areal extent, ease of access to mining equipment and low capital investment required.

Fossil alluvial deposits related to the Cretaceous river system have been worked by hydraulic mining in some areas where they outcrop in the valley sides as they can be treated in the same plants as the alluvial gravels. The limiting factor governing their exploitation is the overburden that has to be removed. The steep valley sides and thin ore horizons mean that excessive stripping ratios rapidly become the limiting factor as mining cuts back into the valley side.

To a limited extent the diamondiferous kimberlites that have been exposed by erosion have also been mined in relatively recent times. This mining, however, has been limited to the superficially weathered portions of the pipes that can be treated in the alluvial treatment plants.

Exploitation of the alluvial deposits has continued without interruption since the 1920s. Originally, mining was carried out in up to 45 small and geographically dispersed mines. In the late 1960s, large-scale, heavy-media plants were built in response to declining grades with the objective of tapping economies of scale. These plants have steadily depleted the alluvial deposits which are now nearing exhaustion. The state enterprise, Endiama, calculates that five years of alluvial reserves remain (Diamond International 1990). The remaining alluvial reserves are of steadily declining quality both in terms of grade and ease of access to mining equipment. Even under normal security conditions and with equipment operating at full capacity, a steadily declining diamond production is probably inevitable if alluvials continue to constitute the sole ore reserve.

The excessive overburden stripping requirements needed to access the diamond resources contained in the Calonda Formation effectively disqualify the Calonda as an significant source of future reserves. One is forced to the conclusion that the future depends on the kimberlites.

The decline in Angolan diamond production can be seen in table 2.1. Production has dropped steadily since 1971 apart from a brief renaissance in the early 1980s when mines were reequipped. The apparent recovery in the last three years is misleading and (if true) is the result of the exploitation of short-life bonanza deposits in the Caungo Division.

Table 2.1 Angolan Diamond Production, 1970 to 1989

Year	Production ('000 carats)	Year	Production ('000 carats)	
1970	2,396	1980	1,480	
1971	2,413	1981	1,400	
1972	2,155	1982	1,225	
1973	2,125	1983	1,034	
1974	1,960	1984	902	
1975	991	1985	704	
1976	340	1986	250	
1977	353	1987	190	(870)*
1978	700	1988	1,000	(1,000)
1979	750	1989		(1,200)

* alternative figures from Diamond International, April 1990
Source: USBM Mineral Yearbooks 1972-88

Some three hundred kimberlites have been discovered to date in Angola, most of which are barren (Diamond International 1990). Those which can be classed as possible diamond resources are restricted to the areas of historical diamond production. There are five serious candidates for exploitation, Catoca, Camatchia, Camafuca-Camazamba, Camutue, and Caixepa (fig. 2.2). Their principal characteristics are set out in table 2.2. All of these pipes are diamondiferous but none are obvious bonanzas of the order of Argyle (Australia) or Jwaneng (Botswana). Each pipe is different in terms of grade, size, diamond quality, and ease of development. Catoca and Camafuca-Camazamba are very large, modest grade deposits of mainly industrial stones. Of the two Catoca at 0.6 carats a ton is the highest grade and probably the better candidate for early development. The other three pipes are of modest size and low grade, but contain better quality stones. Of this group Camutue is probably best placed for development by virtue of its proximity to established infrastructure.

Table 2.2 Diamondiferous Angolan Kimberlite Pipes

Kimberlite	Surface Area (hectares)	Grade (carats/ton)	Stone Value (1977 US$/carat)
Catoca	66.0	0.6	15
Camafuca-Camazamba	70.0	0.19	35
Camatchia	<10.0	0.19	35
Camutue	9.0	0.12	130
Caixepa	2.3	0.10	150

<u>Source</u>: Lyons, L. 1983. <u>World Mining</u>. September. 50-56; Author's records

For the purposes of this study, Catoca and Camutue have been chosen as typifying the principal development options for hard-rock diamond mining in Angola. One option is for a very large producer of relatively low value stones such as Catoca. This would require a large capital investment. The other possibility is for a more modest investment in one of the smaller pipes that contain better value stones of which Camutue is representative.

2.2 Diamond Industry Organization

Historically, Angolan diamond mining was carried out under an exclusive fifty-year concession granted to the Portuguese firm, Companhia de Diamantes de Angola (Diamang). Diamang was a public company in which non-Portuguese institutional shareholders held some 30% of the equity. Diamang had exclusive rights to prospect for diamonds in Angola and was effectively the administrator of the northeast part of the country, which was in practice an enclave. The concession expired in 1970 and other companies were able to take up exploration licenses outside of Diamang's mining areas. As the largest of these, Condiama, was a Diamang/De Beers joint venture, the monopoly was in effect preserved.

At independence the Angolan government gained control of Diamang through nationalization of the Portuguese equity.

Following the enactment of the Mining Law of 1979 the Empresa Nacional de Diamantes de Angola (Endiama) was formed in 1981 (Jourdan 1986). Endiama is in effect a state mining enterprise to which the state has granted the exclusive right to mine and explore for diamonds in Angola. Until 1986 Diamang continued in existence as Endiama's mining division but was dissolved in 1986, whereupon Endiama assumed all operational functions.

The role of Endiama is similar to that of Sonangol, the state oil company. Endiama holds the rights, but most of the physical work is carried out by foreign firms. Operational difficulties in the early 1980s obliged Angola to rely on foreign companies for managerial and technical support. These companies operated under service contracts with Diamang (and, later, Endiama) which retained an administrative and financial role.

In summary, the exploitation of Angola's diamond resources has been conducted firstly under a monopolistic private enterprise system and then under a state monopoly. As the recent diamond production record shows, the latter system has failed to produce the goods and a move is now afoot to reintroduce elements of private enterprise into the industry. Recent policy has been to parcel out various areas for exploitation under service contract by foreign companies of which two (Roan Selection Trust, and Sociedade Portuguesa de Empreendimentos) are active at present. To date these operations have focused entirely on the remaining alluvial reserves.

Chapter 3
COST ESTIMATES

The viability of an ore deposit is dependent upon the capital and operating cost of the plant needed to exploit it, on the revenue received from sale of products, and on the fiscal legislation controlling the distribution of the income between stakeholders. In this chapter capital and operating cost estimates for possible hard-rock mines in Angola are derived. In the first part of the chapter a parametric model for a hard-rock diamond mine is developed. In part two the model is applied to two Angolan kimberlites.

3.1 A Cost Model for a Hard-Rock Diamond Mine

Compared to some other processes for recovering minerals from hard-rock deposits (e.g., copper) the recovery of diamonds from kimberlite deposits is relatively simple. The principal reason is that once liberated from the host rock, diamonds need no further upgrading prior to sale.

Although diamond recovery plants have been built in widely separated parts of the world they tend to be very similar. This is because the only hard-rock source of diamonds, kimberlite, has a fairly narrow range of metallurgical characteristics. Recovery plant similarity suggests that an adequately specified capital and operating cost model of an existing diamond mine should remain valid for mines located in other countries (with suitable adjustments for differing local costs of the factors of production). The objective of this chapter is to build such a model. The model will be based on the USBM Cost Estimating System. A recently constructed diamond mine will be used as a source of technical specifications, and as a check of the accuracy of cost estimates compared to actual, published costs.

In the past twenty years, seven hard-rock diamond mines have been developed in southern Africa (all but one by De Beers) and one has been developed in Australia by CRA. Of these eight mines, published information on mine and plant specifications and capital costs is available for three: Orapa in Botswana (Allen 1981), Letseng-la-Terai in Lesotho (Chadwick 1980) and Argyle in Australia (Lyons 1983; Lang 1986; Mining Magazine 1985). Of these three possibilities the Argyle mine is probably the best suited for modeling: (1) it has the most complete technical specification of the three; (2) it is the newest of the three, representing the state of the art in diamond recovery technology; and (3) at three million tons per year its throughput is about average for a diamond mine. Orapa is twice the size and Letseng-la-Terai half the size. A mid-range model was felt to be the best basis for extrapolative purposes. For these reasons the cost model developed in this study has been based on the Argyle mine (fig.3.1).

The costing system used is based on the USBM Cost Estimating System (USBM, 1987). This is a parametric estimating system in the form of a Lotus 1-2-3 spreadsheet that enables the capital and operating cost of a wide variety of mining and/or metallurgical processes to be estimated from some physical characteristic (e.g., throughput) of the process.

The USBM system is designed with commonplace metallurgical applications in mind. To accommodate some of the specialized processes involved in diamond recovery the spreadsheet had to be considerably modified.

In the case of the X-ray sorting equipment actual costs of the equipment was obtained from a supplier's quotation and from company sources. In other cases (of which the heavy media circuit is the main example) a closely related process modeled in the USBM system was modified to approximate to the diamond plant application. Some parametric equations developed elsewhere (Mular 1982) were imported into the USBM spreadsheet where they more closely accommodated known project characteristics than the standard USBM options.

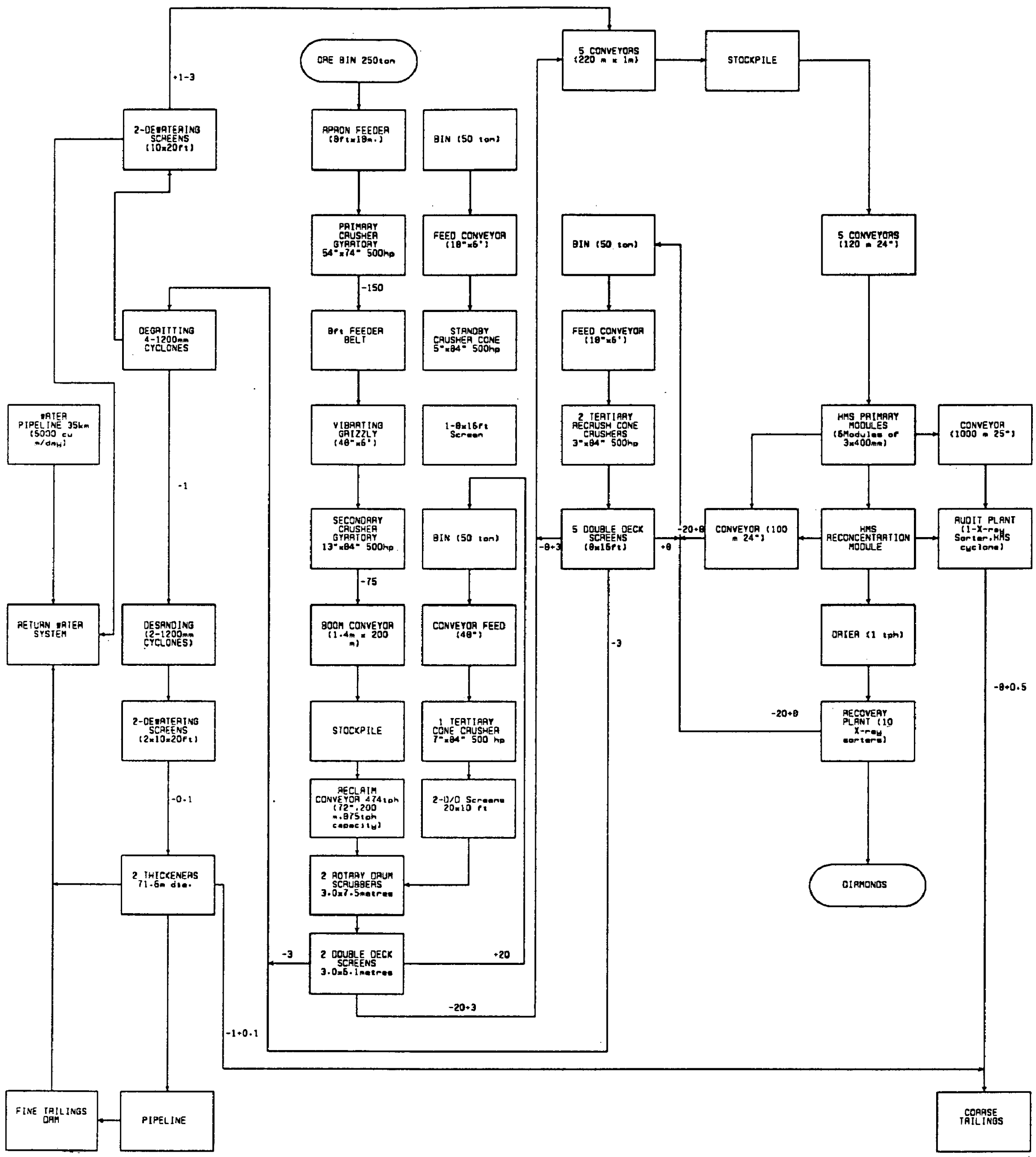

Figure 3.1 Simplified Flow Sheet of the Argyle Plant

Source: compiled from: Lang R. 1986. Mining Engineering. January. 13-16; Mining Magazine. 1985. November. 406-415.

3.1.1 Transport Factors

Transport costs strongly influence project capital costs. In the case of Argyle and the Angolan deposits, transportation is a critical factor as both projects are located several thousand kilometers from a the nearest logical source of equipment and supplies. The USBM system generates costs for a mine assumed to be located close to Denver and supplied from the nearest logical equipment sources. There is no standard routine available to factor in the effect of different transportation distances and this required additional spreadsheet modification.

To model the effect of long distance transportation location, factors for various categories of supplies and equipment were determined and built into the spreadsheet. This was done by selecting the current price of representative items of equipment, such as fabricated structural steel components, and determining the appropriate freight rate for these articles (Richardson 1990). Freight charges are determined by the freight classification of the item and its weight. Total freight charges are a linear function of distance and so the delivered cost of an item can be expressed as a function of factory price and the transportation distance.

For a given distance, delivered costs expressed as a fraction of the factory price are similar among like items (such as screen decks of varying sizes) but vary widely between different freight classes. For example, the price of various sizes of structural steel shipped 2,100 miles by road is 125%-130% of the factory price. Mining equipment moved the same distance costs 102%-103% of list price.

Freight factors for major cost items (vehicles, steel, process equipment, cement) were built into the default section of the spreadsheet and assigned to the various parametric equations that determine cost components by subjectively assessing their weight in that component. For example, one might judge that the supplies required to install a crusher are 80% steel and 20% cement on a factory price basis. The appropriate freight factor will be a hybrid of the steel and building materials factors in those proportions. Freight factors were calculated using 1990 costs corrected back to 1984 using appropriate indices to bring them into line with the rest of the USBM system which uses 1984 as a cost base. Although freight factors were calculated using data for the United States, the spreadsheet adjusts for projects in other countries by factoring in the local transportation and equipment cost indices. The appropriate expression for any freight class is:

$$TF_f = \{CI_f + [(T_d - 1) * TI_f * H]\} / CI_f$$

where: TF_f = Foreign Transport Factor
CI_f = Foreign Cost Index for item
T_d = United States Transport Factor
H = Haul Factor
TI_f = Foreign Transport Index

The Foreign Transport Factor is the delivered cost of a capital item in a foreign country expressed as a fraction of the ex-factory price of the item (CIf)in the same country. The terms within the square brackets on the right hand side of the equation represent the item's foreign freight cost. This is the cost in the United States over a given distance adjusted for differences in transport costs between countries.

The haul factor represents an attempt to correct for the fact that published freight rates for the United States imply that the carrier will be able to pick up a load on both legs of a trip. This is obviously not the case in most mine supply situations, and it is reasonable to assume that carriers will require a premium over standard rates. U.S. transport associations confirmed that such logic does apply in practice but were unable to quote a specific factor which is determined by personal preference in a deregulated and highly competitive environment. In this study a factor of 1.5 was applied somewhat arbitrarily to the case of Argyle but set at 1 for the Angolan models where scheduled rail transport was assumed to be available.

3.1.2 Plant Model Specifications

The equipment and processes that constitute the metallurgical plant at Argyle are summarized in fig. 3.1. One important point to bear in mind is that the plant has been built with expansion in mind. Consequently, although the actual current treatment rate is 11,376 tons per day, many of the major items of equipment have a significantly greater capacity. The primary crusher, for example, has a throughput capacity of 42,545 tons per day based on data from other installations (S.M.E. Handbook 1985). Capital costs have been based on this rated capacity and not on plant throughput. In the following sections, details are given on how the items shown in the flow sheet have been incorporated into the USBM spreadsheet. Only brief notes on the spreadsheet settings are given where they have been modified to suit this model. The reader is referred to the USBM handbook for details of possible adjustments that can be handled by the system.

Crushing Circuit. Argyle has a primary and secondary crusher which feeds onto a stockpile. The ore is reclaimed from the stockpile, fed into two scrubbers and the oversize from the scrubbers passes on to a single tertiary cone crusher. The three crushers were modeled in the spreadsheet under "Crushing" with the final product set to 25 millimeters instead of the default setting of 12.7 millimeters.

Stockpiles. There are two stockpiles at Argyle. One acts as a buffer ahead of the scrubbers, the other as a buffer ahead of the heavy media cyclones. The former is the larger and was modeled under "Stockpile Reclaim" at 11376 tpd capacity. The second stockpile was visually estimated at 75% of the first. Total cost of both was taken at 175% of the larger stockpile alone.

Scrubbers. Kimberlite has a tendency to develop a claylike consistency, and diamond plants go to extremes to remove this clay which interferes with the heavy media cyclone efficiency. Rotating trommels or scrubbers are the first step in this process and Argyle has two. The scrubbers can be modeled in the USBM system under the "Washing" option. The potential capacity of each scrubber was assumed to be related to the potential capacity of the primary crusher. The capacity of each was set at half the capacity of the primary crusher.

Heavy Media Separation. The USBM system provides for heavy media separation in its list of options but the parametric equations are geared towards coal washing in a drum separator rather than the cyclone system used in diamond plants. The two systems are similar to the extent that they use similar methods of feed preparation and media handling, but they differ in the type of separation vessel (drum versus cyclone). Furthermore, drum-based systems are relatively compact installations, cyclone units are tall and thin owing to the gravity fed nature of the process. For the purpose of this study, it was felt that a reasonable approximation of a cyclone unit with a nominal 100 tph capacity could be arrived at by applying the following adaptations to the USBM model.

- A parametric equation for drum separators was derived using manufacturers quotations for drum capacities in the range of 40 to 130 tons per hour.
- The price of a 100 tph unit was subtracted from the equipment cost of the USBM heavy media unit leaving the cost of the ancillary screening and media handling equipment.
- The cost of three cyclones (there are three per heavy media module and six modules in all) was estimated using parametric equations developed by Mular (1982) and this

was <u>added</u> to the cost of the stripped-out drum separator plant.

-A steel structure to house the six heavy media units was estimated at 1984 prices using estimates of dimensions taken from site photos and applying these figures to the Dodge building estimating system (Dodge 1986).

<u>Recrush Circuit</u>. The recrush circuit performs the function of recrushing the coarser sizes of tailings from the heavy media circuit to liberate any small diamonds that may have been locked up inside rock fragments. As is the case with the primary crushing circuit, the recrush circuit has been designed with future expansion in mind and the throughput capacity of the crushers (there are three) exceeds the current throughput. In the spreadsheet a capacity of 340 tph was used as a design figure (the capacity of similar crushers producing a similar product, S.M.E. 1985). The crushing model in the USBM system allows such tertiary crushing to be modeled, but it assumes the crusher feed is run of mine in size and not the actual one-inch feed in this case. This problem was overcome by modifying the appropriate equations so that, in effect, two capital costs were modeled. One was for reduction of ore from run of mine to one inch and the other was for reduction from run of mine to a quarter of an

inch, the actual final product. The difference between the two represents the capital cost of equipment to reduce from an inch to a quarter of an inch, the designed function of the recrush section.

Audit Plant. The function of the audit plant is to monitor the efficiency of the main heavy media plant by checking 10 per cent of the tailings of that plant for diamond content. It is in effect a small heavy media plant in its own right coupled with a single X-ray sorter which evaluates the concentrate produced. This unit was modeled by a single 50 tph heavy media unit (based on the main heavy media model) housed in a building one quarter the size of the heavy media building. The audit plant also contains one X-ray sorter that was priced at a lump sum.

X-ray Sorting. All contemporary diamond mines utilize diamond fluorescence under X-rays to separate them from the rest of the concentrate produced by a heavy media plant. It cannot be realistically approximated by any of the processes included in the USBM system and has been modeled here by a lump sum. This sum is the actual cost of the installation based of information given to M. von Saldern by Argyle (personal communication M. von Saldern). A further point is that the equipment employed at Argyle was designed specifically to handle the large quantities of diamonds produced which would tend to swamp conventional sorting equipment. In applying the model to other situations (i.e., Angola) conventional sorting machines will be modeled. In practice this will amount to more, but cheaper, machines and the total cost is much the same. The cost of X-ray recovery installations tend to be of a fixed size, independent of the mine size.

3.1.3 Mine Model Specifications

The open pit mine at Argyle has only two major capital cost components that require modeling. One is the cost of the mining equipment and the other is the cost of stripping some twenty million tons of waste rock prior to production, an operation carried out by a contractor. A drainage system was not required as initially the mine was drained by gravity.

The mining equipment used at Argyle has much in common with other open pit operations of comparable size, but differs in two respects. First, much of the overburden is ripped by bulldozer rather than drilled and blasted. Consequently the mine has a greater number of bulldozers than typical operations and fewer drills. Second, the mine does not use electric shovels to load ore but relies on large front-end loaders. The USBM system provides an electric shovel and truck model for operations of the scale of Argyle (in which large front-end loaders can be substituted for electric shovels), but given the above differences in equipment the writer had some doubt as to its applicability to the Argyle case.

The capital cost of mining equipment was modeled in two ways. As actual equipment listings have been published (Lang 1986) the cost of this equipment was modeled by importing appropriate parametric equations (Mular 1982) and summing to a total. Secondly, the standard USBM electric shovel model was applied after making standard corrections for the pit depth and haul distance. The former method suggested a capital cost of US$18.2 million while the latter gave a figure of US$19.7 million. This close agreement suggests that either method is acceptable. For general application, the generic USBM model is probably the more robust, but in the case of Argyle the estimate based on individual items was retained. As a further check of the overall reliability of the Mular equations, certain items of equipment were estimated using January 1989 indices. The estimates were then compared with list prices (Western Mining Cost Service 1990). The results are set out below and, with the exception of the 992C front end loader, show good agreement.

	Estimate (US$)	Actual (US$)	Variance
Cat.D9L	517,858	498,985	+3.8%
Cat.777	616,772	615,863- 657,304	+0.1%, -6.6%
Cat.992C	696,327	860,810	-23.6%
GD-100	1,043,802	1,172,049-1,195,968	-12.3%, -14.6%

The prestripping of waste by a contractor is specifically catered for in the USBM system. However, establishment in such a remote location is likely to be a significant item. Establishment charges were modeled by calculating the delivery cost of the same equipment if it had been purchased, and doubling it to account for the return journey.

3.1.4 Exploration Costs

The evaluation of diamond deposits differs from the evaluation of, say, metallic deposits because of the extremely low concentrations of the target commodity in relation to the host rock. Even at Argyle, a rich deposit by world standards, the ratio is only one part in a million. These factors mean that very extensive bulk sampling and pilot plant work is necessary. Large samples of diamonds are also required to establish reliable estimates of value and, as a result, diamond exploration has a different cost structure from other commodities.

In total A$49 million (US$35 million) was spent on the evaluation of the Argyle pipe (Janse 1988) representing 13% of the final total capital expenditure of A$420 million. At Orapa in Botswana, evaluation costs amounted to 29% of all other capital costs combined (Allen 1978).

There are similarities between Orapa and Argyle which suggest that exploration costs as a proportion of other capital costs should be comparable. Both projects are in dry remote areas and have a similar operating environment. Evaluation techniques at both are similar, a mixture of drilling and bulk sampling with material being treated in pilot heavy media plants. The original Orapa plant at 3.5 million tons per year was the same size as Argyle. However, Orapa is a bigger deposit (110 hectares c.f. 45 hectares) and this probably inflated the cost of exploration relative to the cost of the plant above that at Argyle. Taking the size difference of the two deposits into account brings their evaluation costs into close agreement. In essence, the evaluation of a 45 hectare Orapa would should have cost 12% of all other capital costs (cf 13% at Argyle). Implicit in this calculation is the assumption that all evaluation costs are variable (and this is a debatable point). To estimate the evaluation costs for kimberlites of a given area and plant size one should:

1. Adjust the 12 percent figure pro rata relative to a 45 hectare base.
2. Adjust for the difference in mine capital cost relative to the cost of a 3 to 3.5 million ton per year base.

This can be accomplished by using the "six-tenths rule" that states, as a first approximation, capital cost is proportional to capacity raised to the power of 0.6.

3.1.5 Capitalized Interest

Argyle was financed by a mixture of debt and equity. The debt portion (US$235 million) was raised in New York in the form of commercial paper at variable interest rates (Conzinc Rio Tinto Australia, Annual Report 1984). During the construction period the interest rate on such instruments, varied between 8% and 10.9%. To estimate the proportion of the Argyle capital cost which is accounted for by capitalized interest, the interest on debt was capitalized at 10%. An additional simplifying assumption made was that the project was wholly funded by debt.

The interest incurred on debt during the construction period is treated as a capital cost (rather than an expense) because the project earns no income during construction, and so there is no cash flow to service the debt. The interest due on the money borrowed is debited to the capital account, in effect increasing the level of debt above the nominal amount that was borrowed. This increases the capital cost of the project. The degree to which capitalized interest increases project cost depends on the degree of debt leverage, interest rates, the length of the construction period, and the pattern of expenditure during the construction period.

The development of the Argyle pipe spanned the period 1982 to 1985. In 1982 and 1983 evaluation and engineering design was carried out. In 1984 and 1985 the plant and infrastructure was built and the mine was developed. The project was commissioned in December 1985. Table 3.1 shows how capital expenditures have been distributed through time based on the authors estimates.

Table 3.1 Argyle Expenditure Schedule (US$ millions)

Capital Item	1982	1983	1984	1985	Item Total
Exploration	23.2				23.2
Engineering Design	1.8	1.8	0.4		4.0
Construction Management			5.8	5.8	11.6
Mill & Infrastructure			61.4	61.4	122.8
Mine Development			14.1	14.1	28.2
Mine Equipment				19.2	19.2
Working Capital				7.6	7.6
Year Total	25.0	1.8	81.7	108.1	216.6

3.1.6 Model Performance

The capital and operating cost estimates for the Argyle mine model based on the USBM Cost Estimating System with the modifications set described in the preceding sections are set out in Table 3.2. Where actual costs are these are set out in parentheses next to the estimated figure. According to engineers familiar with Argyle the actual final escalated (i.e., including inflation) capital cost of the Argyle Mine was A$420 million. The model therefore underestimates the true cost by just under 20%, or A$70 million.

Table 3.2 Capital and Operating Cost Estimates for the Argyle Mine Model

Cost Item	Capital Cost (US$ millions)	Operating Cost (US$/metric ton)
1.Mill & Infrastructure	144.0	7.44
2.Mine	49.2 (50.5)	6.66
3.Exploration	23.2 (34.3)	
4.Capitalized Interest	29.0	
Total US$	245.4	14.10
Total A$ (@ US$1 = A$1.427)	350.2 (420)	20.12 (16.99)

Note: Actual costs are shown in parentheses. Sources of actual costs are given in the text.

Given the approximations that had to be made to fit plant processes to the models available in the USBM System, the agreement between the two figures is considered quite good. If one considers this estimate to be preliminary or Class II (Mular 1982, 8) then final costs can be expected to be +30% to -15% of the estimate.

Some discrepancies can be identified. Estimated evaluation costs are less than they actually were (US$23.2 million c.f. US$35 million). It is also suspected that the model may not be fully specified. Company annual reports mention extensive training of staff in Perth to sort the diamonds (and possibly the purchase of sorting equipment) which may also have been considered part of the project cost.

In conclusion the model seems to function reasonably well, and with appropriate adjustments for local conditions, should serve as a fair estimate of potential projects elsewhere. However, any such application will require a fairly large contingency.

3.2 Cost Estimates for Angolan Kimberlites

In this section the hard-rock diamond mine cost model developed in the preceding chapter will be applied to the Catoca and Camutue kimberlites with due allowance being made for local conditions and deposit characteristics. The capital and operating costs derived will be used as input to the financial models developed in Chapter 6.

It is taken as a given that kimberlite development in Angola will only proceed once the current conflict has been resolved. As this, in turn, is linked to a resolution of South Africa's domestic political problems it seems reasonable to assume that a peaceful Angola will come hand in hand with a South Africa that is politically acceptable to other African nations. This would be crucial to kimberlite development as South Africa is probably the most cost-effective source of construction and operational supplies. Angola simply does not have the industrial capability to undertake major mine development and neither do any of its neighbors.

The kimberlite prospects examined here are linked by 275 to 400 kilometers of black-top road and 3,450 kilometers of rail to South Africa's industrial centers. This is a long distance (though comparable to Argyle-Perth) but the alternative sources of supply are 900 to 1,100 kilometers to Angola's ports and then at least an ocean away. This suggests that capital costs would be best measured in terms of South African costs (where most fabrication would take place) with due allowance for the effect of the long transportation distances.

While a pool of the needed artisans would be available locally within Endiama's operations, the need to minimize construction time would likely mandate the use of skilled expatriate construction crews. Once again the logical source of this labor is South Africa, and a realistic assumption is to use South African wage rates with an expatriate premium.

Many of the skills required to operate a kimberlite mine and plant are the same as those involved in operating an alluvial plant. It is realistic to assume that any operation could be fully staffed locally with only management being recompensed at expatriate rates. However, it is debatable whether the current Angolan system of imposed wage rates and controlled prices would remain valid under the conditions necessary to foster investment. As will be seen from table 5.1 Angolan wage rates are at least double those in neighboring countries when converted to dollars at the official rate. To encourage investment, one has to assume that either the investor will be granted a "parallel" exchange rate or that the economic order will shift towards that prevailing in neighboring countries. In these the purchasing power of wages bears some resemblance to the prices of goods required to motivate performance. At the moment this is not the case in Angola. Under the current Soviet style system, goods are officially cheap but rarely available at official prices. Presumably an Angola that is attractive to investors will have to reach some equilibrium with its neighbors as far as wages are concerned. Whether this is by gross devaluation of the kwanza or by concessionary exchange rates is immaterial. For projects of equal technical merit, investors will stay away if the hard currency costs of operating in Angola are much higher than elsewhere. For the purpose of this study it may be useful to apply mine labor costs in a comparable country with a market economy that can be taken as a model of the future Angola. Botswana provides a suitable model given the dominance of diamonds in that country's mining industry wage structure. Costs will also be calculated at the official exchange rate to determine the effect on project economics.

The USBM Cost Estimating System makes an allowance for the relative productivity of labor in different countries when computing costs. For Botswana the USBM figure for mine labor productivity relative to the United States is 48.8%. There are problems in accepting this figure at face value as it incorporates the aggregate mining industry productivity of both countries and makes no allowance for differences in the cost structures of different mining industries.

Productivity data is available for Orapa in Botswana (Allen 1978) where production averaged 3,150 tons per man year between 1973 and 1975. In order to arrive at a more industry specific figure for labor productivity the cost model developed in the previous chapter was used to estimate labor operating costs for a hypothetical similar operation in the United States for 1975. This simulation indicated labor costs of $1.53 per metric ton (out of a total operating cost of $4.00 per ton). This figure combined with the 1975 mining wage rate of $5.90 per hour and assuming a 250-shift working year suggests an American productivity figure of 7,712 metric tons per man year (this figure does not change significantly years other than 1975). On this basis productivity in Botswana (and by inference, Angola) is 41% of United States productivity and is the figure used in the cost models.

The figure used to account for interest capitalization during construction was 10.16%. This represents the London Interbank Offer Rate (LIBOR) for 1989 plus a 1% risk premium. This figure was established in discussions with the International Finance Corporation (telephone interview with S. McCleod) as a reasonable rate for sovereign loans to that part of the world. For corporate loans the risk premium was 2.5%.

As the projects are denominated in dollars, project costs were escalated at 4% per year. This figure represents the GNP price deflator for the United States in 1989. While inflation in Southern Africa in recent years has been considerably more than 4% this has been largely offset by exchange rate depreciation. In dollar terms inflation has moved in parallel with the United States.

3.2.1. Catoca Description and Model Specification

The Catoca prospect is a large kimberlite with a surface area of 66 hectares. At the surface it is roughly circular in shape and about 800 meters in diameter (Lyons, 1983). The average grade is 0.6 carats per ton. Diamonds are of poor quality. In 1977 they were valued at $15 per carat, which suggests they are predominantly of industrial or cheap gem quality. Catoca is located 25 kilometers northwest of Saurimo (fig. 2.2) which has an airstrip capable of handling a Boeing 737. A black-top road passes within 5 kilometers of the prospect and links up with the railway at Luena, 250 kilometers to the south. The nearest point on the Endiama power grid is at Lucapa, 125 kilometers to the north. Catoca lies in gently rolling savanna country on the west bank of a small river. This river, the Lova, contained high grade alluvial deposits derived from the pipe and has been mined out. Water flow is adequate to service any likely mine.

Suitable accommodation would not be available locally and a permanent townsite would be required for at least the expatriate staff. A single status/commute system could be devised for the Angolan labor which would almost certainly be recruited from the established diamond communities to the north. Married accommodations for management and hostels for commuting labor has been assumed in the model.

A considerable amount of large diameter drilling was carried out at Catoca before independence which would reduce the amount of additional evaluation (perhaps by 50%) required to bring the pipe into production. A figure of 6% of all other capital costs has been used to allow for evaluation costs.

The size of Catoca makes large-scale mining possible and the poor quality diamonds suggest that economies of scale will be necessary if the pipe is to prove viable. For these reasons an open pit mine and mill with a capacity of 7 million tons per year will be modeled. The choice is somewhat arbitrary and is influenced by Orapa which has similar grade and stone quality and which has a throughput of 7 million tons per year. Given the size of the pipe, it is not anticipated that waste stripping would be required for many years, a consideration built into the model.

The options for the power supply are to generate it locally using diesel sets or to install a transmission line to the existing power grid to the north. Orapa (Allen 1981) consumes about 10 MW in the treatment of kimberlite at the modeled rate. Endiama generating capacity is 16 MW at present with the possibility of expansion to 18 MW (Helmore, 1986). Without knowing the power demand of existing operations, one cannot say whether there would be enough power left over for Catoca. In this case, electric power generation by diesel has been assumed.

One assumption underlying the modeling is that the costs are calculated from the perspective of 1989 which represents project Year 0. Project construction would occur in subsequent years and this requires a time/expenditure schedule to capture the effects of interest capitalization and cost escalation. The expenditure schedule is set out in table 3.3 where the expenditure in any one year is distributed as a percentage of the capital item total (and not as a dollar amount).

3.2.2 Camutue Description and Model Specification

Camutue is a medium-sized kimberlite with a surface area of 9 hectares located 8 kilometers east of Lucapa within the established diamond mining area (fig. 2.2). It was mined as an open pit up until 1975 when it closed down after the Portuguese left. The pit has a current depth of about 40

Table 3.3 Catoca Capital Expenditure Schedule Excluding Capitalized Interest and Escalation (% of item total)

	1990	1991	1992	1993	Row Total
Exploration	100				100
Engineering Design	45	45	10		100
Construction Management			50	50	100
Mill & Infrastructure			50	50	100
Mine Development			50	50	100
Mine Equipment				100	100
Working Capital				100	100
Total	6.6	1.0	43.5	48.9	100

meters but the treatment plant is obsolete. Diamang records suggest that some 10 million tons of ore remain at a grade of 0.12 carats per ton. Camutue contains exceptional quality diamonds for a kimberlite, valued at $130 per carat in 1977 (see table 2.2). A second pipe, Caixepa is located four kilometers to the east. Caixepa is smaller at 2.3 hectares but contains better stones at a slightly lower grade. For the purposes of this model, it seems reasonable to assume that the two pipes together should be capable of supporting a million-ton-per-year operation for a decade. In the text the terms "Camutue" and "Camutue/Caixepa" are synonymous and refer to joint exploitation of adjacent deposits.

Unlike Catoca, both pipes would require some waste stripping by virtue of their geometry. A ratio of two to one appears reasonable to the writer from personal knowledge of the area.

The infrastructure around Camutue is good. Power is available from the Endiama grid and the required Angolan labor is established in the area. In all probability no accommodation would have to be built other than for expatriate staff. The Lucapa airstrip is dirt but can accommodate large transport aircraft. The road system is black top and links to the railway at Luena 375 kilometers distant. Dirt service roads would require upgrading.

As with Catoca, both Camutue and Caixepa have been drilled out and little if any additional evaluation would be required. An allowance of 3% of other capital costs should be sufficient to capture the impact of this item.

The estimated capital expenditure schedule for Camutue is set out in table 3.4. As with fig. 3.3 the figures represent percentages of the capital item total (and not dollar amounts).

A modern diamond recovery plant was built in 1986 at Lucapa (Diamond International 1990) and would probably be able to handle the modest quantities of stones from Camutue/Caixepa. X-ray sorters would be required between the secondary and tertiary crushers to detect and remove large stones. A system similar to that used at Letseng-la-Terai in

Lesotho (Chadwick 1980) was incorporated into the Camutue model.

Table 3.4 Camutue Capital Expenditure Schedule Excluding Capitalized Interest and Escalation (% of item total)

	1990	1991	1992	1993	Row Total
Exploration	100				100
Engineering Design	45	45	10		100
Construction Management			50	50	100
Mill & Infrastructure			50	50	100
Mine Development			50	50	100
Mine Equipment				100	100
Working Capital				100	100
Total	3.8	0.8	43.6	51.8	100

3.2.3 Cost Estimate for Catoca

A 7 million ton per year open pit mine and treatment plant was modeled for Catoca using the USBM Cost Estimating System. The model specifications conform to those set out in section 3.2.1. The summary of capital and operating costs is set out below. Operating costs represent 1989 prices and will be escalated before inclusion in the financial model. The total capital cost is the estimated final, finished cost of the mine and plant. The rate at which interest is capitalized assumes 100% debt finance. This was done for the sake of simplicity. In reality a proportion of equity finance would be employed and this generally costs more than debt. The contingency factor used, 20%, was selected on the basis of by how much the modeled cost of Argyle was observed to fall below actual final cost.

The breakdown of the components of the cost estimate is set out below.

<u>Estimated Capital Cost (US$millions)</u>

1. Treatment Plant and Infrastructure	177.0
2. Open Pit Mine	28.1
3. Exploration @ 6% of Item 1+2	12.3
4. Interest Capitalized (10.16%).	51.8
5. Escalation (4%)	36.7
6. Contingency @ 20% of Items 1 & 2	43.5
<u>Total Escalated Capital Cost</u>	349.4

<u>Estimated Operating Cost (US$/metric ton)</u>

1. Treatment Plant & Infrastructure:	Labor	0.67
	Equipment Operation	0.89
	Supplies	2.52
2. Mining:	Labor	0.30
	Equipment Operation	0.69
	Supplies	0.29
	<u>Total</u>	5.34

3.2.4 Cost Estimate for Camutue

A one million ton-per-year open pit mine and treatment plant was modeled for the Camutue/Caixepa pipes. The model specifications are those set out in section 3.2.2. The summary of capital and operating costs (in 1988 dollars) follows.

Estimated Capital Cost (US$millions)

1. Treatment Plant and Infrastructure	48.7
2. Open Pit Mine	10.4
3. Exploration @ 3% of Items 1+2	1.8
4. Interest Capitalized (at 10.16%)	13.7
5. Escalation	10.6
6. Contingency @ 20% of Items 1 & 2	12.2
Total Escalated Capital Cost	97.4

Estimated Operating Cost (US$/metric ton)

1. Treatment Plant & Infrastructure:	Labor	2.17
	Equipment Operation	2.04
	Supplies	3.43
2. Mining:	Labor	2.31
	Equipment Operation	5.11
	Supplies	1.61
	Total	16.68

CHAPTER 4

MARKET STRUCTURE AND PRICE ESTIMATION

The previous chapter established estimates of the likely costs associated with building and operating diamond mines in Angola. In this chapter the structure of diamond markets are briefly described. Historical production data from Angola is combined with published material on diamond price trends to predict future time series trends for Angolan diamonds.

4.1 Market Structure

Diamonds are not a homogenous commodity but occur in some three thousand different grades and specifications which can be best regarded as forming a continuum. At the low end of the scale are small, flawed, misshapen, and poor color stones which are suitable only for crushing to powder for polishing applications. Diamonds such as this sell for about a dollar per carat. At the other end of the spectrum are large, flawless, colored gems which can fetch tens of thousands of dollars per carat. In terms of industrial organization there is also a variation in market structure across the same continuum. At the industrial end the market approximates to a competitive structure while the gem market approaches a monopoly.

There are two sources of industrial diamonds, natural stones and synthetics. Natural industrial diamonds occur in varying proportions with gems in all diamond deposits. The proportion of industrials can be as much as 98% by weight (as at Miba in Zaire) or as little as 2% (as in Namibia). In terms of relative value in a given mine, industrial diamonds are invariably subordinate to gems and near gems and can be regarded as byproducts or, occasionally, as co-products. In 1988 the world mine capacity for industrial diamonds was about 80 million carats, most of which was controlled by the Central Selling Organization.

Synthetic industrial diamonds compete with and are in many respects superior to the smaller sizes of natural stones. The superiority stems from the ability to produce material to close mechanical specifications during manufacture and also from the fact that sintered composites can also be produced as required. In the past thirty years the production of synthetics has grown from nothing to about 370 million carats a year. In 1988 eleven countries produced over a million carats a year, and of the total production only 110 million carats are controlled by De Beers. Competition between manufacturers, increasing economies of scale, and learning curve effects have combined to steadily push down the price of industrial diamonds with time and in the process the price of low quality natural stones has also declined. However, it is still uneconomical to synthesize large monolithic industrial diamonds suitable for drilling. In this sector natural stones have maintained their position and appreciated in price. Between these two extremes there has been some substitution of natural drill stones by polycrystaline composites. The impact of this relative penetration of industrials into the historical market of natural diamonds can be seen in the price trend data set out below. Prices are in current dollars per carat. The data source is USBM Bulletin 675, Mineral Facts and Problems, 1985.

Year	Synthetic Grit	Natural Grit	Average Natural Stones	0.75 Carat Natural Drill Stone
1974	3.75	3.95	5.95	93.7
1984	1.34	1.19	7.56	120.15

It should be noted that the effects of competition decrease from left to right in the above data. Large natural stones have no synthetic competitors and their supply is controlled by De Beers/Central Selling Organization.

From the point of view of diamond cutters, the market for gem diamonds approximates a monopoly with the

DeBeers/Central Selling Organization in the role of monopolist or, at the very least, the dominant firm. From the viewpoint of producers the market resembles a monopsony, once again with the C.S.O. in the leading role. About 70% of gem diamond sales are controlled by the C.S.O. with the remainder sold directly by fringe producers at C.S.O.-linked prices. The reasons for such a market structure has evolved from the fact that, as gems have no intrinsic value, their value lies purely in perceptions of rarity. To preserve this perception supply has to be carefully controlled. De Beers manages this by guaranteeing to purchase and stockpile gems at set prices come hell or high water and has the financial muscle to do so. It is in no producer's interest to rock the boat by discounting prices, and so the monopoly has remained stable for a long time. As a result the price of gem diamonds has shown a fairly steady upward increase in both real and nominal terms over a long period in contrast to the mixed fortunes of industrial diamonds.

4.2 Price Estimation

Time series data for the prices of three representative classes of diamonds, gems, near gems and industrials is presented in fig. 4.1. The data for the first two categories are taken from the Antwerp Price Index; the industrial

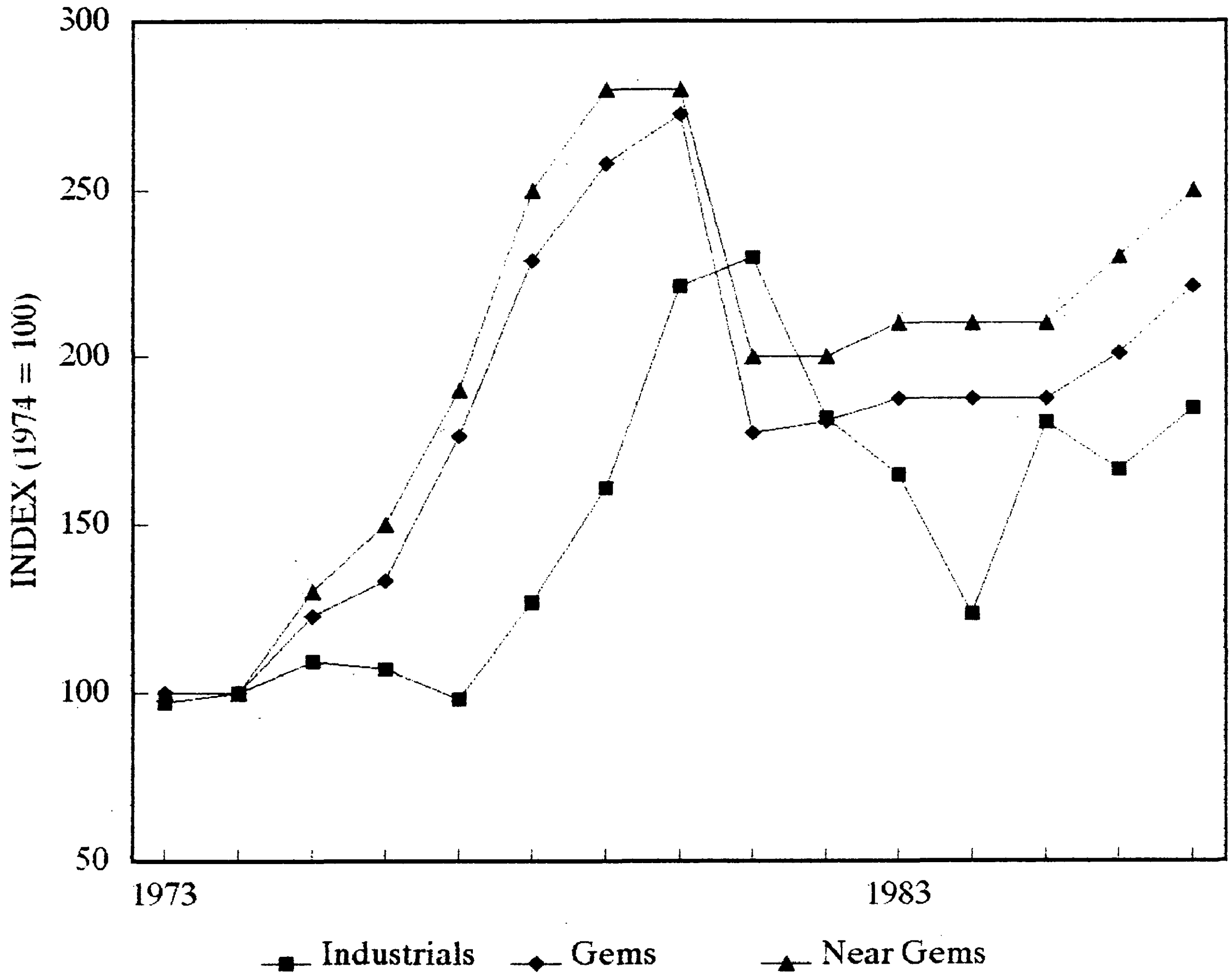

Figure 4.1 Current Dollar Diamond Price Index

Source: USBM

series has been constructed from USBM statistics on the value of South African industrial diamonds imported into the United States. South African statistics were used in preference to other possible measures because (a) there were no changes in the number of producing mines over the time period tracked, and (b) the data is weighted towards Finsch Mine whose stones are similar to those at Catoca.

Historical production/evaluation price data is available for the kimberlites evaluated in this study. In 1977 Camutue diamonds were worth $130/carat and Catoca stones were valued at $15/carat. Comparative 1977 prices for the three diamond categories which comprise the above index were $185/carat for gems, $19/carat for near gems and $6.24/carat for industrials. By comparing the two sets of data it should be apparent that Camutue production was dominated by large gems. The valuation for Catoca lies between the value of industrials and gems indicating that it contains both industrials and more valuable diamonds.

The proportion of industrial diamonds, gems and near gems in Catoca is not known. However, one can construct an infinite number of hypothetical mixtures of the three classes which have a value of $15/carat, any one of which might represent reality. Three such mixes (thought to represent the most likely stone combinations) were constructed and updated to 1988 (the base year for extrapolation). The time series for these mixtures are plotted in fig. 4.2 where it can be seen that there is no great difference in the extrapolated prices which range from $22.7/carat to $23.3/carat. A figure of $23.0/carat was adopted for the purpose of price extrapolation. Although the true composition of Catoca diamonds is unknown the close agreement of the three models enables one to have confidence that the true figure is probably not much different.

Given the probable very high proportion of gems in the Camutue kimberlite it is reasonable to assume that the price of these stones can be updated using the Antwerp Gem Index alone. On this basis the 1989 price of Camutue diamonds is estimated at $214/carat.

To arrive at an estimate of future values of the diamonds in the two prospects the following assumptions have been made:

1. Based on the projections of Johnson et al. (1989) the real price of gems should increase at the rate of 1.5% a year they have maintained since 1960. The reasoning behind this is that De Beers should be able to maintain its market power.

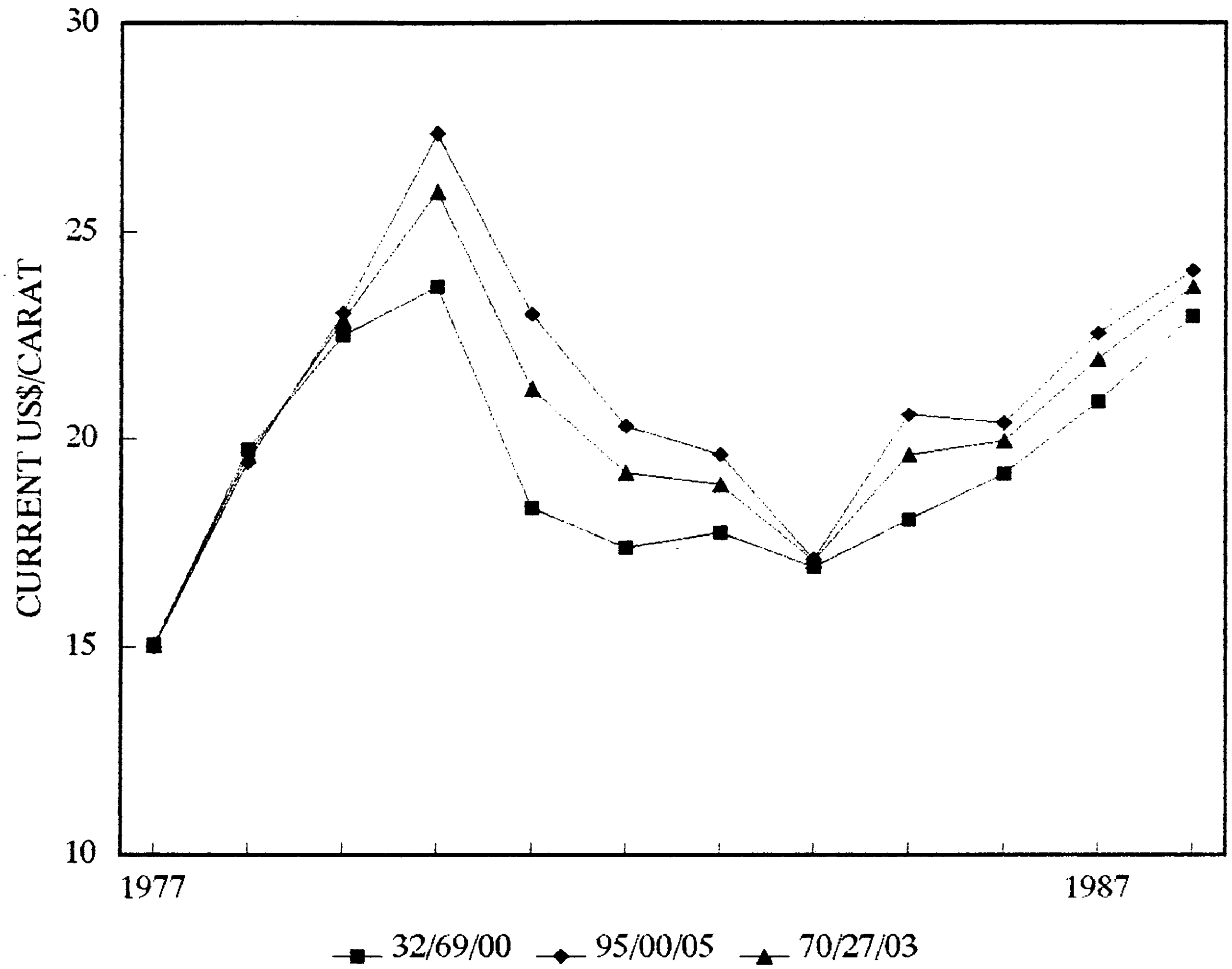

Figure 4.2 Price Time Series for Various Percentages of Industrial, Gem, and Near Gem Diamonds in the Catoca Kimberlite

Source: USBM; Central Selling Organization.

2. Johnson et al. (1989) suggest that the supply of near gems should grow at about half the rate of gem supply growth to the end of the century. On this basis the price of near gems should increase faster than that of gems. For the purpose of this study a conservative, real price increase of near gems equivalent to that of gem diamonds (i.e 1.5%) has been assumed.
3. The USBM suggests that the price of average industrial stones decreased by 7% a year over the decade prior to 1988. However this decline was from a historically high peak and includes the one-off effect of an extra 20 to 30 million carats a year from Argyle. Assuming that large synthetics will remain uneconomic there is no compelling reason to assume a continued decline and in this study a constant price in current dollars has been assumed.
3. Inflation over the forecast period was assumed to be 4%.

These considerations were used to extrapolate likely prices for Camutue and Catoca diamonds to the year 2020. The results for Catoca are plotted in fig. 4.3 which consists of an extrapolation of the fig. 4.2 time series with the addition of the mean of the three trends deflated to constant 1988 dollars. The actual prices for Camutue and Catoca used in the financial models are given in table 4.1.

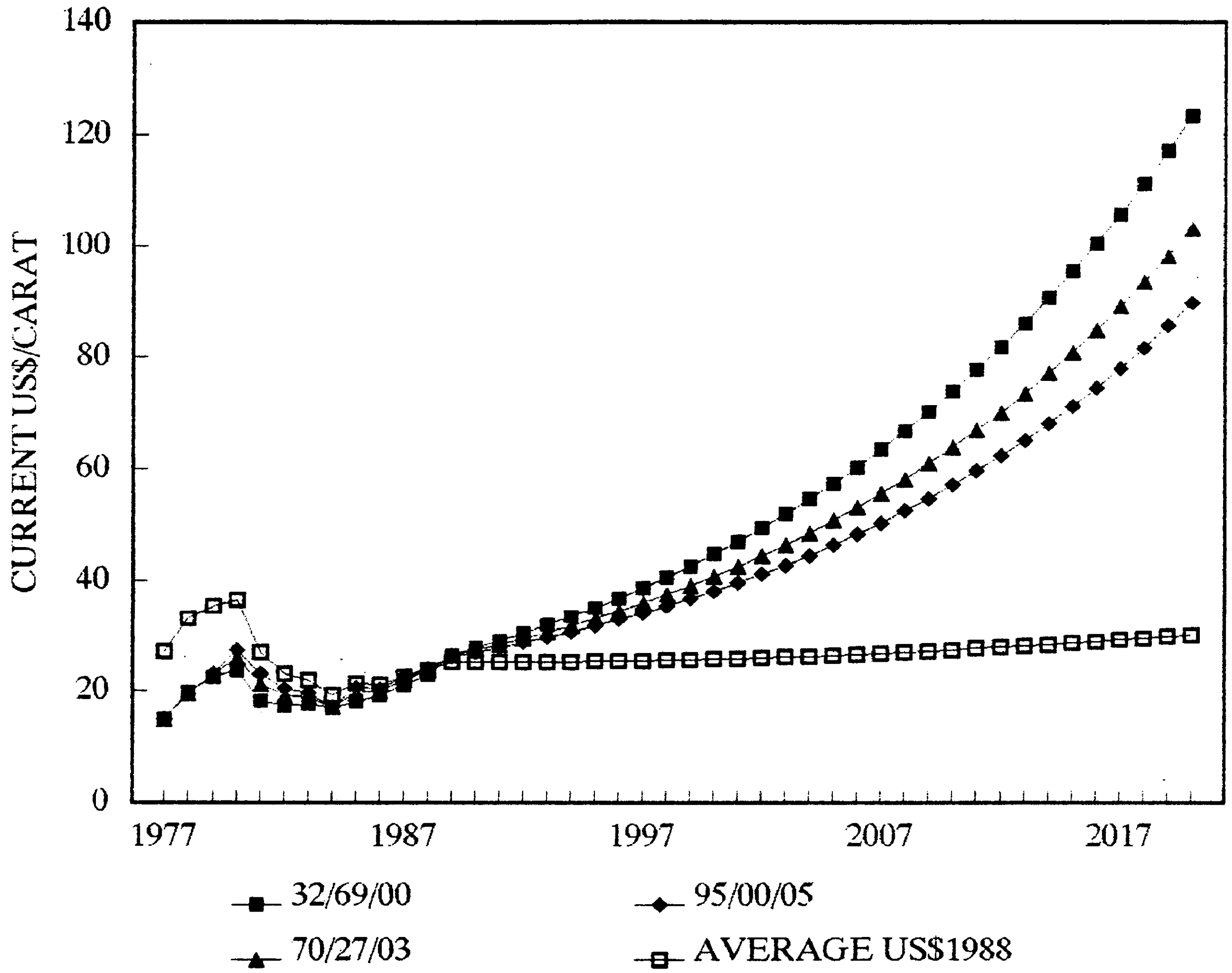

Figure 4.3 Forecast Price Trends for Various Percentages of Industrial, Near Gem, and Gem Diamonds in the Catoca Kimberlite

Table 4.1 Price Forecasts for Catoca and Camutue

Year	CATOCA Current $/carat	CATOCA 1988 $/carat	CAMUTUE Current $/carat	CAMUTUE 1988 $/carat
1988	24	24	185	185
1989	26	25	214	192
1990	27	25	225	200
1991	28	25	238	208
1992	29	25	251	216
1993	31	25	265	225
1994	32	25	279	234
1995	33	25	295	243
1996	35	25	311	253
1997	36	25	328	263
1998	38	25	346	274
1999	39	26	365	285
2000	41	26	385	296
2001	43	26	406	308
2002	45	26	428	320
2003	47	26	452	333
2004	49	26	477	346
2005	51	26	503	360
2006	54	27	531	374
2007	56	27	560	389
2008	59	27	591	405
2009	62	27	623	421
2010	65	27	658	438
2011	68	28	694	456
2012	71	28	732	472
2013	75	28	772	493
2014	78	28	815	512
2015	82	29	859	533
2016	86	29	907	554
2017	91	29	957	556
2018	95	29	1009	579
2019	100	30	1065	623
2020	105	30	1123	648

Chapter 5

GOVERNMENT POLICIES AND TAXATION

In the preceding two chapters estimates were derived for the likely costs of, and revenues from, hard-rock diamond mining in Angola. Project costs and revenues determine the level of operating profit but project attractiveness as an investment is also dependent on the impact of fiscal legislation. Fiscal legislation determines how profits will be distributed. This chapter will examine how current Angolan legislation (and possible alternatives) interacts with geological, market, and engineering realities facing kimberlite development in Angola. The net objective is to determine a fiscal system which encourages investment and maximizes benefits to stakeholders.

5.1 Current Angolan Mineral Legislation

In Angola, legislation that has proved successful in promoting investment has been enacted to regulate the petroleum industry. Petroleum contracts in Angola can take the form of production-sharing agreements or joint ventures with foreign oil companies (Barrows 1983). With such a system Angola has been able to attract foreign investment, though whether that is because of natural endowment or perceived legislative fairness is debatable. In comparison, mining legislation has failed to attract any significant investment; the law is currently under review. From various fragmentary sources it is possible to estimate the format the revised version may finally take, but definitive legislation has yet to materialize.

The two pieces of legislation that currently guide mining in Angola are the Law on Geological and Mining Activities of 1979 and the Law on Foreign Investments of 1988. The former is generally held to have failed to attract investment and the latter represents a provisional attempt to improve matters.

The 1979 law established the state's exclusive right to conduct mineral exploration and to exploit mineral resources in Angola. Foreign companies were allowed to participate but only on a service contract basis. This has been the basis of three contracts with different companies (Mining and Technical Services, Roan Selection Trust, and Sociedade Portuguesa de Emprendimentos) who have provided technical and managerial services to the diamond mines from 1979 to the present. Apart from these contracts and a few aid-based projects there has been no private investment in any other Angolan mineral sector since independence. According to United Nations personnel who have advised the Angolan government on mineral legislation (R. Brown, 1990) the RST contract is "cost plus". Under a "cost plus" contract the contractor recovers his costs out of production and earns a management fee dependent on production. Arrangements such as this differ from revenue sharing in that the contractors use plants that have already been built and paid for and make no major capital investment of their own. Such contracts are in effect management contracts. Capital for small-scale capital investment and replacement is furnished by Diamang/Endiama out of current earnings. The contractors have operational but not administrative control.

In 1987 the 1979 law was amended to allow foreign equity participation and, apparently, even foreign majority share holdings (Diamond International 1990).

The Law on Foreign Investments of 1988 provides for foreign investment in Angola in several modes, those which apply to mining are:

Mixed Companies: registered companies with a minority foreign partner and a majority state company as shareholders. Majority foreign equity can be negotiated but the law does not specify how equity is paid for.

Joint Companies: as above but where the Angolan partner is not a state company.

Joint Ventures: contracts between foreign and national enterprises which do not require the formation of a registered company.

The 1988 law also sets out in general terms the rights and obligations of foreign companies in Angola (articles 14, 15, and 18).

Repatriation of profits

Fair compensation for expropriation and an arbitration mechanism

Concessional exemption from taxation for specified periods on a case by case basis

Exemption from import and export duties on a case by case basis

Right of operational autonomy subject to state monitoring

Obligation to train Angolan nationals and transfer technology

While the 1988 legislation is short on specifics and leaves a lot to be decided by bilateral negotiation, it represents a radical turnaround in state philosophy. Though the legislation is not specifically directed at the mineral sector it suggests that just about any of the forms of mineral agreements in force in market economy countries are now permissible in Angola. The provisions in the legislation resemble those present in the mineral laws of other African states such as Ghana which have had some success in recent years in attracting mineral investment (Commonwealth Secretariat 1989).

5.2 Constraints on Diamond Agreements

While all possible contractual arrangements may be theoretically possible under the 1988 law, there are certain structural considerations that limit the form that major investments in an Angolan, hard-rock diamond mine can be expected to take.

Angola is a member of the Southern African Development and Coordination Council (SADCC). The SADCC encompasses a fair number of major diamond producers (Tanzania, Botswana, Zaire) and there is probably sufficient technical expertise within these states to make the operation of a major mine by the state a realistic option. However, the problem of capital still remains.

Angola is signatory to the third Lome Convention which governs the granting of aid from the European Economic Community (EEC) and lesser developed countries. The convention made specific allowance for grants and cheap loans to promote mining projects (Gruss 1986). These funds are earmarked for reconstruction projects, projects which have industrial development linkages, and which serve the long-term strategic interests of the EEC. Unfortunately a diamond mine does not seem to fit into any of these categories.

In theory, funds for mine development might be available from one of the development banks, such as the World Bank, which have financed mining ventures in the past. As with the case of the Lome Convention, development funds for mining are usually justified if other economic linkages are generated as a result. Diamond mining produces few, if any, economic linkages. In all probability, Angola would be percieved to be able to make better use of development capital in projects with more immediate social benefit such as agriculture. Diamond mines would come a long way down the list of development priorities. The best that could be reasonably expected would be for, say, minority development bank participation (as in the case of IFC participation in the Aredor Project in Guinea) to reduce private investors perception of risk.

Given a lack of substantial development bank funding the participation of private capital appears mandatory. The role of development funds is probably limited to risk insurance, and financing infrastructure which has a social benefit as well as benefiting a mine.

The need for substantial capital (as well as efficient use of this capital) effectively rules out ventures such as the present management contracts. Such arrangements are not suited to large-scale investments unless the contractor makes a substantial capital investment. The reason for this lies in the incentive to cost inflation in cost plus contracts and consequent inefficient use of capital (Walde 1989).

Past diamond mining operations in Angola have developed an infrastructure and a labor force which could make a significant contribution towards the cost of a new mine compared to a greenfield investment. The Camütue prospect for instance, stands to benefit significantly from the availability of hydroelectric power and certain local alluvial plant facilities. This infrastructure can be regarded as a shadow contribution by the government to project capital. This in turn suggests that the logical format for a project would be the Joint Company option contained in the 1988 law. Free government equity in a project can thus be justified on grounds of supply of infrastructure.

Despite the fairly liberal provisions of the 1988 Law on Foreign Investment there has not been any significant onshore investment of any kind in Angola to date. While one reason is undoubtably the security situation, the current exchange rate mechanism is also a strong discentive to investment (Brown, 1990). The Angolan kwanza is officially valued at about thirty to the dollar and is grossly overvalued compared to the parallel (or black market) exchange rate. In theory at least, foreign investors face the prospect of having to convert foreign currency at the official exchange rate in order to meet domestic expenses. This makes local labor very expensive as can be seen by referring to Table 5.1.

Table 5.1 shows the level of dollar denominated mining wages in various African countries for 1975 and 1988 relative to wages in the United States. When nominal wages are adjusted for labor productivity we obtain labor costs per unit of output, the proper basis for comparison between countries.

Some of the figures in table 5.1 should be viewed with caution. For example, the productivity of Angolan labor is high compared to surrounding countries and may reflect use of oil industry statistics as a proxy for the mining industry. Also implicit in the figures is the assumption that absolute and relative productivity has remained unchanged over the period 1975 to 1988. This is an unlikely state of affairs. Table 5.1 shows that, compared to the prevailing rates in adjacent countries, Angolan labor was expensive in 1975 and was apparently even more expensive in 1988. Unfortunately for Angolan workers this does not reflect increased

Table 5.1 Comparative Mining Labor Costs

	USA	Zambia	S.Africa	Botswana	Angola
1. Relative 1975 Wages	1	0.29	0.15	0.18	0.30
2. Relative Productivity	1	0.68	0.44	0.49	0.71
3. 1975 $ Mine Wage Index	100.0	100.0	100.0	100.0	100.0
4. 1988 $ Mine Wage Index	214.9	89.4	196.3	201.4	346.2
5. 1975 Mine Labor Cost	100.0	42.6	34.1	36.7	42.3
6. 1988 Mine Labor Cost	214.9	38.1	66.9	73.9	146.3
Above as % of U.S. Cost	100.0	17.7	31.1	34.4	68.1

Note: Item 5 = (Item 1/Item 2)xItem 3
Item 6 = (Item 1/Item 2)xItem 4

Source: Bureau of Mines International Mining Cost Indices.

prosperity but is merely a product of local currency wage increases and a fixed exchange rate. While this is patently an artificial state of affairs it is the theoretical labor cost that an investor faces.

In the diamond-related service contracts agreed to date, this problem has been overcome by assigning local costs to the Angolan enterprise (Endiama) as part of its contribution to the project with the foreign partner being recompensed with part of the foreign exchange earnings of the project. In principle this system could be extended to larger joint equity projects such as a hard-rock diamond mine, but it would still require that an equitable exchange rate for accounting purposes be established in order to properly determine the relative contributions of the partners. The Angolan partner would have to be prepared to meet the costs denominated in local currency, while the foreign partner would meet the offshore, largely capital costs.

There has been some recent speculation (Diamond International 1990) that the mineral law may be restructured along the lines of the petroleum law. There is some evidence to support this supposition in the 1988 Law on Foreign Investment which provides for production-sharing (Article 14, Clause 4). In Angola, oil production-sharing agreements typically allow costs to be recovered from 50% of production with the remainder split between the state and the investor. The investor is taxed on his share and also usually supplies the capital (Barrows 1983). While such a scheme could be extended to hard minerals, and therefore be administered within the present tax collection system, it might be difficult to administer. With diamonds, there would be the additional problem of equitable stone valuation particularly in the case of large and valuable stones. There is also a significant difference between the cost recovery schedule for oil and hard minerals under the above production-sharing format. Revenue from an oil well is concentrated towards the beginning of production. The investor, who recovers costs from a percentage of production, in effect enjoys an accelerated depreciation schedule.In contrast cost recovery for a hard mineral project (with fairly constant output) is effectively straight line depreciation. Finally there is the question of the value of the government's contribution in terms of infrastructure. In brief, as a revenue-raising mechanism and as an incentive to investors, production-sharing applied to diamond mining appears to have no apparent advantages and several potential pitfalls compared to more conventional agreement structures. Possible mechanisms are discussed in the following section.

5.3 Alternative Mechanisms of Mineral Taxation

The objective of mining is to convert minerals into wealth, wealth which accrues to the different stakeholders in differing proportions dependent on the structure of the agreement between them. The purpose of this section is to briefly review the motives behind mineral contracts and how they are percieved by the various stakeholders. Contemporary mining legislation in diamond producing countries will be discussed and a suitable framework for the Angolan industry proposed.

In Angola, as in most developing countries, ownership of mineral resources is vested in the state. Mining is seen as a means of improving the lot of country's inhabitants through generation of foreign exchange, and through secondary industrial and welfare linkages. In developing resources the state is faced with two options: it can exploit the minerals itself through the mechanism of a State Mineral Enterprise (SME) or it can contract the work to a third party. The third party is usually a transnational mining company (TNC). At first glance the former option appears the best since it promises to capture all of the rent generated by the project. In practice the second option is usually adopted. There are various reasons for this.

1. Mineral projects are inherently risky and bear a signifi-

cant risk of overall financial failure. The involvement of a capital providing third party effectively insulates the state from this source of risk.

2. Developing countries are usually short of capital and what they do have is earmarked for welfare and infra structure projects. Mining comes a long way down the list.
3. A TNC will often possess specialized technological, financial, and marketing skills not available to the host country.
4. A TNC's survival depends on the successful outcome of the project. This is a greater spur to efficiency than the social or prestige-based motives driving a SME.

For the above reasons foreign companies are usually involved to some degree in the mineral industries of developing countries. In the case of diamond development in Angola the participation of private capital becomes almost mandatory given the probable lack of cheap development finance for a mine producing a "luxury" product with no real economic linkages.

A government wants two things from a mineral contract. It wishes to maximize its revenue from a project, and for political reasons it wants to maintain its sovereignty over the deposit. These two objectives can work against each other if government control requirements act as a discentive to investment in the first place. Sovereignty issues are particularly sensitive in Africa where the colonial past is by no means dead and buried.

A company wants a contract that enables it to maximize its profit, that minimizes its exposure to risk, and that (since it is usually providing the capital) gives it a high degree of autonomy in the management of the project in question. From the company's viewpoint "profit" can cover considerations other than the direct economics of a specific project. In the simplest case, profit is the cash earned in excess of costs by the venture. With some commodities (and with diamonds in particular) the profit maximization motive may arise from the perpetuation of a noncompetitive market structure which enables the firm to earn abnormal returns. The economics of a given mineral project may be relatively unimportant in the calculations of the TNC.

It should be clear by now that the motivation of the two parties contain considerable scope for conflict and this potential for instability is further enhanced by the unstable nature of mineral markets. Market instability alters the relative income of project stakeholders and can thus increase risk through the possibility of ex post renegotiation of terms.

Good mineral legislation will be so structured that (a) the objectives of various stakeholders can be achieved and (b) it adapts to changing market conditions in a manner which preserves stakeholders perceptions of equitable distribution of benefits.

Garnaut and Clunies Ross (1983) have proposed nine criteria for judging the quality of mineral legislation:

1. It should be neutral and not effect investment or production decisions.
2. It should remain stable under the changing conditions that characterize the mineral industries.
3. It should minimize the investor's perception of risk.
4. It should collect the maximum amount of economic rent possible.
5. It should be responsive to varying levels of profitability.
6. It should minimize fluctuations in state revenues.
7. It should not unduly delay revenue inflows to the state.
8. It should be simple to impose.
9. It should be easy to administer.

Some of the above criteria are mutually incompatible and no single fiscal regime can achieve full compliance with the above criteria. For example, tax rates varying with profitability necessarily imply fluctuations in government revenues. In practice perfection, as defined above, can be approached but never entirely achieved.

Governments that play host to mining operations by TNCs can choose from a variety of mechanisms to obtain revenue from the projects. Considerations of sovereignty aside, the prime objective is to maximize revenue without adversely affecting the TNC's decision to invest. The principal mechanisms that are applied in various combinations are the following:

Flat Fees

Royalties

Income Taxes

Equity Participation

Production-Sharing Agreements

The incidence of these instruments and how they are perceived is discussed below.

5.3.1 Flat Fees

Flat fees take the form of fixed annual payments (as in a Mining License) and/or as an up-front fee (as in the bidding for offshore oil licenses). Given conditions of certainty about the resource's value, known sovereign risk, and competition, bidders would be prepared to offer the net present value of the project as a flat fee. In theory, the income from such a system would recover the total available economic rent.

From the state's point of view, flat fees are desirable as they represent a stable and early realization of income from a project, although the conditions of uncertainty that apply in practice invariably mean that flat fees represent only a portion of economic rent. The negative aspects of flat fees depend upon at what stage of a venture they are paid. If they are paid at the exploration stage they may convey (implicitly or explicitly) the right to mine. This weakens competition and implies that the investor can extract higher returns from the government than in the absence of fixed fees.

To an investor, flat fees represent an irrecoverable outlay, increase the project risk, and hence the required return. At the exploration stage, flat fees may be a discentive to investment, but if the fees concern a deposit of known worth (as is approximately true in the Angolan situation) then fixed fees are acceptable and can be recouped by negotiated concessions elsewhere in the fiscal package.

Small, annual fees usually labelled "Mining License" are common in the mining industry, but as far as the writer is aware, up-front payments are rare. In the Angolan context where certain deposits are well enough known to ensure profitability (e.g., the Cuango alluvials) up-front fees would be a feasible option but not across the entire range of prospects.

The prime drawback to fixed fees in hard-rock mining is that the industry is characterized by considerable uncertainty, particularly at the exploration stage, and so it is practically impossible to determine net present value of a project for the purpose of bidding a flat fee. Hard-rock diamond deposits are as subject to uncertainty as any metal mine. Although diamond grade may be less irregularly distributed than in some metal deposits this is offset by the relative complexity of diamond price determination compared to metals.

In the narrow case of the two deposits considered in this study (where past production data is available and where risk is therefore relatively low) one could argue for flat fees as part of the fiscal package. However, if one designs a general scheme of legislation around one or two special cases there is the risk that future exploration (yielding potentially far greater benefits) may be deterred. On this basis fixed fees are rejected as a means of mineral taxation in Angola.

5.3.2 Royalties

Royalties are charges on mineral production levied as a fixed sum per unit of output or as a percentage of sales value, irrespective of project profitability. The charge is usually set out in legislation but is occasionally subject to bidding, as in recent gold projects in Tanzania (Daniel 1989). Royalties are effectively an operating cost and will thus deter investment in marginal deposits and encourage high grading on established operations. On this basis they fail the Garnaut test of neutrality.

From the state's point of view, royalties have the merit of ensuring a early flow of revenue from a project particularly as mines tend to exploit the high grade first. Secondly, ad valorem royalties reflect fluctuation in mineral prices and therefore go some way to satisfying the revenue maximization criterion. These factors, plus ease of imposition and administration, have ensured that royalties are a near universal feature of mineral legislation.

Investors view royalties as an added source of project risk since they are imposed whether the mine is making profits or not. The response is to seek a higher return on investment than would be required in the absence of royalties. In practice this consideration may have little effect at the investment decision stage since the level of royalty is typically in the range 3% to 5%. For a project to be approved in a developing country it would have to promise a return well above the level of the royalty. The possibility of operating profit being insufficient to service the royalty is remote. Consequently, investors tend to view royalties as a minimum tax and take this into account when negotiating other fiscal terms.In the case of diamonds, royalties may have a greater influence on decision making than with other minerals as the royalty tends to be significantly more. This tendency is apparent in the data set out below (Commonwealth Secretariat, 1989). Ghana bucks the trend but in this case the diamond industry is state-owned, and so the tax system is relatively unimportant.

Country	Diamonds	Other Minerals
Botswana	10%	3%
Ghana	3-12%	3-12%
Lesotho	15%	N/A
Malawi	10%	5-7%
Tanzania	15%	1.5-5%

The only explanation that the writer has for higher royalties on diamonds is that they are percieved to be intrinsically more profitable than other commodities. There are indeed very profitable diamond mines but, like any other commodity, these are only end members of a continuum and there are marginal deposits at any royalty or tax rate. It seems likely that the prevailing royalty levels for diamonds (if applied to new projects) may well have the power to dissuade investment if the project is marginal. This would seem to be the case with Camutue (where operating costs are close to the value of the ore) in Angola. On the other hand Catoca initially appears to be a more profitable proposition. Without wishing to anticipate the results of financial modeling one can anticipate that if Angola is to adopt royalties they should be low, responsive to profitability, or both.

5.3.3 Income Taxes

A wide variety of revenue raising instruments can be included under the heading of income taxes. They all tax profit (i.e., revenue less allowable expenses) but the means of imposition vary. Commonly (e.g., in Botswana) the tax rate applied is the standard corporate tax rate, but this is invariably applied in conjunction with other instruments such as royalties and government equity.

The principal drawbacks to a simple proportional income tax is that it does not adjust to variations in project profitability and that a rate which is appropriate to an average industrial company may be inappropriate to a venture whose profitability is partly a function of natural endowments. From the point of view of the state this means that economic rent can escape the tax net. An overly generous tax scheme may not necessarily encourage investors who may perceive it leading to increased sovereign risk when the state is tempted to unilaterally impose more equitable terms.

If standard corporate tax rates are an inappropriate mechanism, one solution is to impose a higher rate income tax (HRIT) on a project-by-project basis, the rate being established by negotiation. This can use the existing tax administration structure but still fails to adjust to volatile revenues. It is also next to impossible to establish a fair rate at early stages in the investment process.

In recognition of the shortcomings of single-tier tax systems recent mineral legislation has tended to employ tax instruments which adapt in a predetermined manner to varying profitability. Such systems are the progressive profits tax (PPT) and the resource rent tax (RRT). The PPT possesses two or more tax rate thresholds which are triggered when a project earns returns in excess of certain profitability ratios. For example, in Ghana, where a PPT is imposed, the profitability ratio is defined as the ratio between taxable income and depreciated capital investment (Commonwealth

Secretariat 1989).

The RRT taxes any positive net present value the project may generate when cash flows are discounted at the required rate of return for the capital employed. Such a tax will often function as a second tier tax beyond, say, standard corporate income tax, the effect of which is built into the NPV determination. The RRT will be triggered when NPV is positive.

Taxes such as PPT and RRT have the merit that they capture a high proportion of the economic rent of highly profitable investments but do not discourage investment in marginal deposits. A further positive aspect often mentioned is that the PPT and RRT are manifestly equitable from the state's point of view. This should lower the investor's perception of sovereign risk. With reduced risk, investors should be willing to accept lower rates of return on any given project which in turn increases the total economic rent.

While PPT and RRT are efficient in many respects (they satisfy the first five of the Garnaut & Clunies-Ross criteria) they do have deficiencies. They are not simple to administer, particularly in the case of the RRT, as profitability is as much a function of accounting practice as anything else. Revenue streams from such taxes are volatile and can be pushed well into the future by the need to recover capital. Walde (1989) also points out that they are often percieved as profit caps that can deter investment in an industry where "bonanza psychology" is prevalent. In fact (unless the tax rate is 100%) they only capture part of the economic rent. A final consideration is that if supernormal profits are taxed away in the early years of a project to be followed by weak prices and low profits, then the final rate of return to the investor can fall below his required rate of return.

The price of diamonds are determined in a market that approximates a monopoly and which places a premium on market stability. Revenue volatility is thus less likely to be as important a justification of variable tax rates than it is the case of, say, a metal mine. On the other hand the historical track record of gem diamonds at least is one of increasing prices in real terms. This implies increasing profitability with time, making the determination of an equitable and stable fixed tax rate very difficult. On this basis there would seem to be a strong case for something like a progressive profits tax in future Angolan mining legislation.

5.3.4 Equity

Equity participation in mineral projects is a popular means by which the state can both obtain revenue and gain influence over the conduct of operations. Equity is either acquired free during bilateral negotiations or is paid for on a pro rata basis. In the latter case the equity will often be paid for out of the state's share of the dividend stream from the project. The initial capital is raised wholly by the TNC partner who debits the state's account accordingly and the debited amount will normally accrue interest. A variant on this theme, possibly applicable to the Angolan situation, is where the state contributes infrastructure and this is assigned some equity value.

Economically, free equity has exactly the same effect as a rate of corporate income tax equal to the state's equity share and thus has the effect of discouraging private investment. The economic effect of equity that is paid for over time is relatively neutral with respect to its impact on the investment decision but depends on the tax status of the state's payments. If they are not counted as part of the TNC's income and are tax free, then the effect is akin to a tax holiday, early cash flows are increased, and investment is encouraged. This is a useful situation if creditors insist on a short payback period. If the state's payments count as taxable income then the effect on investor revenue is as if the TNC has 100% of the equity during the period of state payments and a fully participating joint venture partner there after. In this case paid equity has a largely neutral impact on investment decisions and may be slightly positive in that it may reduce perceptions of risk.

Government motives for acquiring equity have been discussed at length by Sims (1985) who identifies the following reasons:

Revenue maximization

Training of residents

Control over decision making

Monitoring the TNC

Oligopoly/monopoly control

Sims argues convincingly that the first three of the above objectives can be equally well achieved through legislation as by the state having a seat on the board. The monitoring function does justify a board presence as TNCs may well be tempted to suborn the interests of the project to their international interests. Transfer pricing is a pervasive practice by which such externalization is accomplished. In rare cases the state may wish to establish control to maintain an oligopolistic or monopolistic market structure of which OPEC is the prime example. This bears consideration in the case under consideration as the diamond market is hardly a competitive one. Nevertheless, legislation specifying sale of minerals to a government agency can perform this function as well as equity can.

From the perspective of the TNC there are good and bad aspects of government equity. As mentioned above the main benefit of state equity is that it can serve to reduce perceptions of sovereign risk and thus reduce the required rate of return (this in turn increases available economic rent for the state to tax). Negative aspects are potential loss of operational autonomy and the effect on the TNCs offshore tax liability. In many cases, where double taxation treaties exist, a company can credit foreign taxes paid against liabilities in its home country. Dividends to shareholders are not deductible. Given the choice a TNC might therefore choose to pay tax rather than dilute its equity holdings.

5.3.5 Production-Sharing

Production-sharing is a means of taxation which is common in the oil industry and which is employed in Angola. There is a possibility that this may be applied to the mining industry in Angola and provision is made in the 1988 Law on Foreign Investment for such an eventuality.

The revenue raising mechanisms incorporated into production-sharing agreements can have the economic effect of an ad valorem royalty or of a higher rate income tax depending on how they are structured. There are two basic variants, but in both the TNC bears all the exploration risk and all the capital cost of development. In one variant (type 1) the state then takes a proportion of the production. The TNC recoups its costs from the balance and is taxed on remaining net income. This case is equivalent to a royalty plus corporate income tax. In the second variant (type 2) the company first recoups its costs (subject to limits on capital recovery) from production and then the balance is split between the state and the TNC. The TNC is taxed on its share. This method is equivalent to imposing a higher rate of income tax and is the method employed in Angola.

The disadvantages of applying production-sharing to hard minerals was set out at the end of section 5.1. Briefly, production-sharing in oil agreements amounts to accelerated depreciation. In hard mineral production, with relatively constant production, it amounts to straight line depreciation and is therefore a discentive to investment.

Chapter 6

FINANCIAL MODELING

Previous chapters have established likely costs, revenues, and fiscal regimes for Angolan diamond prospects. In this chapter the above data is incorporated into a discounted cash flow spreadsheet to determine project viability under a variety of economic and fiscal scenarios.

6.1 Discount Rate

Mining projects in developing countries are usually financed by more than one means. The principal instruments employed are (a) equity finance by mining companies, (b) loans to companies by commercial banks and development agencies, (c) loans to governments by commercial banks and development agencies, and (d) export credits on imported capital equipment. In this study an attempt will be made to estimate the cost of funds derived from the first three sources for use as discount rates in the financial modeling process.

6.1.1 Cost of Equity

In the sense employed here, cost of equity is taken to mean the rate of return required by investors in a mining firm. There are various ways of calculating the cost of equity, but the method used here has been to employ the Capital Asset Pricing Model (CAPM).

The expression for the CAPM is

$$K_f = K_{rf} + (K_m - K_{rf}).\beta$$

where: K_f = Cost of Equity for the firm
K_{rf} = the cost of risk free borrowing (treasury bills)
K_m = rate of return on the market (e.g. Capital appreciation and dividends on, say, the S&P 500 Index)
β = Covariance of the firms share price and the market index.

The "beta" value (β) for a firm is a measure of the risk associated with investing in the firm compared to investing in the market (e.g., the New York Stock Exchange) as a whole. Beta measures share price volatility relative to the market. This is a function of the industry and degree of debt leverage of the firm.

In the diamond industry, there are several publicly quoted companies but De Beers Consolidated Mines (DBCM) is the only one for which information is easily available. Since DBCM is also a prime candidate for investment in the Angolan industry, it was used to estimate the required rate of return for investors in diamond mining companies.

The "beta" for De Beers's American Depository Receipts is 0.85 (source: Value Line, May 1990). For the year ended

June 1990 the average return on United States Treasury bills was 8.02% and the return on the Standard & Poors 500 Index was 16.6%. On this basis the CAPM predicts a cost of equity of 15.3% for De Beers. For the year ending June 1989 the T-bill rate was 8.13% and the return on the S&P 500 was 17% giving an estimated cost of equity of 15.7%. The average of the two estimates, 15.5%, has been used in this study. From the author's personal knowledge of the industry this figure is very close to the traditional rule-of-thumb figure used by De Beers in capital budgeting.

6.1.2 Cost of Debt

The main lenders to the mining industry are commercial banks and development organizations; the main borrowers are either private mining companies or state mining enterprises (SMEs) giving four possible lender-borrower combinations. The most expensive combination occurs when commercial banks lend to private companies; the cheapest is when development organizations lend to SMEs (i.e., sovereign governments). Beyond such institutional costs of debt are additional costs associated with commercial and political risks, and both act as a premium over and above the basic cost of debt. Current practice is to take the London Interbank Offer Rate (LIBOR) as the base rate. The International Finance Corporation (which is mid-range in cost of debt between, say, the World Bank and commercial banks) offered the following educated guesses for the premiums mining loans might attract in different circumstances (telephone interview with S. McCleod, IFC, 19/07/90).

Development loans to credit worthy countries, LIBOR plus 0.75%

Commercial loans to credit worthy countries, LIBOR plus 3%

Development loans to high risk countries, LIBOR plus 2%

Commercial loans to high risk countries, LIBOR plus 6%

In the case of Angola it might be best to use the rates applicable to a country that may represent Angola a few years down the road, Ghana for instance. Ghana is a newly stable country with an attractive minerals policy and where loans for gold mines have recently been made. In the case of Ghana the IFC suggests that risk premia of 1% for loans to SMEs and 2.5% to companies would be appropriate. For Ghana (and, by implication, Angola), these figures added to the 1989 LIBOR rate of 9.16%, give 10.16% and 11.66% as the cost of debt to the state and companies respectively.

6.2 Financial Model Structure

The financial template used to evaluate the Angolan prospects under various fiscal regimes follows the logic set out below. It follows a conventional capital budgeting format (Stermole, 1987) except that provision is made for deductions that equate to free government equity and a resource rent tax. The logic is as follows (for details of Production-Sharing types see section 5.2.5):

```
GROSS REVENUE

deduct: ad valorem royalty/Production-Sharing Type
        1/ production based service contract fee
deduct: operating costs
        interest
        depreciation
        loss carried forward
Balance
deduct: dividends to free equity/Production-Shar-
        ing Type 2

TAXABLE INCOME
deduct: standard income tax/higher rate income tax

NET INCOME
   add: depreciation
   add: loss carried forward
deduct: principal repaid
deduct: capital expenditure

CASH FLOW
deduct: resource rent tax

NET CASH FLOW
```

The above framework was used to evaluate the Camutue and Catoca prospects. As a first step each property was evaluated as if it were a wholly state-owned and operated enterprise. This determines the total profit (as measured by NPV) available if the project were funded by a development loan, the cheapest source of funds. Projects that are not viable under this scenario will not be viable under any other form of financing.

6.3 Base Case Model Performance

The assumptions underlying the base case evaluation of the two financial models are as follows:

- --General price and cost escalation of 4% per year in dollar terms.
- --Capital cost as per USBM cost model prediction plus 20% contingency, escalated and with interest capitalized. Replacement capital at 5% of original investment after five years operation.
- --100% debt finance at 10.16% repayable over four years.
- --Tax-free state run operation.

6.3.1 Camutue

In addition to the above model specifications the Camutue model also contains the following input:

- --Ore grade of 0.12 carats/ton and a diamond value of $214 per carat increasing at 1.5% a year in real terms.

--One million ton-per-year mining rate and a ten year mine life.

The model yields marginal results when the project is wholly funded by state borrowing at 10.16%. The NPV at 10.16% is $0.5 million.

The sensitivity of the project to critical variables is demonstrated in fig. 6.1. which shows that Camutue is extremely sensitive to changes in grade (changes in diamond prices have an identical effect), is not particularly sensitive to changes in capital or operating costs, and quite insensitive to interest rates.

As Angola is a member of the Lome Convention and as Camutue might, at a pinch, be considered an old mine in need of new capital, then Camutue might qualify for development finance. Short of an outright grant (which is unlikely for the reasons elaborated in chapter 5) the most likely form of aid would be in the form of an interest rate subsidy. Under Lome III this amounts to 3% (Gruss 1986) and would reduce the cost of debt to 7.16%. When the Camutue model is evaluated, assuming it is financed wholly by debt at the above subsidized interest rate, the NPV (at 7.16%) is $15.3 million.

Under the conditions of the base case evaluation it appears that the development of Camutue would only be viable

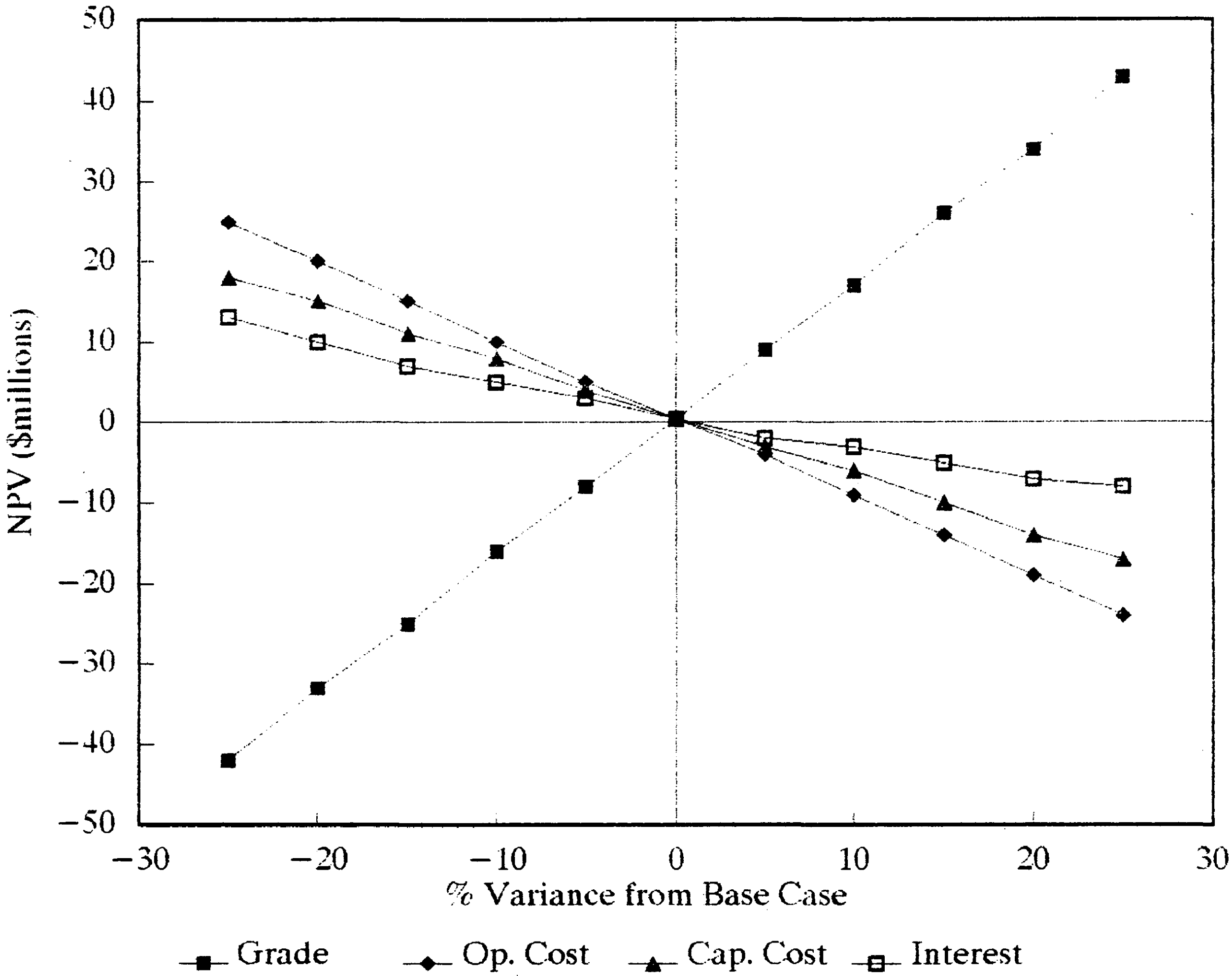

Figure 6.1 Camutue Base Case: Sensitivity Analysis

as a subsidized development project. However, whether would actually proceed under these conditions is open to question. It was previously stated that a major reason for developing a pipe such as Camutue would be to generate funds to finance a larger investment (such as Catoca). From the above analysis it appears that, even under optimal conditions, the net income from Camutue is low. It is certainly insufficient to fund any larger development.

Only a significantly higher grade and diamond price seems to have the power to make Camutue an attractive proposition to private investors. Significantly improved grade is unlikely as the grade used in the model is that from past production and is more reliable than an ore reserve estimate based on exploration data. There is room for doubt as to the real value of Camutue diamonds. They were escalated by an index based on "average gems" and Camutue diamonds are better than average. Current information is insufficient to test the truth of the matter.

In summary, Camutue is too small to support a large mining operation and enjoy significant economies of scale. It is therefore an intrinsically high cost operation. Grades are too low to cover this high cost and provide a reasonable return on the investment at commercial interest rates. Under the best case of concessionary development bank finance and (tax free) state operation returns are marginally attractive but the net return on the project is low in absolute terms. Of the major parameters that affect project economics only the current value of the diamonds leaves sufficient room for doubt, and has the economic leverage to transform this gloomy picture.

6.3.2 Catoca

All of the basic model parameters set out above apply to Catoca plus these additional ones:

- --A grade of 0.6 carats/ton and an initial diamond value of $26/carat increasing as shown in table 4.1.
- --A mining rate of 7 million tons per year and an evaluated mine life of twenty years.
- --In addition to normal price escalation, operating costs were escalated at 2% a year in real terms to capture the effect of a deepening open pit mine throughout the evaluation period. A depth of 120 meters by the twentieth year of operation is envisaged.

The base case evaluation of Catoca indicates that there is a reasonable probability of satisfactory economics. Under the base case conditions, Catoca has an NPV at 10.16% of $288 million. The sensitivity of the escalated rate of return to the principal model parameters is shown in fig. 6.2.

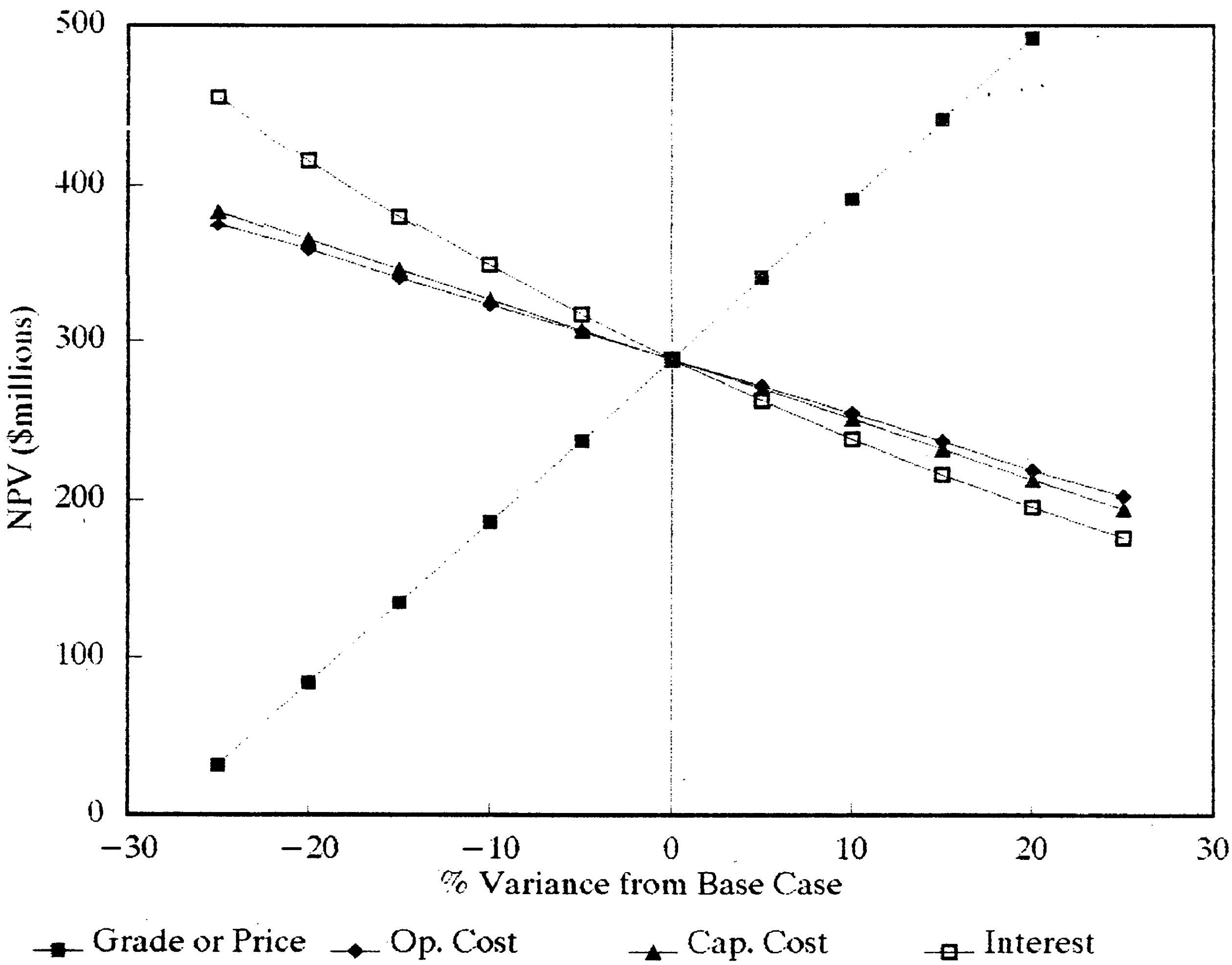

Figure 6.2 Catoca Base Case: Sensitivity Analysis

As was observed with Camutue the principal down-side risk with Catoca is associated with diamond values and/or grades that are substantially less than those used in the base case. The project economics are quite insensitive to changes in the other variables (other than low capital cost which is most unlikely). The conclusion that can be drawn from this preliminary look at the project economics is that Catoca represents a potential mine at least from the viewpoint of a state-run operation.

In the following sections the impact of various project structures and fiscal regimes on Catoca will be examined.

6.4 Impact of Alternative Fiscal Regimes

Given the variety of revenue raising instruments available to governments, the various possible depreciation schedules, and the numerical values that can be assigned to both, there is literally an infinite number of fiscal permutations that could be applied to the Catoca prospect. In this study it was decided to observe the impact of different tax systems by applying those that apply in other African countries that have a diamond mining industry. As it happens, there is considerable variation in the systems that are applied. The countries modeled are Botswana, Tanzania, and Ghana. In addition the production-sharing agreement structure used in the Angolan oil industry was modeled as there has been speculation that it might be applied to the hard minerals sector. The basic elements of these four fiscal systems are as follows:

Botswana

Ad valorem royalty of 10%.
Corporate income tax at 35%
Non-resident income tax of 15% on balance of above
Straight line depreciation over the life of the mine
Minimum free state equity of 15%

Tanzania

Ad valorem royalty of 15%
Corporate income tax at 55%
Depreciation of 40% in year 1 followed by straight line depreciation of the balance over the next six years
No mandatory minimum free equity to the state

Ghana

Ad valorem royalty of 3% to 12% related to profitability
Corporate income tax at 45%
Resource rent tax on excess returns at negotiable rates (75% of cash flow beyond a DCF-ROR of 15.5% was applied)
Minimum free state equity of 10%
Depreciation at 75% in year 1 followed by 50% per year on the reducing balance

Angola

Capital provided by investor
Cost recovery from 50% of gross revenue in any one year
Minimum government share of 40% of the balance
Investor taxed at 50% on his share of the balance

The above fiscal regimes were modeled in combination with two different financial project structures. In one case the project was financed 67% by equity and 33% by debt using the cost of funds to corporations that were derived above (15.5% and 11.66%, respectively). In the second case the project was funded 100% by equity, as is often the practice with De Beers.

The results of the financial simulations are expressed in terms of the DCF-ROR and millions of dollars of NPV to the investor. Income to the state is expressed in millions of dollars of gross retained value (GRV) and present retained value (PV-RV) discounted at a nominal 8% which is taken to represent a social discount rate.

While the absolute revenue derived from a project is important from the viewpoint of the state, the timing of the revenue is also a significant factor given the time value of money. The relative efficiency of the above tax systems in bringing revenue forward can be judged by dividing the present value of revenue by the gross amount raised. This procedure gives the figures set out in the second part of table 6.1.

Table 6.1 represents the best deal that is theoretically available to an investor taking published legislation at face value. In practice more onerous conditions might apply,

Table 6.1 Comparative Returns for Catoca Under Different Fiscal Regimes

	Investor Return			State Return	
Debt/Equity Ratio	DCF-ROR (%)	NPV @ 15.5%	Cash Break-Even (years)	GRV	PV-GRV
Botswana					
33/67	8.8	-68.5	13.9	1123.7	354.9
0/100	8.5	-87.5	12.6	1148.7	368.3
Tanzania					
33/67	8.8	-54.6	10.6	1379.4	400.0
0/100	8.3	-73.8	9.4	1410.2	417.0
Ghana					
33/67	14.4	-9.8	8.3	1080.6	303.3
0/100	13.1	-27.1	7.7	1104.5	315.8
Angola					
33/67	9.9	-40.4	8.4	1404.2	390.0
0/100	8.7	-64.3	8.0	1441.5	411.5

Present Value of State Revenue as a Fraction of Total State Revenue

Debt/Equity	Botswana	Tanzania	Ghana	Angola
33/67	0.316	0.290	0.281	0.278
0/100	0.321	0.296	0.286	0.285

particularly with respect to free state equity. On the other hand a government faced with the prospect of losing an investment would probably make concessions in individual cases. While in reality the rules can be (and are) bent, they have to be taken at face value for purposes of comparison. Keeping in mind the above caveats, the following conclusions can be drawn from the four financial models:

1. The Angolan production-sharing model would fail to attract private sector investment. The main reason for this is that the governments take is too large, and is in fact the largest of the four models. From the state's perspective the timing of state income is also the worst of the four models. It is concentrated towards the end of the project due to the projected real in crease in diamond prices. This stands in stark contrast to the case of an oil project (for which production sharing was designed) where production is great est in year one and declines thereafter.
2. The Botswana system of taxation also fails to attract private investment. While it recovers revenue at a fairly early period the gross amount is less than for Tanzania and Angola. The reasons for this lie in the use of straight line depreciation. Straight line depreciation decreases taxable income over a longer period,

and reduces the return to the investor by allowing inflation to erode the value of capital recovery.

3. The Tanzanian system is much the same as the Botswana system in its structure and performance. In Chapter 5 it was argued that high ad valorem royalties (which are, effectively, additional production costs) act as a strong discentive to investment in marginal deposits. The truth of this can be seen in the case of Tanzania where a 15% royalty is imposed on diamonds.
4. The fiscal regime employed in Ghana yields significantly greater returns to investors than the other regimes and would almost be successful in attracting private investment under the base case assumptions and one can easily visualise that slightly greater debt leverage would tip the scale. This relatively successful outcome is achieved at the price of some sacrifice in government revenues although the amount raised is not significantly less than in the case of Botswana. The income concentrates towards the end of the project rather than at the beginning due to the increased incidence of the variable royalty and the resource rent tax once an economic rate of return has been made.
5. Debt leverage increases returns to the investor under all fiscal regimes. The effect on critical project variables

under Ghanaian taxation is shown in fig. 6.3.

Fig. 6.3 shows that Catoca would be attractive to a private investor when financed by at least 50% debt. The investor would have to be able to borrow at the given rate (11.16%) and be able to persuade a bank to lend a relatively high proportion of the total capital (33% is the usual limit). These two conditions strongly favor the larger company. Small mining companies would be at a relative disadvantage because: (a) banks would add a greater risk premium to the interest rate, (b) banks would be unwilling to loan such a high proportion of the total capital to a high risk company, and (c) a small company will probably be faced with a higher hurdle rate than a large one. The net result of these factors combined with the relatively marginal economics of Catoca suggests that the Angolans may be stuck with De Beers whether they like it or not.

6.5 Effect of Fixed Exchange Rates

The reader will remember that the preceding DCF-ROR estimates used mixed indices based on South African capital costs and Botswana operating costs. These are thought to represent more realistic costs than those published by the USBM for Angola which are distorted by a fixed

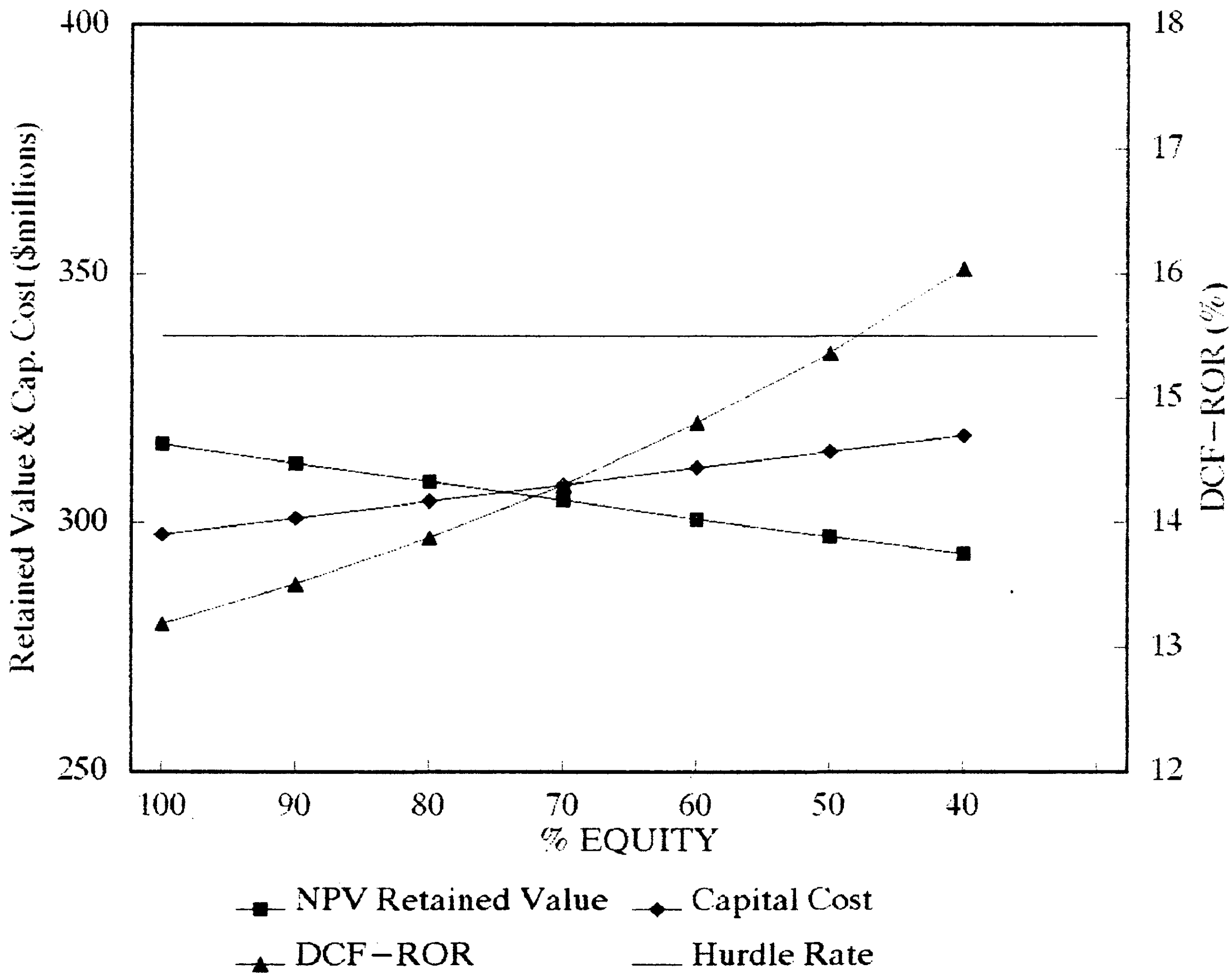

Figure 6.3 Effect of Debt Leverage On Catoca Economics

exchange rate. It was argued in chapter 2 that the artificially high exchange rate of the Angolan kwanza has a deterrent effect
on investment in Angola as it makes domestic prices appear very expensive in dollar terms. The magnitude of this effect can be seen from the following example.

Capital and operating costs for Catoca were calculated using the cost model derived in chapter 3 and cost indices for Angola supplied by the USBM. The results were compared with the costs derived using mixed indices. The mixed indices, it will be remembered, consist of South African capital costs and operating costs for Botswana which are based on convertible currencies. The transportation factors built into cost model to account for long supply lines were discarded when using the Angolan indices (which should have transport costs built in).

Cost estimates based on Angolan indices are approximately 60% greater than those based on the mixed indices (which simulate an environment that would encourage investment). The basic costs, exclusive of escalation and interest capitalization are set out below.

	Mixed Index	Angolan Index
Mill Capital ($million)	177	280
Mine Capital (")	28	55
Mill Operating ($/ton)	4.07	6.87
Mine Operating (")	1.27	2.76

As one might expect the costs based on Angolan indices have a dramatic, and negative effect on project economics. Taking the Ghanian fiscal model and the 67% equity finance option as a basis for comparison, the following results are obtained. DCF-ROR to the investor drops to -10.1% from +14.4%. Gross retained value decreases from $1081 million to $350 million with the latter figure being composed entirely of royalties.

Too much significance should not be read into the above results. The main point is to demonstrate the distorting effect of overvalued exchange rates on project economics. Artificially high exchange rates can only have a negative impact on how investors perceive the investment climate. "Expensive" local costs may influence the all important first impression, even if in practice investors realize that some form of parallel exchange rate may apply.

Chapter 7

SUMMARY AND CONCLUSIONS

The Angolan diamond industry is approaching an economic crossroads. Past exploitation has brought alluvial ore reserves to the point of economic exhaustion and diamond production is making a decreasing contribution to the national economy at a time when growth is sorely needed. To reverse this trend will require the development of hard-rock diamond deposits and considerable capital investment. The issue facing the Angolans is how to get from here to there.

The viability of known, hard-rock diamond deposits in Angola depends on two interrelated factors. First, what are the five prospects actually worth to a mining company (be it privately or state owned)? Second, what kind of fiscal regime should govern mining activities? In essence, how big is the cake and how should it be divided?

There are two technical options for kimberlite development in Angola, one (modeled under the Camutue case) is to develop one of the smaller pipes and use the cash flow to develop larger and more expensive deposits. This approach is conceivably within the financial resources of the state, numerous potential investors and, possibly, international development organizations. The second option is to make a large capital investment in a major deposit (represented by Catoca). This leads to early production of significant quantities of diamonds but reduces the number of potential developers. The economics of both options are heavily dependent on the final form of currently evolving fiscal policy in Angola and on the introduction of a flexible exchange rate system. The present system of fixed exchange rates makes Angola an expensive place to operate compared to surrounding countries.

Recent changes in Angolan investment policy indicate a greater willingness to allow foreign, private sector investment in industries previously reserved exclusively to the state. The new policy allows for the full range of contemporary mineral agreements from service contract to foreign majority ownership and is designed to encourage foreign investment. Mineral investment can now proceed along more than one avenue. At one end of the spectrum the state could develop the deposits and take the risk itself. At the other extreme is foreign majority ownership where state revenues accrue through taxation and other fiscal instruments.

To determine the worth of Angola's known diamond resources, a capital and operating cost model for a hard-rock diamond mine was developed (based on the USBM Cost Estimating System) using the Argyle Mine in Australia as a technical model. Although the USBM system is based on engineering data for the United States it can be applied to the evaluation of foreign mines by using the USBM International Mining Cost Indices. That such an approach is viable is demonstrated by the fact that the model underestimated the actual capital expenditure at Argyle by just under 20% and overestimated operating costs by 18%, acceptable accuracy for a preliminary estimate. To have reasonable assurance of similar accuracy in the case of Angola, due allowance was made for the effect of long transportation distances and the distorting effect of fixed exchange rates on project costs.

The cost model was used to estimate the costs of a 7 million ton-per-year mine at Catoca in Angola and a 1 million ton-per-year operation at Camutue. These pipes have the highest value ore (in terms of dollars per ton) of known deposits and possess infrastructure advantages over other kimberlites.

Cost modeling of Camutue and Catoca indicated capital costs in 1989 money (excluding escalation, contingency, and capitalized interest) of $60.9 and $217.4 million respectively. Operating costs were $16.68 and $5.34 respectively.

To determine the total returns available to various stakeholders from the deposits, a hypothetical project structure was simulated which assumed state ownership and

100% debt finance at rates applicable to loans between the IFC and sovereign borrowers. The model provides a first estimate of state income under the most favorable of conditions and provides a datum against which to compare income under alternative scenarios.

Diamond prices used in the financial simulation were based on past valuations updated using published diamond price indices.

The financial simulation indicated unsatisfactory rates of return for the Camutue deposit under all conditions other than when cheap, subsidized development funds are available. With state ownership, and finance by low-cost loans through the Lome Convention at around 7.16%, Camutue has an NPV of $15 million, a trivial income to the state for the required effort. The available rent is also insufficient to finance any larger developments.

The potential returns from the development of Camutue are particularly sensitive to revenue which is, in turn, sensitive to the values used for diamond price, grade, and price escalation. The tabulation set out below shows the percentage increase in the above parameters that would be required to give an investor a satisfactory rate of return (15.5%) from Camutue under Ghanaian fiscal conditions (the most advantageous).

% Equity Finance	% Increase in Grade or Initial Price	% Rate of Increase in Real Price over Project Life
100	63	7.4
67	52	6.4

For reasons set out in the text the required increases in grade and rate of increase in diamond price are considered unrealistic. An initial diamond price of between US$325 and US$350 per carat is barely conceivable given that the assumed price was based on an "average gem" index and Camutue gems are considered superior. The question on diamond value can only be resolved by market evaluation of a significant sample of stones which implies the need for test mining.

The fundamental weaknesses of Camutue (and by implication, other small prospects) are short life, high operating costs, and low contained value. Small scale, hard-rock diamond mining in Angola is not likely to get the industry back on its feet.

The basic financial simulation on Catoca shows an NPV of $288 million. This might represent an attractive investment to the state or, possibly, to an outside investor. Evaluation of Catoca under various fiscal regimes yields the following four findings.

1. Under existing Angolan taxation (based on petroleum pro-

duction-sharing agreements) Catoca does not yield an adequate return to a private sector investor. The best return an investor could hope to make is 9.92% which is inadequate when compared to an estimated cost of equity for a large diamond company of 15.5%. Production-Sharing is better suited to hydrocarbon projects rather than hard minerals because cost recovery (i.e., depreciation) is related to the level of production. With maximum hydrocarbon production at the beginning of a project the net effect is one of accelerated depreciation. Mineral projects have a relatively flat production curve and thus experience something like straight line depreciation under production-sharing.

If the project is evaluated using current legislation for Botswana and Tanzania as a model (based on royalties, income tax, and state equity) it also fails to achieve the investors required rate of return. The basic flaw in the Botswana and Tanzanian taxation systems is a heavy reliance on fixed-rate fiscal instruments. The Tanzanian and Botswana schemes levy high royalties on diamonds and thus effectively raise operating costs.

2. The literature on mineral taxation argues for flexible fiscal instruments (such as sliding-scale royalties) whose incidence varies with project profitability. Such

instruments do not deter marginal investments but still recover a high proportion of economic profits from the occasional bonanza. Ghana has just such a system of taxation and when this is applied to the Catoca project (at 100% equity finance), a return to the investor is 13.19%. Under conditions of 60% debt finance, the return to the investor increases to just over 16% which is sufficient to promote investment. The present value of state revenue is $293.7 million.

3. The marginal nature of Catoca, the scale of the investment and the degree of leverage needed to achieve a satisfactory return on investment suggests that large companies (i.e., De Beers) would be the likely channel of private investment. Smaller companies would probably experience problems raising the required capital, would probably pay more for debt finance and would face a higher required rate of return than a large diversified firm.
4. Angola appears to have a natural endowment in hard-rock diamond deposits with the potential to encourage private investment. The best of the known deposits, Catoca, would just be attractive to a private investor given a fiscal scheme that uses flexible rate instruments (such as Ghana). However, this conclusion is based upon the assumption of a flexible exchange rate policy that would bring

capital and operating costs into line with those in adjacent countries. Under the present regime of fixed exchange rates an outside investor is, in theory, faced with capital and operating costs some 60% greater than would apply under flexible exchange rates. Given the marginal economic characteristics of even the best of the known deposits (Catoca), fixed exchange rates represent an absolute barrier to investment.

In conclusion, Angola has the potential to become a middle rank diamond producer on the basis of known deposits. Whether it will ever be a major producer depends on the potential of the southeast sector of the country, and to quantify this potential will require a lot of exploration. The Ghanaian style of mineral taxation that is indicated for Catoca is also that which provides the best incentive to exploration by virtue of its adaptability to both marginal deposits and bonanzas.

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