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THE THEORY OF WASTING ASSETS WITH REFERENCE TO THE REGULATION AND PRICING OF GOLD IN THE SOUTH AFRICAN GOLD MINING INDUSTRY

by

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All errors, omissions and biases remain my responsibility alone.

Abstract

Aim, Scope and Method

The main aim of this thesis is to present and critically analyse the theory of wasting assets with regard to extractive mineral industries in general and to the pricing and regulation of gold in particular.

Furthermore, to consider the contention that the price of minerals (such as gold) has been "too low" in the current generation and that market forces have led to a "too rapid" depletion of these resources.

The argument that it is the government's duty to intervene and extend the lives of the mines is also queried. A detailed examination of the South African gold mining taxation formula attempts to show how this type of government intervention (in the form of a sliding scale taxation formula) results in uneconomic actions by mine owners and non-optimal extraction patterns of the resource. The contention is put forward that, given certain considerations, market forces should lead to the most optimal use of an exhaustible resource where property rights exist and are definable.

Unlike common property resources, such as the fisheries, where market forces fail to make the most optimal use of the resource, government intervention is unjustified.

The scope of the paper is intended to cover both the underlying theory of wasting assets and to relate this theory to gold in particular. The determinants of the gold price will be considered as well

as the effects of government intervention via the gold mining taxation formula on the South African gold mining industry. Hence, the thesis is divided into two sections: "Theoretical" and "Gold and Gold Mining".

With regard to the method of paper - literature from as far back as 1931 regarding the theory of wasting assets, was collected and analysed. The information for the section on "Gold and Gold Mining" was collected from the various organisations involved in the industry, notably the Chamber of Mines and the Mineral Engineering Department of the University of the Witwatersrand. Information regarding the Gold Mining Taxation and Lease Formulae was obtained from the various Government Reports that have been printed since the introduction of the Mining Taxation Act No. 6 in 1910.

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Glossary of Terms

Conglomerate: Rounded fragments of rock or pebbles cemented together by another mineral substance.

Dip: The angle between the horizontal and a line on the reef body at right angles to the strike.

Fine ounce: A troy ounce of 99.5% gold with 0.5% silver. The gold bar of commerce is normally 403 fine ounces.

Grade: Amount of gold per metric ton of ore, expressed in grammes.

Mill, milling rate: The mill is the plant in the reduction works where the ore is crushed and ground. Tonnage milled, or milling rate, is the total quantity of ore treated (usually expressed as ton/month) after waste rock has first been sorted out.

Over-mining: Over-mining occurs when the grade of ore taken from the mine is substantially and persistently higher than the average grade of the ore reserves.

Pay limit: Grade of ore below which mining is unprofitable.

Payable, payability: Ore that can be mined at a profit is termed payable. "Payability" is the percentage of reef sampled which proves payable.

Reef: A narrow gold-bearing conglomerate in the Witwatersrand geological formation.

Reserves, ore reserves: The tonnage of ore opened up and proved by development or stoping. In addition to ore available for stoping, considerable tonnages of unavailable ore are locked up in shaft and safety pillars until the mine break-up stage.

CONVERSION TABLE

Unless otherwise specified, weights and measures quoted are in metric units. Where ounces are quoted in respect of gold, the unit is the troy ounce.

1 metric ton (t)	=	1.102 short tons 2,204.6 pounds
1 gramme (g)	=	0.0322 ounce (troy)
1 kilogramme (kg)	=	32.151 ounces (troy)
1 gramme per metric ton (g/t)	=	0.583 pennyweight per ton
1 kilogramme per metric ton (kg/t)	=	2.0 pounds per ton
1 pennyweight (dwt)	=	0.05 ounce (troy)
1 Rand (100c)	=	$ U.S. 1.03) at 25.1.82
£ 1 Sterling (100p)	=	$ U.S. 1.856)

SECTION 1

THEORETICAL

CHAPTER I

INTRODUCTION

1.1 Focus of this thesis

Traditional economic analysis passes over the interrelated problems of time and uncertainty. The central elements of economic reasoning have been shaped into models of ever-increasing precision but little cognisance has been taken of the fact that almost every phase of economic behaviour is affected by uncertainty.

Recent years have seen burgeoning work in economics related to the analysis of uncertainty, and of exhaustible resources. The optimal allocation of exhaustible resources through time is a function of many uncertainties. Any analysis of wasting assets is an application of capital theory - the extention of economic analysis into the domain of time and consequently, uncertainty (the future being intrinsically uncertain). The recent energy crisis, in particular, has stimulated work on exhaustible, wasting assets.

Work on resource allocation and optimal extraction patterns of wasting assets in South Africa appears to have been minimal. Research has been pre-occupied with macro-economic questions of employment, inflation and balance of payments considerations. Given the importance of the gold mining industry to the South African economy, as an employer of labour, source of foreign exchange, strategic value and source of tax revenue to the State, the dearth of vigourous analysis of the industry is surprising, especially given the tremendous amount of information and data that is readily available.

The aim of this thesis is to provide an insight into the relevance

of intertemporal analysis (i.e. time and uncertainty) and to critically review the work that has been done on the theory of wasting assets. These issues are analysed under the "theoretical" section. In the second section, entitled "Gold and Gold Mining", the principles already analysed are applied specifically to the regulation and pricing of gold and to the South African Gold Mining industry, in particular. The effect of Government intervention (in the form of gold mining taxation, leases and subsidies) on optimal extraction patterns is examined in detail.

I.2 Summary of Contents

Chapter Two, "An Introduction to Intertemporal Analysis", analyses the interrelated problems of time and uncertainty. The meanings and relevance of the interest rate are examined with particular attention being paid to the difference in the opportunity costs of holding renewable and non-renewable assets. The role of futures markets is analysed and attention is addressed to the perplexing problem of time horizons. Finally, the general relevance of expectations is reviewed with an explanation of the meanings and problems of adaptive and rational expectations.

Chapter Three, "Resource Conservation and Cptimal Depletion of a Wasting Asset", is one of the core chapters of this thesis. Wasting A ssets are defined and the optimal depletion of exhaustible resources in theory is examined. The inability of the Standard Model of Wasting Assets to explain observed movements in the Gold Price between 1968 - 1974 is reviewed at the end of this section. Finally, the principles of intergenerational equity and the conservation of resources are examined and assessed.

Chapter Four, "Demand for and Supply of Gold - The Determination of Price", provides a chronology of the International Monetary System and the Gold Price. The demand for gold is analysed by dividing total demand into ten different market segments, while the supply of gold from South Africa, Communist and "other" western countries is examined. Some possible causes of changes in the supply of gold are postulated and, finally, determinants of the Gold Price are discussed.

Chapter Five, "The History and Role of Gold in the South African Economy", discusses the discovery and location of Gold in South Africa, the factors which encouraged the rapid initial development and expansion of the South African gold mining industry and the organisation of the Industry, i.e. the Mining Finance Houses. Finally, the Role of Gold and its importance to the South African economy is analysed in two periods, the period 1886 to 1978 and the period 1978 to 1982.

Chapter Six, "Government Intervention in the South African Gold Mining Industry", examines the aims and effects of the Government's attempts to lengthen the lives of the gold mines through the gold mining taxation formulae, leases and subsidies of marginal mines. The structure of the mining tax system is examined since its inception in 1910. A qualitative analysis of the effects of the sliding scale taxation formula on optimal extraction patterns in the industry is made and, finally, a quantitative analysis of the same issue is given.

Chapter Seven, "Conclusions", provides a summary of the major

conclusions drawn from the previous chapters and recommendations and policy implications are made accordingly.

1.3 The Accumulation of Data and Statistics

The most disconcerting thing about the South African gold mining industry is that it defies cool, detached examination. To know it is to become involved.

In the process of gathering information for this thesis I met and consulted with people at various levels of management, who were involved in different facets of this industry. In order to do so, I conducted research trips to Johannesburg where information was obtained from, inter alia, the Chamber of Mines, Anglo-American and the University of the Witwatersrand.

There is no lack of data and statistics pertaining to the gold mining industry and little difficulty was encountered in this field. The only problem arose from the change in economic conditions in South Africa and the rest of the world from the inception of this thesis in early 1981 to its completion in mid 1982. During this period, interest rates here, and in the U.S.A., soared and have remained at a high level; the U.S. inflation rate decreased dramatically, the South African rand fell and reached an all-time low against the U.S. dollar while the gold price fell from around $500 per ounce in 1981 to $325 per ounce in June 1982, and I expect that it will fall through the $300 barrier in the near future.

In writing this thesis it was, therefore, difficult to stick to one particular gold price, and hence several gold prices are mentioned.

However, I have attempted, as far as possible, to use the most recently available data.

CHAPTER 2

AN INTRODUCTION TO INTERTEMPORAL ANALYSIS

"We live only by knowing something about the future, while the problems of life, or of conduct at least, arise from the fact that we know so little. This is as true of business as of other spheres of activity. The essence of the situation is action according to opinion, of greater or less foundation or value, neither entire ignorance nor complete and perfect information but partial knowledge. If we are to understand the workings of the economic system we must examine the meaning and significance of uncertainty..."[1]

(F. H. Knight)

2.1 Introduction

The distinctive and crucial feature in the study of man is the concept of action. Man's imperfection of knowledge has important consequences for his actions. Human action is defined simply as purposeful behaviour - a means to achieve a certain end. Of the many factors which modify and affect human actions, those of time and uncertainty will form a central part of this thesis. The field of uncertainty is a very wide and controversial one and a thorough analysis of this subject would be the work of an entire thesis. The intention of this chapter, therefore, is to provide some basic insights into the economics of uncertainty and intertemporal analysis.

Furthermore, the market as a source of temporal information will be discussed as well as arbitrage over time and the structure of futures markets. An introduction to adaptive and rational expectations will be incorporated in the discussion of uncertainty.

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1. Knight, F.H., Risk, Uncertainty and Profit, Haughton Mifflin Company, New York, 1922. p.199

2.2 Time and Uncertainty

All human life takes place in time. Human reason cannot even conceive of an existence or of action that does not take place through time. At a time when a human being decides to act in order to attain an end, his goal can be finally and completely attained only at some point in the future.

A man's time is almost always scarce. Furthermore, all actions must take place through time. Thus, time is a means that man must use to arrive at his ends. Time is scarce for man only because whichever end he chooses to satisfy, there are others that must remain unsatisfied.

Another fundamental implication derived from the existence of human action is the uncertainty of the future. This must be true because the contrary would completely negate the possibility of action. If man knew future events completely, he would never act, since no act of his could change the situation. This uncertainty about future events stems from two basic sources: the unpredictability of human acts of choice and insufficient knowledge about natural phenomena. All human choices are continually changing as a result of changing valuations and changing ideas about the most appropriate means of arriving at ends. This does not mean, however, that people do not try their best to estimate future developments. But no-one ever has certain knowledge of the future. All man's actions are of necessity speculations based on his judgement of the course of future events.

How, then, do time and uncertainty affect exhaustible resources? The optimal allocation of exhaustible resources through time, is a

function of many uncertainties - the extent of reserves, future demand and supply and, hence, future prices, the development of substitutes and the anticipated cost of extraction.

Any analysis of wasting assets is an application of capital theory - the extention of economic analysis into the domain of time and consequently uncertainty (the future being intrinsically uncertain). In effect, we are addressing the time dimension problem of the general economising problem to the efficient allocation of satisfactions among different points in time.

2.2.1 Further Implications of Time

A fundamental and constant truth about human action is that man usually prefers his end to be achieved in the shortest possible time. This is the universal fact of time preference. The less the waiting time, the more preferable it is for him.

Time enters into human action not only in relation to the waiting time in production but also in the length of time in which the consumer good will satisfy the wants of the consumer. The duration of the durability of the consumer good is the length of time the end served by the consumer good continues to be attained. Obviously, this duration differs for each good.

"Ceteris paribus", the individual will prefer a consumer good of greater durability to one of lesser, since the former will render more total service.

There is also a third time period that enters into action. Each person has a general time horizon, stretching from the present into

the future, for which he plans various types of action. This period of provision (the time horizon) is the length of future time for which each person plans to satisfy his wants. This period of provision differs from person to person in accordance with his choice. Some people live from day to day, others plan not only for the duration of their own lives, but for their children as well. (Further attention is addressed to the problem of time horizons in section 2.4.3)

2.3 The Interest Rate

2.3.1 The Meanings of the Interest Rate

The expression interest rate is associated with several different concepts.

First is the net rate of increase in wealth from a rand more of investment, which can be denoted as w, the net productivity of investment.

Second is a personal, subjective valuation of present consumption rights, measured in terms of the amount of future income that is valued as equivalent to one rand of consumption now.

Third is a market rate of return on loans, called a rate of interest on credit - on bonds or promissory notes. If this third rate is greater than the second, people will reduce present consumption (save more). If the second is less than the first, investment will increase.

Fourth is an interest rate that is implicit in the relationship between present prices of capital goods and their future income streams.

All these rates -

1) the net productivity of investment,
2) personal valuation of future income relative to current consumption,
3) return on bonds or loans, and
4) the interest rate implicit in relative prices of capital goods -

are brought toward equality by switching activity among the various markets and goods. When all are equal, the common value is the interest rate. If any are not equal then arbitrage (the simultaneous buying and selling of the same thing by the same person) will induce adjustments of profit prospects in the various markets, pushing them all toward equality.

Since the most easily perceived and measured rate is the rate in the market for secure bonds, we usually look at the rate in that market to measure the interest rate (e.g. Treasury Bill Rate). This explains why the interest rate is referred to variously as the price of "current consumption", the price of "credit", the price of "savings", the price of "loans", the "rate of time-preference", the "net rate of investment productivity" and the "price of money". Correctly interpreted it is a measure of all these things in equilibrium.

2.3.2 The Determination of the Pure Rate of Interest: The Time Market

The rate of interest plays a crucial role in the system of production in the complex monetary economy.

The level of the pure rate of interest is determined by the market for the exchange of present goods against future goods. The establishment of money as a general medium of exchange has greatly simplified the present future market as compared to the conditions under barter. In the monetary economy, the present-future market, (time-market), is expressed completely in terms of money. The money commodity is the one completely marketable good in society and can be exchanged for consumption goods at any time that its owner desires. It is, therefore, a present good, which is also a claim on future goods.

Future goods are goods that are now expected to become present goods at some future date. They, therefore, have a present value. Because of the universal fact of time preference, a particular good is usually worth more at present than is the present prospect of its becoming available as a present good at some time in the future. A good at present is worth more now than its present value as a future good, if the real rate of interest is positive.

Because money is the general medium of exchange, for the time market as well as for other markets, money is the present good, and the future goods are present expectations of the future acquisition of money. It follows from the law of time preference that present money is normally worth more than present expectations of the same amount of future money, i.e. future money will always exchange at a discount compared to present money.

This discount on future goods as compared with present goods (or the premium commanded by present goods over future goods) is the rate of interest.

2.3.3 The Speculative Rate of Interest and the Valuation of a mine

i) The speculative Rate and the Safe Rate of Interest

The ore within a mine represents potential wealth. Its value at any point in time will depend on the immediate valuation of its future income at that particular instance. Furthermore, the dividends of a mine represent the periodic payments through time, like those of an annuity.

If capital is definedas wealth used in the production of further wealth, then the capital value (the value of the mine) depends on the wealth it is expected to produce in the future.

At any instant the value of a fully equipped mine will consist of the future dividends discounted to that point in time. (This is true only if dividends are arrived at after allowances are made for capital depreciation). Thus, the present value is a function of life (i.e. the 'spread' of the dividend payments); the speculative rate of interest, and the depreciation of capital.

The speculative rate of interest (henceforth called "the speculative rate") will vary with the degree of risk involved and with the reward demanded by the investor for uncertainty bearing.

Thus the speculative rate is likely to be greater than the aforementioned pure (safe) rate of interest.

The pure rate gives the degree of preference which investors attach to present income as compared with future income. If no preference existed, there would be no rate of interest. If future income was preferred to present income, the rate might be negative, since the investor would be prepared to secure the right to the income in the future. The speculative rate is made up of the pure rate of interest multiplied by a risk factor.

In valuing a mine, the purchaser must use a rate which will take account of the mining and financial risks involved. In the calculation he must also make allowance for the distribution of the future income in time. This involves the choice of a rate, and the selection of a formula for discounting (an annuity formula).

ii) Risk and Uncertainty in Investment Decisions

It may be useful at this point to try and distinguish between risk and uncertainty. Decision situations can be broken down into three types:

i) certainty
ii) risk
iii) uncertainty

The distinction between risk and uncertainty is that risk involves situations in which the probabilities of a particular event occurring are known; whereas with uncertainty, these probabilities are not known. According to Knight[2], risk is measurable probability. Nevertheless, one often finds the terms "risk" and "uncertainty" used interchangeably.

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2. Knight, F.H., Risk, Uncertainty and Profit, p. 284

Investors in speculative undertakings require a return, albeit uncertain, higher than that on a perfectly safe investment. If the expected but uncertain average rate of return were lower than the certain rate of return (the pure "safe" rate), no investment in these enterprises would occur.

In practice, income from risky sources must be discounted to a present value by a rate of discount greater than the pure rate of interest. In other words, the greater the uncertainty, the greater will be the preference of the potential investor for immediate consumption of his income. To determine this speculative rate it is necessary to multiply the safe rate by a numerical quantity which expresses the investor's allowance for financial risk and which may be called, the risk factor.

The yield on gilt-edged securities will tend to express the safe rate, although it will be somewhat greater since it must include a payment for the supervision given by any investor to his holding.

The risk factor contains elements relating to:[3]

a) A potential profit on the investment before production commences.

b) Insurance against the risk of capital loss.

c) Insurance against the loss of income.

d) Payment for the supervision of investments.

e) A potential profit sufficient to attract investment into the risky undertaking.

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3. Van Horne, J., Financial Management and Policy, 4th ed. Prentice Hall Inc., London. p.114

2.4 The Market as a source of temporal information.

2.4.1 Futures Markets

Resources can be divided into two categories, renewable and non-renewable resources. Consumable commodities, such as wheat and barley, fall into the former category, whereas minerals fall into the latter. Furthermore, minerals can be classified as "wasting assets" (non-renewable resources which are destroyed in consumption, such as coal and oil) and "everlasting assets" (non-renewable resources which are never destroyed in consumption, such as gold and platinum). This is a rather "loose" definition of these terms and stricter attention will be given to detailed definitions in the following chapter on wasting assets. For the purposes of this analysis of commodity markets, however, the division of commodities into renewables and non-renewables is sufficient.

A future contract is a contract to deliver or to receive a specified quantity of a particular kind and grade of a commodity at a specified price at, or during, a specified time in future. Price, quantity, grade and time of delivery are agreed upon as of the present, only delivery and payment are in the future. The market for these transactions is the futures market.

F orward sales for future delivery are not uncommon in the cash markets for the products of agriculture (renewable resources). The reason for the existence of organised future trading is to furnish the merchant and manufacturer with a means of protection against the risk of price change. Trading in the staple agricultural commodities, with respect to which future trading is carried on, involves exposure to constantly fluctuating prices. Merchants and manufacturers must

operate continuously in these markets, their handling margins are typically small, the size of individual transactions is large. Both the direction and amount of price change and the trend of prices over a period of time are unpredictable. In order to survive, there must be some means by which the risk of price change can be either shared or shifted to those who are more willing or able to bear it. The futures market furnishes such a facility through the medium of hedging.

Futures prices in todays futures markets provide predictions of what the spot price will be in the future. If anyone can make a better prediction of what the future spot price will be, he can quickly reap a fortune.

However, a consequence of this activity is that increased current demand for, say, wheat for delivery in the future, pushes up the current "futures price" of future wheat toward the predicted futures price. In this way, beliefs that the current "futures" price of future wheat is too low will increase the current "futures" price and reveal to the world the new expectations of future spot prices.

The existence of futures markets and speculators permit individuals to adjust their patterns of risk bearing, as well as their pattern of consumption goods. Complete avoidance of risks is not possible, but selectivity and choice of types of risks are possible with open markets and private property rights.

2.4.2 Opportunity Costs of holding renewable and non-renewable assets

Wheat is a renewable asset, the production of which occurs discreetly over time (i.e. not continuously, but in harvests that are seasonal). Furthermore, current production is likely to be large in relation to stocks currently being held and unlike wasting assets a larger production level now does not imply less production in the future. Hence, the expected price trend of wheat remains constant (at least in real terms), though a systematic fluctuation in price is expected to occur within each season, reflecting the opportunity cost of holding stocks in between each harvest (Fig. 2.1). The opportunity cost of holding wheat consists mainly of storage costs, insurance costs and, to a lesser extent, loss of interest.

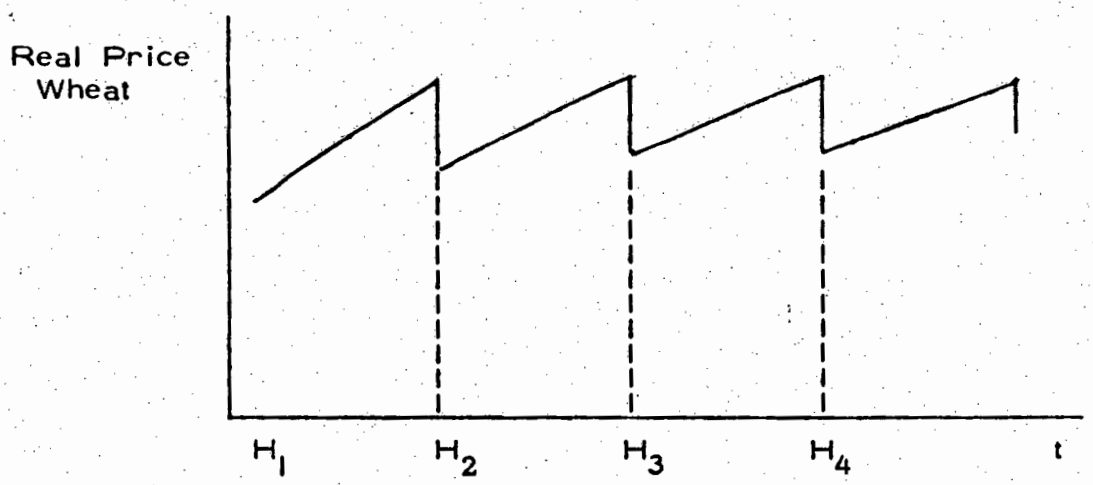

Fig. 2.1

On the other hand, silver, like gold, is a non-renewable asset. Production is continuous and is a small fraction of total stocks in existence. More production now means less in the future. An opportunity cost is incurred in holding silver, whether above or below the ground. Thus, the expected (real) price of silver increases by the opportunity cost of holding silver which comprises mainly the (real) rate of interest (Fig. 2.2). Naturally, the nominal price of silver is expected to increase by the nominal rate of interest.

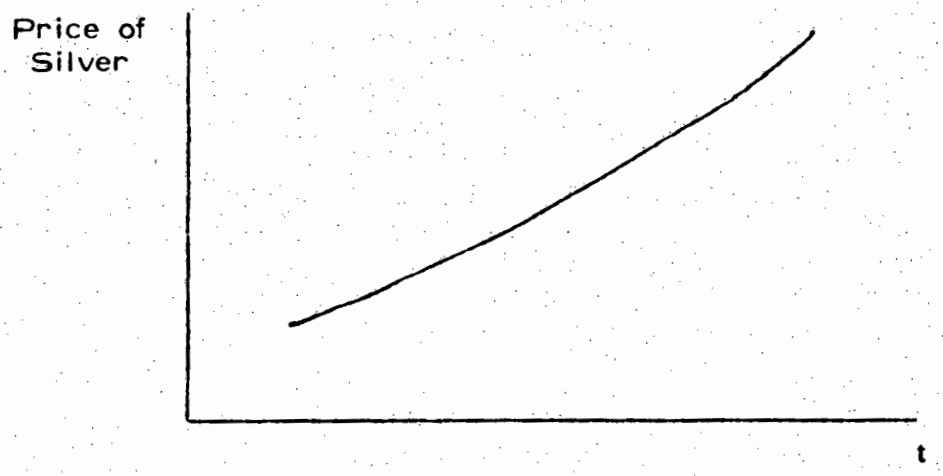

Fig. 2.2

At any point in time, the price of silver is expected to rise by the rate of interest (plus costs of storage) and by no more and no less.

The spot price for silver is determined by the expected future price of silver. These expectations incorporate the rate of interest (plus storage costs) which is reflected in the slope of the line (see Fig. 2.3)

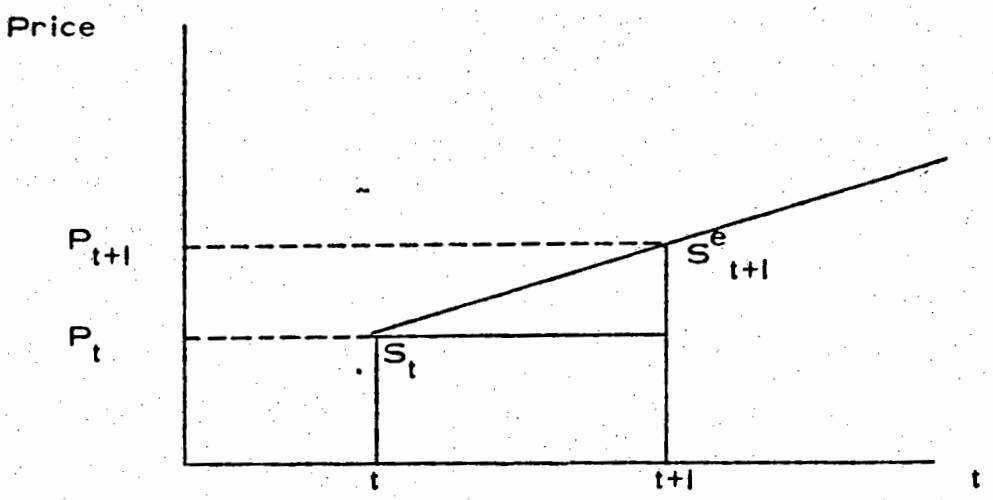

Fig. 2.3

Where: P_t/S_t is the current spot price at time period, t, P_{t+1}/S^e_{t+1} is the future spot price expected to prevail at time period t+1.

$P_{t+1} = P_t + i$ where i is the rate of interest (plus storage costs).

If the price of silver were expected to increase by less than the opportunity cost of holding it, no one would hold it. That would force down the current spot price in relation to any given future spot price and vice versa. If the price of silver was expected to increase by more than the opportunity cost of holding it, everyone would want to hold silver, thus forcing the current spot price up.

2.4.3 Time Horizons

In determining the present value (i.e. the spot price) of any asset, the market takes all expected future costs and benefits into account, appropriately discounted, up to the time horizon. All estimated costs and benefits that are expected to occur beyond the time horizon, have no impact at all on the current price of assets.

There are two main reasons why the market has a finite time horizon, and why the market's time horizon is always shorter than the "theoretic" (arithmetic) time horizon.

i) Arithmetic Reason

We are given that the present value of an asset is calculated as follows:

$$P.V. = \frac{Y_1}{1+r} + \frac{Y_2}{(1+r)2} + \frac{Y_3}{(1+r)3} \cdots\cdots\cdots + \frac{Y_N}{(1+r)N}$$

where $P.V.$ = current price of the asset
Y = income or utility derived from the asset
r = rate of interest
N = time horizon

A constant r will permit the "later" denominators in the series to "explode" (i.e. increase exponentially) thereby reducing the value

of the later increments to approximately zero. Additions to the present value become increasingly smaller and when this value becomes negligible, the market is said to have reached the time horizon.

This may be illustrated in the following diagram (Fig. 2.4). Where the curve begins to flatten out (as the denominator begins to explode) the time horizon is reached.

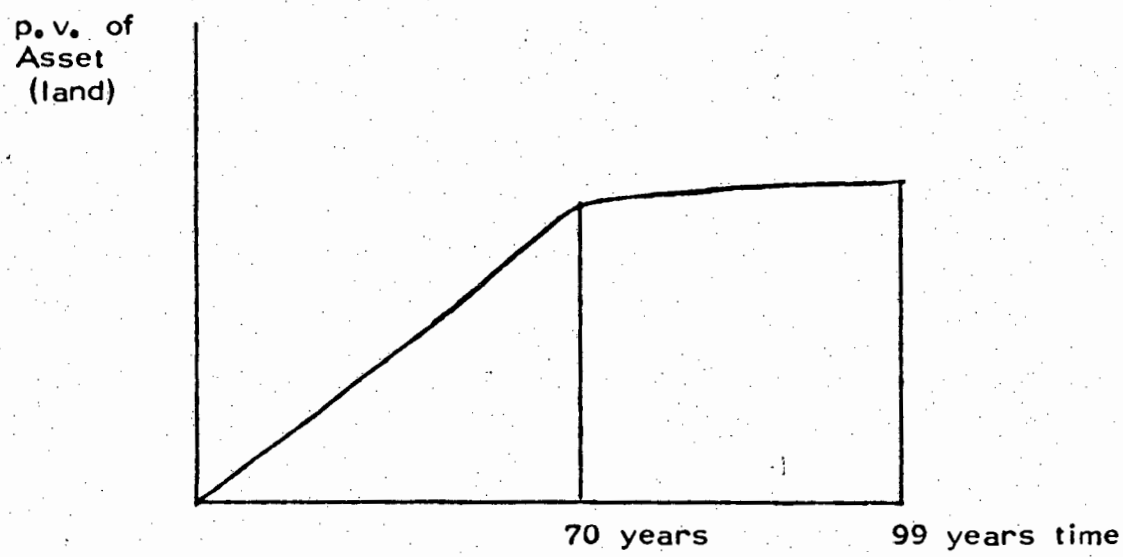

Fig. 2.4

For example, 99 year leases on land do not increase in value after about 70 years. Thus, the present value of the asset becomes unaffected after about 70 years and the arithmetic time horizon is 70 years.

ii) Uncertainty

Added to these arithmetic considerations we must accept that r is not a constant but increases as one looks further and further into the future. Thus, the greater degree of uncertainty associated with the more distant future, must be reflected in the interest rate.

As we move further into the future, the value of r rises in the present value formula and the time horizon is shortened as the denominator "explodes" at an earlier stage than if the interest rate were constant.

Thus the market does not have an infinite time horizon. In the U.S.A. it has been estimated that the time horizon is about 20 years. In South Africa, it has been quoted at about 10 years; the shorter length being due to the greater uncertainty of the future. When property rights are threatened, the time horizon is drastically reduced.

The concept of a time horizon gives rise to the problem that speculators and other market agents are basing their decisions on a finite period. Thus generations beyond the time horizon will not benefit by the present actions of speculators. With regard to the conservation of natural resources, it is often contended that state intervention is justified in order to lengthen the time horizon.

Within the time horizon, the market makes every effort to optimally "conserve" resources. For example, if coal in the future is expected to become scarce, its expected future spot price will rise. The excessive profits that would then be available to coal-holders would immediately be eliminated by a rise in the current spot price. That, in turn, would discourage current consumption, thereby conserving coal. However, if coal were expected to become scarce only beyond the time horizon, the market would not react at all. There is immense uncertainty associated with any estimates of the distant future. New technologies may well be available by then or the world

may no longer exist. The market, therefore, abandons the distant future to the chance costs and benefits (externalities) of its current activities.

Within the time horizon, the market works impeccably. The longer the time horizon for the resource (e.g. extractive industries such as mining), the more optimal the market's extraction of that resource and the greater the provision for future generations.

The main question is whether information is good or bad. The case regarding State intervention delves into the realms of normative economics. Obviously in setting up a time horizon the market is not taking account of generations beyond this point. Will these generations suffer if the resource is exhausted "too quickly"?

The question as to whether the State should impinge on the market and provide for future generations, through artificial conservation or extension of the time horizon, is a subjective choice and involves the concept of welfare. However, the problem remains - does the State have better information than the market? Even if it did, the State is made up of politicians who serve a certain period of office. Is their time horizon necessarily longer than that of individual market participants? I think not. More attention will be paid to this issue in the next chapter. However, it still remains to consider how a time horizon for gold is formed.

2.4.3.1 Time Horizon for Gold

Determining a time horizon for gold and other non-renewable assets which are held for speculative purposes is indeed a perplexing

problem which can best be solved empirically. However, an attempt will be made here to posit a time horizon for gold in theoretical terms.

Consider the following diagrams:

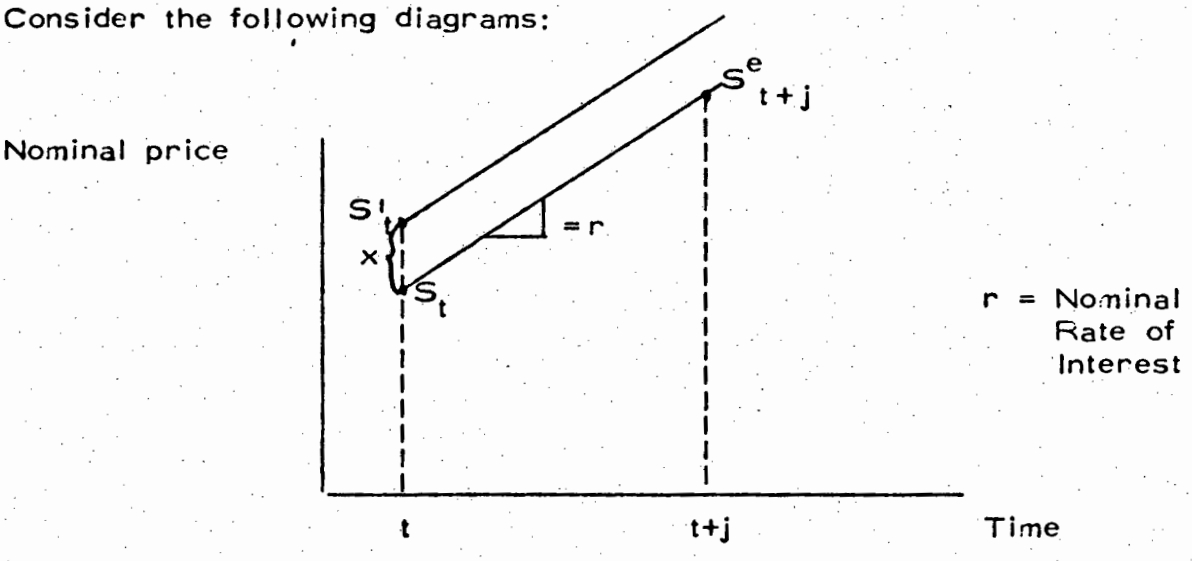

Fig. 2.5

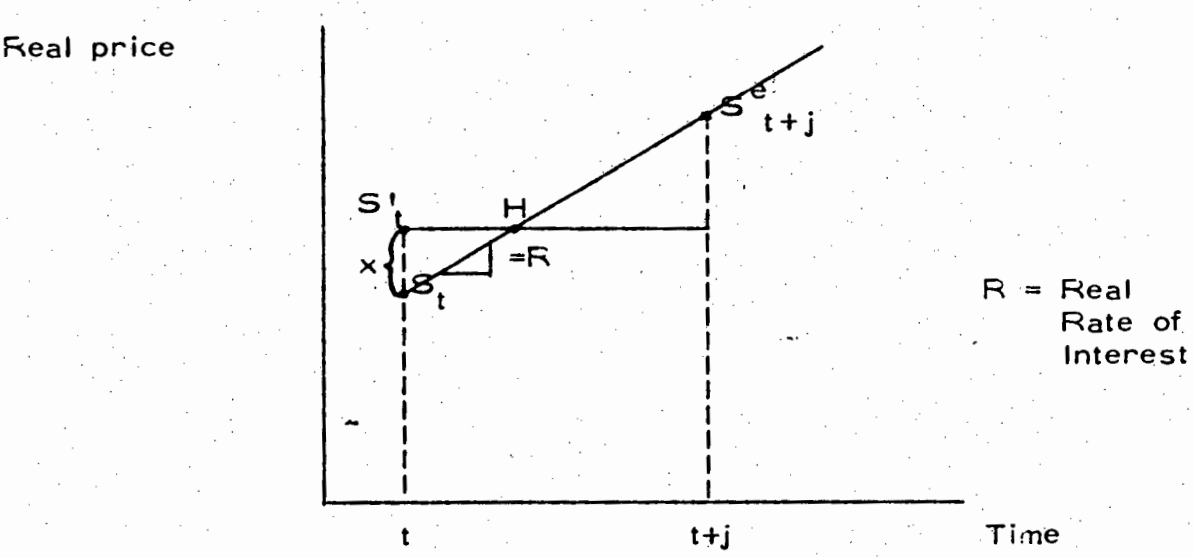

Fig. 2.6

There are certain costs and benefits involved in holding gold. The opportunity costs consist mainly of storage and possibly insurance costs and to a larger extent the rate of interest on other interest-bearing assets. The former costs could be termed the marginal costs of holding gold which would, we assume, be cancelled out by

the benefits of holding gold, which we will call the "marginal convenience" of holding gold. Therefore, the sole opportunity cost of holding gold can, to all intents and purposes, be regarded as the interest rate. Thus, the price of gold is expected to increase by the interest rate.

Fig. 2.5 reflects spot and future prices in terms of nominal prices and nominal interest rates, whereas Fig. 2.6 depicts the same situation in real terms.

S_t is the spot price prevailing in period t.
S^e_{t+j} is the spot price expected to prevail in period t+j.

In Fig. 2.5 the slope of the line reflects the nominal interest rate. In Fig. 2.6, the slope of the line reflects the real interest rate. Obviously the latter is shallower than the former as the real rate is always lower than the nominal rate.

Let us accept that the nominal rate of interest increases because expected inflation has increased (the reasons for this will be discussed in Chapter 4, Section 4.6.4). Given that

$$\text{nom } i = \text{exp. real } i + \text{exp. inflation}$$

then the expected real rate of interest will decrease causing current prices to increase to S'_t, by an amount equal to x in both diagrams. As the nominal rate of interest has increased, the slope of the line in Fig. 2.5 has become steeper, whereas in Fig. 2.6, where the real rate of interest has decreased, the slope of the line has become flatter.

It is possible that the time horizon occurs at the intersection of these two paths, i.e. at H in Fig. 2.6 What happens to the time paths in Fig. 2.5 is a matter of conjecture. It is possible that, as the denominator "explodes" in the present value equation, the two paths converge towards infinity. At what point this occurs is difficult to say. Uncertainty about future income streams or "utility yields" is not the only factor which causes the denominator in the present value equation to "explode" at an earlier period than is theoretically the case. A further subjective factor, the individual's assessment of risk, must also be introduced into the denominator, and will thus alter the rate of discount which is used in the equation.

It has been said that the time horizon for gold could be as short as two and a half years. It is possible that this estimate could have been based on an examination of nominal rates as in Fig. 2.5, and not on real rates as in Fig. 2.6. It is possible that lower real rates would extend the time horizon beyond the point to which higher nominal rates would extend it.

2.5 The Economics of Uncertainty

2.5.1 Uncertainty in Microeconomics

The two main economic agents of microeconomic theory, viz. the household and the firm, are both plagued by problems of uncertainty. The interest of this thesis, however, lies solely with the effect of uncertainty upon the decision-making of the firm. Among its many decisions, it must decide what technical process to use in the production of goods, and what magnitude of output to produce. Moreover, it must decide on the quantity of its inputs and on the price to be

paid for them - generally it must decide on its pattern of activity between the present and the future.

What are the uncertainties that it faces? There is the uncertainty of demand, both in the present and in the future. Uncertainties also surround the technical processes available to produce the good and whether new processes will become available in the future. Uncertainties over input markets also exist - will the firm be able to get regular and continuing supplies? Will the price be stable? (A question which is obviously of crucial importance to the gold mining industry at present and in the future.) In order to cope with this inherent uncertainty, economic agents have evolved certain institutional frameworks. For example, the existence of organised markets reduces the amount of uncertainty in matching buyer to seller, while the existence of institutionally provided price sellers (the existence of a fixed gold price prior to the collapse of the Bretton Woods System) reduces uncertainty concerning the price at which transactions will take place.

Institutional frameworks have been designed to ameliorate the effects of uncertainty. The existence of certain economic phenomena, notably the twin evils of unemployment and inflation, is dependent on the presence of uncertainty.

For many years economists attempted to explain these dis-equilibrium phenomena within a theoretical framework based on certainty (i.e. based on perfect information and perfect knowledge, both now and in the future). What was needed to describe dis-equilibrium phenomena was a <u>disequilibrium</u> framework for analysis.

This disequilibrium is, in fact, uncertainty. A study of economic agents in disequilibrium is, in fact, a study of the behaviour of economic agents (such as the mine-owner) facing the kinds of uncertainties already mentioned.

2.5.2 Uncertainty and the Theory of the Firm

In regard to the theory of the firm, the specification of the firm's objective function remains an unsettled issue. However, the majority of writers maintain that the objective is to maximise profits and for the purposes of this thesis, attention shall be confined to profit maximisation.

There are a variety of ways in which uncertainty can and does enter the picture, whereas in the certainty theory it is assumed that demand and supply conditions and the production function, are all constant and known with certainty - any or all of these could be uncertain in practice.

The theory of the firm is conventionally divided up into separate topics according to the type of conditions prevailing in the markets in which the firm is operating. These are 1) perfect competition, 2) oligopoly, 3) duopoly and 4) monopoly. Of these 1) and 4) are the polar cases: in perfect competition the firm is a price taker in that it has no control over the price, while in monopoly the firm is a price setter and has total control over the product price. Oligopoly is an intermediate case (with duopoly being a particular example); here the firm has some control over price, though it must take into account the behaviour of the other firms in the market. The essential feature of the firm in perfect competi-

tion is that it is a price taker in its output market. Although, in local terms, the S.A. Chamber of Mines may have a monopoly on exploiting the country's gold resources, it is merely a price taker on the international world-market for gold.

2.6 The general relevance of expectations

Traditional neo-classical economic theory omits two of the most important elements in any real world analysis; time and uncertainty. All economic decisions are taken in the light of expected variables rather than actual variables. In that sense, almost all economic activity is speculative. When an asset-transaction is affected, both the buyer and the seller have their own expectations about future incomes and future yields on that particular investment. Similarly, consumers and producers take into account, not only the current price, but the spot price in relation to their expectations of future prices.

Differing expectations can provide the only explanation for the trading of shares (if buyers' and sellers' utility functions remain unchanged). When individuals save money by depositing it in a bank they have some idea of the expected inflation rate over the relevant period and hence the expected real rate of return on their savings. Adaptive and rational expectations provide a means of incorporating expectations into economic theory.

2.6.1 The meaning of adaptive and rational expectations

The range of possible adaptive expectations formulae is extremely large. The crudest and most unrealistic form of adaptive expectations

is the following formula which is used in the traditional "Cobweb Model" which explains the effect of farmers' price expectations on the supply and demand of agricultural commodities:

$$ {}_{t}p^{e}_{t+1} = p^{a}_{t} $$

where ${}_{t}p^{e}_{t+1}$ is the price that is expected to prevail at time period t+1. p^{a}_{t} is the actual price that prevails at time period t. In the Cobweb Model we find that at period t+1 expectations were incorrect and hence

$$ p^{a}_{t+1} \neq {}_{t}p^{e}_{t+1} = p^{a}_{t} $$

and so forth.

Furthermore, this model assumes that farmers do not learn by their mistakes and even though the magnitude of their errors (i.e. $p^{e}_{t} - p^{a}_{t}$) may increase exponentially, they do not adjust their expectations formulae.

However, more sophisticated versions of the adaptive expectations formula can be advanced.

For example, expectations could be formed by calculating a weighted average of past prices:

$$ {}_{t}p^{e}_{t+1} = a\,p^{a}_{t} + b\,p^{a}_{t-1} + c\,p^{a}_{t-2} + \cdots\cdots\cdots\cdots $$

where a, b, c ..... are weights such that $a > b > c$ .....
and $a + b + c \cdots\cdots = 1$.

The more sophisticated and realistic the formulae, the more difficult

they are to formalise and the less directly testable they become. Ultimately one arrives at the stage where all economically available information is used in forming expectations. This is known as Rational Expectations.

No formula can directly capture the process by which rational expectations are derived - all we can do is capture the result of forming expectations rationally:

$$ {}_{t}p^{e}_{t+1} = p^{a}_{t+1} + E $$

where E is a random error variable such that for a large number (n) of time-series observations (t) its mean is zero:

$$ \frac{1}{n} \sum_{t=1}^{n} E = 0 $$

This theory does not imply that for every observation t, E = 0, i.e. that expectations are always correct. The theory admits that errors are an inevitable result of the inherent uncertainty of the future and cannot be accurately predicted except by chance. All that the theory claims is that errors will be random, i.e. unsystematic and unbiased. Once market agents detect systematic errors, profits can be made by discovering their source and eliminating them. What remains are the random errors that are inherently unpredictable.

The expected variable (p^{e}) even though it may be a very bad predictor of the actual variable (p^{a}) is nevertheless the best generally known estimate.

2.6.2 The difference between adaptive and rational expectations

Adaptive expectations are formed by using past information in a systematic way. Some formulae may include a learning process that takes place through trial and error. Rational expectations are arrived at by using all economically available information.

In many situations it may be rational to form one's expectations adaptively since the best available guide to the future may be data from the past.

However, when the variable to be predicted moves in one direction at an accelerating rate, adaptive expectations will yield a biased result. For example, over the past twenty years aggregate prices have been rising at an accelerating rate. If expectations were adaptive, expected inflation would have persistently fallen short of actual rates for the relevant periods.

According to the "Monetarist-Expectational Approach", the fact that $p^e < p^a$ would have resulted in artificial booms, stimulating output and keeping unemployment below its "natural rate". (Monetarists such as Friedman implicitly assume that expectations are formed adaptively.)

Rational expectations, however, implies that expected variables are, on average, unbiased predictors of actual future variables:

$$\frac{1}{n}\sum_{t=1}^{n} p^e_t = \frac{1}{n}\sum_{t=1}^{n} p^a_t$$

Thus governments are unable to either depress or stimulate an

economy by "Stop-Go" monetary policies since at no stage can one predict with confidence whether p^e will be greater or less than p^a, as the error (E) is entirely random.

2.6.3 Some Problems

Several problems surround the rational expectations approach. Formal rational expectations theory assumes zero-cost information. When new information emerges, the whole market adopts it. Those who do worse than the market over time may be totally wiped out. On the other hand, if a minority of well-informed agents use the superior information while the rest of the market does not, this minority group stands to make a fortune. In this way, good information drives out bad and market expectations are always determined by the well-informed operators at the margin.

In reality, however, information is costly and difficult to test. Even the best informed analysts may use different theoretical models which generate different expectations. Thus, these competing models may survive side by side for a long time until the good model eventually drives out the bad.

However, these problems may not be as serious as they sound. Rational expectations theory suggests that market agents are not likely to be systematically stupid, and people tend to behave rationally in their own interest. The underlying assumption is that markets tend to be efficient. Of course, everybody does not use information efficiently, but on average, people do. Irrational behaviour cannot be predicted. It cannot be modelled, just because it <u>is</u> irrational. Good models have to assume that people act rationally. The economist

always has to hope that neurotic or irrational behaviour won't dominate markets. If it does, there is nothing the economist can do about it. However, it must be remembered that, in competitive markets, irrational people will go out of business.

Economists are unlikely to develop useful theories based on specific instances of market inefficiency. Rational expectations provide some good approximations of reality which is basically all that economics can do anyway. It has, therefore, been assumed throughout this thesis that expectations about future prices are formed rationally. The reason for assuming rational expectations being, in accordance with Robert E. Lucas of the University of Chicago, that "a rough theory that is refinable can catch more truth than an elegant model that does not fit the real world".[4]

4. Guzzardi, W., "The New Down-to-Earth Economics", Fortune, Dec. 31, 1978. p.75

CHAPTER 3

RESOURCE CONSERVATION AND OPTIMAL DEPLETION OF A WASTING ASSET.

3.1 INTRODUCTION

Wasting Assets are those assets with strictly limited, although not necessarily determinate lives. Economic activity involves the consumption of two kinds of naturally occurring resources;

1) Replenishable resources such as fish, timber, etc., and

2) Non-replenishable resources such as petroleum, natural gas and other minerals.

In other words, these exhaustible natural resources may be divided into two groups - resources which have the character of a fixed stock that is non-replenishable in its existing form and the flow resources which are self-generating, albeit with difficulty and delay should imprudent management at any stage weaken or destroy the self-generating mechanism. Into the first category fall the world's extractive mineral deposits, especially the mineral fuels. The second category includes forests, fisheries, wild life and soil where common property ownership may lead to market failure and inefficiency.

The lives of wasting assets are not necessarily determinate as future demand and cost conditions are not known; there is imperfect knowledge about the size of the stock of the resource due to the high cost involved in discovering the magnitude of the total stock. The present stock of a wasting asset includes only known reserves which may be worked profitably under existing economic and technological conditions. Depletion may occur either when physical stocks are literally exhausted or when the marginal cost of extracting the asset exceeds the marginal revenue from sale.

3.2 The fundamental nature of mineral resources.

As with all wasting assets, the key to a sound conception of the conservation of minerals lies in the recognition of their representing part of the nation's capital. A concern for the optimal depletion of exhaustible resources becomes a concern for the optimal rate of investment and capital formation in the economy at large. "It clearly makes no economic difference whether we save resources for tomorrow by not using them today, or instead, use them today in a process that does not yield direct satisfaction, but creates capital goods which yield their services tomorrow."[1]

The principle that determines the rate of investment - the rate of return on capital - must thus be used to govern the extraction of mineral resources.

The latter part of this chapter will deal more fully with the principle of the conservation of minerals for future generations. However, it is to the optimal depletion of wasting assets that attention will now be turned.

3.3 The optimal depletion of exhaustible resources in theory.

Before continuing with the discussion it must be pointed out that the wasting assets referred to from now on relate solely to the first category mentioned above, i.e. the world's extractive mineral deposits - resources which have a fixed character and are non-replenish able in their existing form.

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1. Gordon, S., "Economics and the Conservation Question", Journal of Law and Economics, Vol. 1, 1958

The objective function to solve the problem of the optimum rate of depletion is to maximise the net present value of the stock. In partial equilibrium market theory, there will be stock equilibrium in an asset market when all assets of a given risk class yield the same rate of return, partly as current dividends and partly as capital gains.[2]

Resource deposits yield no current dividend as long as they remain "in situ" so that the rate of return is purely in terms of capital appreciation.

A resource deposit draws its market value ultimately from the prospect of extraction and sale. The only way a resource deposit left in the ground can produce a current return for its owner, is by appreciating in value. The present value of a resource deposit is the net present value of future sales from it, after deduction of extraction costs. So, in equilibrium, net price or scarcity rent must be increasing at the market rate of interest. Under pure competition, net price or scarcity rent is market price minus marginal extraction cost, and in monopolistic conditions it is the marginal profit - marginal revenue less marginal cost - that has to be growing proportionally, like the interest rate.

Hotelling considers this "fundamental principle of the economics of exhaustible resources"[3] as a condition for flow equilibrium in the market for ore - if net price is increasing like compound interest,

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2. Solow, R., "The Economics of Resources or Resources of Economics", American Economic Review P + P, 1974 (pp. 1-2)

3. Hotelling, H., "The Economics of Exhaustible Resources", Journal of Political Economy, Vol. 30, April 1931 p. 139

owners of operating mines will be indifferent at the margin between extracting and holding at every instant in time. One can envisage production just equal to demand at the current price and the ore market clears. No other time profile for prices can elicit positive production in every period of time.[4]

If net price rises at less than the rate of interest, the return on investment in conservation of a resource is less than the return on other investment so the rate of extraction will be increased and the resource will be exhausted more quickly. If net price rises faster than the rate of interest, owners of mines delay production while they enjoy supernormal capital gains.[5]

According to the "fundamental principle", "If we observe the market for a wasting asset near equilibrium, we should see the net price - or marginal profit - rising exponentially. This is not quite the same thing as seeing the market price to users of the resource rising exponentially."[6] The price to consumers is the net price plus extraction costs, or the analogy for monopoly. The market price can fall or stay constant while the net price is rising if extraction costs are falling through time, and if the net price or scarcity rent is not too large a proportion of the market price. That is presumably what has been happening in the market for most exhaustible resources in the past.

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4. See Solow, R. (p. 3)
5. See Adelman, M., The World Petroleum Market, (p. 40) for an alternative approach using "User cost" as the criterion.
6. See Solow, R. (p. 3)

Eventually, as the extraction cost falls and net price rises, the scarcity rent must come to dominate the movement of market price, so the market price will eventually rise, although, according to Solow, this may take a long time to happen.

Whatever the pattern, market price and rate of extraction are connected by the demand curve for the resource. So, ultimately, when the market price rises the current rate of production must fall along the demand curve. Sooner or later, the market price will become high enough to choke off the demand entirely and, at that moment, production falls to zero.

Under conditions of perfect knowledge about future price and cost conditions, taking the interest rate as known, the theory allows an optimal rate of depletion so that, at infinity, the resource would be exhausted and the demand for the resource would be zero at the high market price. However, the mining industry operates under uncertainty about technological change and the total level of reserves due to the length of the time horizon involved.

At the margin, extraction cost in known fields includes the cost of finding new fields and a return on capital equipment invested in extraction. Costs are increasing over time for two reasons:-
Low cost deposits will be exploited first, followed by successively higher cost deposits. As reserves decline, net price rises exponentially and market price increases.
Secondly, the discovery of new fields is subject to diminishing returns, given fixed total reserves, so the marginal cost of finding new fields must increase.

Proven reserves do not equal the total resource available. As market price increases or cost of exploitation decreases, proven reserves increase without additional discovery as it becomes economically profitable to recover previously uneconomic marginal reserves. New discoveries also increase proven reserves. An increase in proven reserves in time period t + 1 means that an investment decision based on the expected net price has resulted in over-conservation compared to the ex post optimum, as future price will now not rise as fast as anticipated. Since there are costs involved in obtaining information about total reserves, it does not pay to obtain this information unless the cost of this information is less than the capital loss that results from over-conservation in period t.

Technological change may affect the optimal decision in two ways:
Firstly, it may lead to a lower cost technology for exploiting reserves (and thus increased proven reserves) which will result in increased exploitation so that the market price will rise less than expected in the future, leading to a capital loss for the over-conserving mine owner.
Secondly, technological advancement may result in the development of substitutes for the resource - either low cost or non-exhaustible. Consequently, existing reserves of the resource will become worthless as future sales will be zero and the return from investment in conservation will be zero. An example is the development of a generator using wind power or wave power to generate electricity at a low cost - neither wind now waves are exhaustible and thus have no scarcity rent. Therefore, the cost of a wave-powered generator would be the upper limit to the price of coal.

From the above discussion we can deduce that the "fundamental principle of the economics of exhaustible resources" is simultaneously a condition of flow equilibrium in the market for ore (Hotelling) and of asset equilibrium in the market for deposits (Solow) as well as stock equilibrium in the asset market. When these conditions hold, they provide a relatively adequate explanation of the probable pattern of resource exploitation.

However, what we need to know is how this explanatory value is affected, if and whether these conditions do not hold. The analysis is complicated by the fact that the flow market that has to be cleared is not just one market but a sequence of futures markets for resource products from now until the date of exhaustion. However, although we might accept the idea that the equilibtium path of such markets (if they existed) is stable, we do not have a full set of futures markets. Markets for natural resources work with relatively short-sighted flow transactions and more far-sighted asset transactions. Thus, the bone of contention remains whether observed resource prices are good approximations to equilibrium prices or whether the equilibrium is so unstable that monetary prices are not only a bad indicator of equilibrium relationships, but also a bad guide to resource allocation.

The answer to this depends upon the nature of flow and stock considerations, which work in opposite directions. Flow markets, by themselves, may be unstable; however, asset markets can provide a corrective force.

The flow equilibrium condition is that net price grows like compound

interest, at the prevailing rate. If producers expect that net prices are rising too slowly, then resource deposits are a bad way to hold wealth. If mine owners think only in flow terms, they will try to get out of the resource business by increasing current production and converting the ore to money. If current production increases, the current price moves down the demand curve.

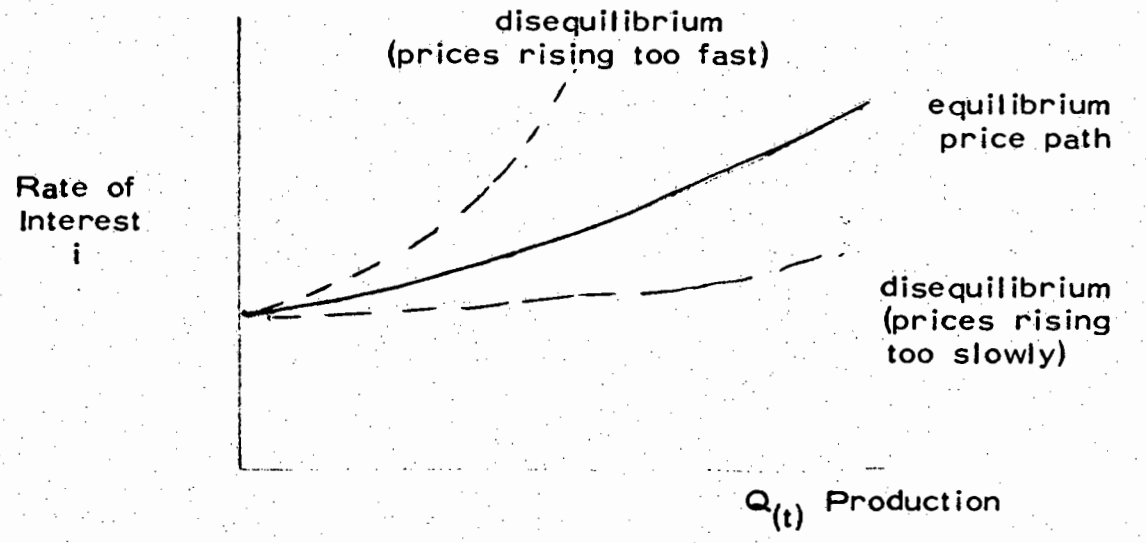

Fig 3.1

So, initially, pessimistic price expectations on the part of producers have led to more pressure on the current price. If expectations about future price changes are responsive to current events, the consequence can only be that pessimism is reinforced and deepened. Thus, the initial disequilibrium is worsened by this chain of events, i.e. this market mechanism is unstable. (See Fig. 3.1)

Conversely, if prices are initially expected to be rising too fast, the withholding of supplies will lead to a speculative increase of prices which is self-reinforcing.

Depending on which way we start, the production schedule is tilted either toward excessive current dumping or speculative withholding of supply.

However, this instability in spot markets can be amended if we take the asset market into account and allow the longer run prospect to have an influence on current events. If producers do expect that the resource does have a future value determined by technological and demand considerations, not merely by speculation, then if prices are rising towards this at too slow a rate, owning deposits would be bad business. However, this will lead to capital losses on existing stocks, not to dumping of current production.

Once existing stocks have been written down in value, the net price can rise towards its future price at more or less the correct rate. As well as being destabilised by flow reactions, the market can be stabilised by capitalisation reactions. The reduction in flow price coming from increased current production, (Q(t)), can be read as a signal and capitalised into losses on asset values, after which near-equilibrium is re-established.[8]

So far, the economic theory of exhaustible resources has been discussed as a partial equilibrium market theory. The interest rate is taken as given to the mining industry by the rest of the economy, as was the demand curve for the resource itself. When market price has risen up the demand curve to the point where quantity demanded falls to zero, the theory maintains that the resource has been exhausted. Let us look at this contention in more detail.

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8. See Solow, R. (p.7)

We define R_t to be equal to the price of the metal (P_t) minus the current cost (c) of extraction and processing. Now R, which is the price of the metal (price per unit metal recovered) in the ground, must rise at the rate of interest, or discount, r. P_t does not rise at the rate of r per unit time. The relative rate of increase of P_t does approach r as a limit, however, as P_t becomes large in relation to c.

We know that net price (R) must rise at the rate of interest. But at what level is the initial price?

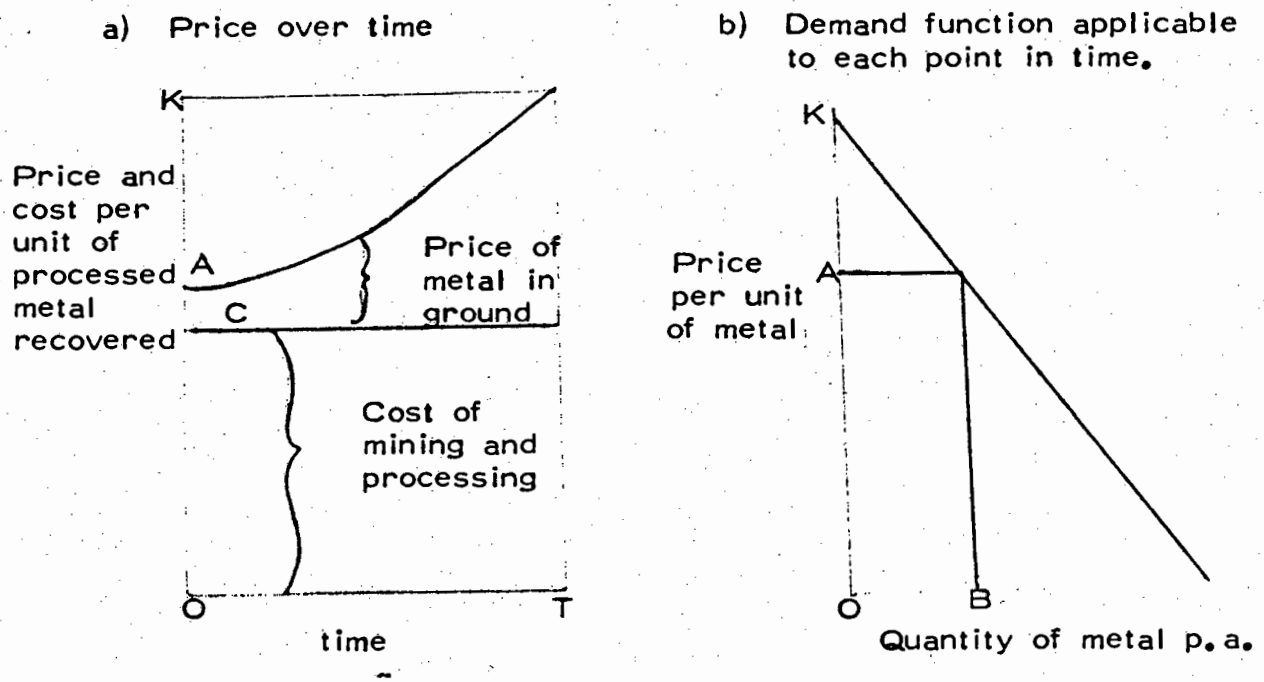


Fig. 3.2.

If the market participants foresee the future correctly, an initial price of OA will yield production and sales of OB per year. As price increases, production and sales will decrease - the metal will no longer be used in less important uses - until finally at P_T = OK nothing will be produced or demanded.

Let us call T the period of exploitation. If the initial price is too low, the deposits will be used up before price has reached OK, the maximum that buyers are willing to pay. And too high an initial price will result in the maximum price being reached before the deposits are exhausted.

From this simplistic situation we observe several important points. Although they may not be very realistic, they are, nevertheless, instructive.

Firstly, production and consumption in any one period depend on what happens in all other parts of the period of exploitation. If consumers feel that a deposit should be used up later rather than earlier, as indicated by the price that they are willing to pay for metal in the ground being higher for the later than for the earlier period (with both prices discounted to the same point in time), the time of exploitation will be shifted.

Also, the determination of the rate of use of the mineral deposits is integrated with the whole investment process in the economy by virtue of the fact that holding a mineral deposit is an alternative to holding other forms of capital and to consumption.

Hence, a discounting process is necessary to perform the comparison, simply because of the existence of the option to invest and secure a net return over time. That is, there is a possibility that by using the services of a mineral deposit now, the outlay on other current productive services to produce the same amount of product (as measured by market value) can be reduced. This saving can be

used to produce either capital goods or consumption goods. The equation of the value of these opportunities at the margin is automatically secured by the profit seeker making his choices on the basis of present values calculated by using the market rate of return on investment. The price of metal in the ground will be such as to bring equilibrium in the market for mineral properties to enable mineral deposits to play their role in the maximisation of income over time. From the point of view of society or the firm, a mineral deposit is best viewed as a piece of capital that can yield a flow of services which represent its consumption, just as with a machine which eventually wears out.

Furthermore, it is interesting to consider what the effect of a lower rate of interest would be (Fig. 3.3).

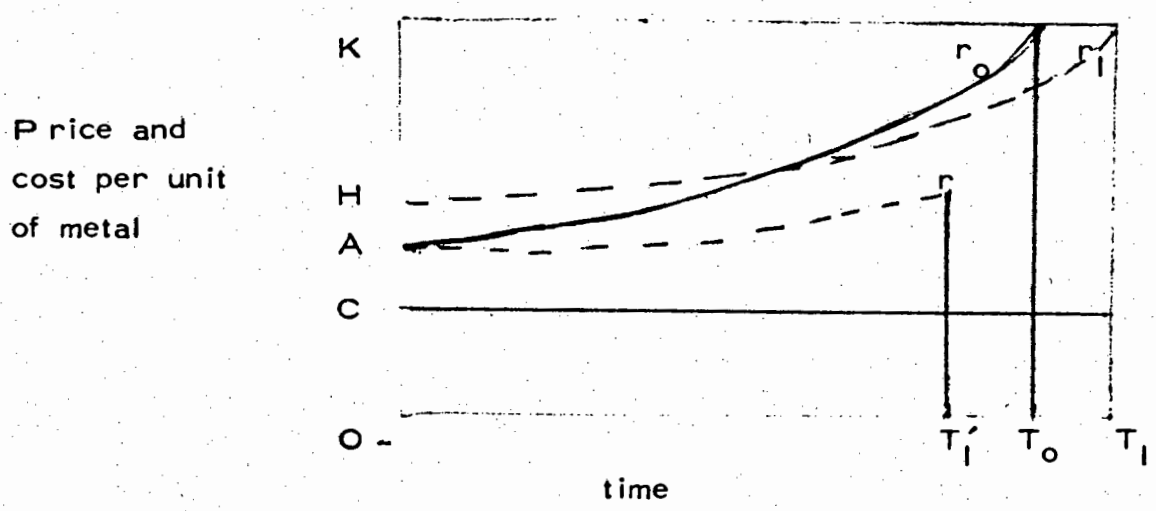


Fig. 3.3

As in Fig. 3.2, the initial solution with r_o is represented by the solid curve, with the time of exhaustion at T_o when the maximum price of OK is reached.

If a lower interest rate, r, were associated with the same initial

price, A, the course of price through time would be the dashed curve below curve r_o. But, if price is lower at each point in time than in the other situation, the quantity purchased at each point in time would be larger, and the deposits would be exhausted before the maximum price is reached, say at T_1'. Thus, the new solution must start at a higher price, H. But, if earlier prices are higher, later prices must be lower if the maximum price, OK, is not to be reached before exhaustion. Hence, the new price curve must cross the first and the period of exploitation is lengthened, as indicated by the curve, r_1.

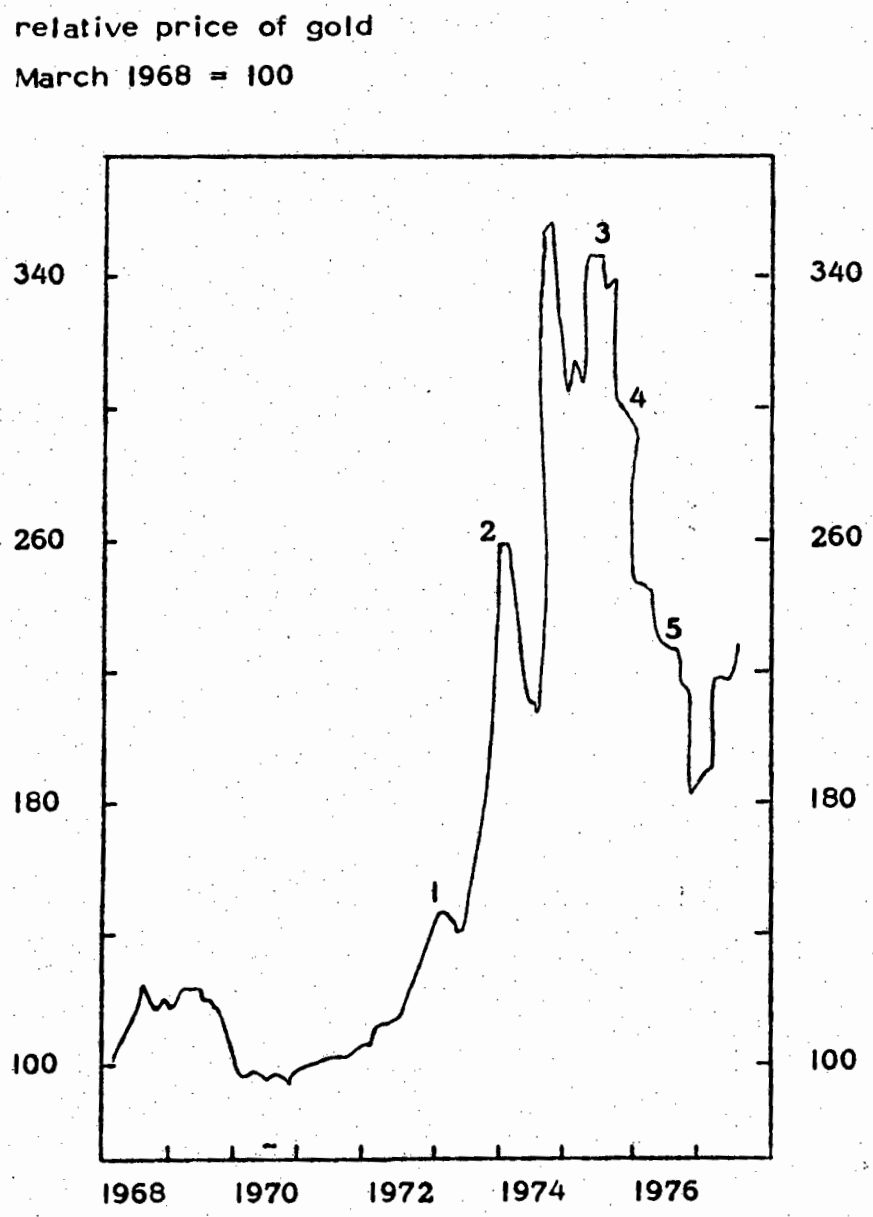
With a lower rate of interest it is no longer so urgent to use the services of the deposits early - the cost of not using them is lower. Or, think of the effect of the decrease in the interest rate, r, on the present value of the net price, R. For early t's there is little effect, but the increase is more for later t's. Hence, it pays to shift production and consumption to the future.

As previously indicated, these simplistic models of wasting assets are not very realistic, although nevertheless useful. As gold is the particular wasting asset to be considered in this thesis, it is relevant to consider how well this standard model of wasting assets can explain observed movements in the gold price.

3.4 Inability of Standard Model of Wasting Assets to Explain Observed Movements in Gold Price (1968-74)

Between March 1968, when central banks stopped their pegging operations and December 1974, when the U.S. government announced its first gold auction, the path of the real gold price (see Fig. 3.4)

Real Gold Price (1968 - 1976)



Monthly index of the dollar price of gold relative to the U.S. Consumer Price Index. 1, First explicit reports that the United States and the IMF were considering gold sales. 2. Reports of impending agreement to permit central bank sales. 3. Announcement of first U.S. auction. 4. Announcement of second U.S. auction. 5. Agreement reached in Jamaica on IMF gold sales.

Fig. 3.4

Source: International Monetary Fund. International Financial Statistics, Washington: I.M.F., Nov. 1977

exhibited two striking features. Firstly, the price rose at a rate much greater than the real rate of interest for intervals as long as eight months. Secondly, each upward surge was interrupted by a sharp setback. During that six-year period, little or no gold was actually decumulated from the massive stockpiles controlled by world governments. But, since the role of gold in the international monetary system had been reduced, the possibility persisted that significant sales to the private market might some day occur.

Because of its profound consequences, this possibility could not be disregarded by market participants owning gold. Government stocks are about 25 times as large as global annual production at its peak and are roughly equal to estimates of the entire stock remaining underground on earth.[8] One possible explanation is that market anticipations that governments would sell a portion of these stocks at an unpredictable time, exerted a significant influence on the gold price during this period.

3.4.1. Shortcomings of the Standard Model.

To review the simplest model of an extraction industry; suppose a collection of competitive firms with zero extraction costs and fixed stocks of known size, sell to consumers whose demand at any time depends only on the price then prevailing in the market. Under such circumstances, only one sequence of prices will make the optimal decisions of extractors and consumers consistant at all times. The equilibrium price path must begin at a specified level and rise at

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8. Meadows, D. and D., The Limits to Growth, Earth Island, London, 1972.

the rate of interest during all periods of positive sales. If the price did not rise at that rate, some prices would have lower discounted values than others. Mine owners maximising the present value of their profits would sell nothing in those periods, and excess demand would result. Similarly, if the initial price were set too low (high), the cumulative amount demanded by consumers would exceed (fall short of) the cumulative supply, an indication that some of the inter-temporal sequence of markets would fail to clear.

When speculators with neither costs of storage nor initial inventories are added to this model, the equilibrium price path does not change. Extraction in a period where speculators buy (sell), exceeds (falls short of) gold consumption, the difference going into (coming from) speculative inventories. While competitive extractors make profits because of the rents on the scarce resource they own, competitive speculators make no profits.

In this simple form, the exhaustible resource model fails to capture the most salient characteristics of the path of the gold price since 1968. It does not predict persistent increases in the price at greater than the rate of interest, nor can it explain, either the existence or timing of most drops in the price.[9] However, since the assumptions of this simple model do not reflect several important features of the gold market, the omission of some pertinent characteristics may account for the poor predictive power of the model.

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9. It does suggest that gold extraction might fall as price rises, a phenomenon which has occurred, to the puzzlement of some analysts.

There are three characteristics of gold which distinguish it from the exhaustible resource of the simple model.

First, extraction costs in the gold industry are not negligible and have risen.

Second, the gold market is not competitive, but is dominated by one seller, the South African Reserve Bank. The Reserve Bank acquires and markets all South African production, an amount equal to three-quarters of the world total.[10]

Third, gold holders cannot know with certainty the size of the stock which will be available for private use, since the possibility always exists that governments may sell to the private market some of their enormous holdings.

Of these three distinguishing features of the gold market, only the third could account for the basic characteristics of the observed gold price path. For, while the presence of increasing extraction costs or of monopolistic behaviour could conceivably give rise to the observed pattern of prices in the absence of speculators, neither factor could explain the observed pattern in a world where competitive speculators can enter and do operate.

Since competitive gold speculators have no extraction costs and negligible storage costs, they prevent the price from persistently rising in percentage terms faster than the rate of interest. For, if speculators came to foresee a more rapid increase, they would attempt to make unlimited profits by borrowing, buying gold in one period and selling it in the next - thereby carrying cheaper ore

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10. Chamber of Mines Annual Report, Tvl. Chamber of Mines, 1980, p.12.

into a period in which it would have been more expensive. Such actions would cause the price path to change until all foreseeable opportunities for profitable arbitrage were eliminated (efficient markets hypothesis).

Since competitive speculators place an upper bound on the rate of increase of the gold price, under the circumstances considered so far, a model which purports to explain movements in those prices must explain why speculators did not flood the gold market when persistently faced with apparently unexploited profit opportunities. The key ingredient to such an explanation is the persistent anticipation of gold holders that a portion of the large stocks held by the world's government would be sold on the private market at an unpredictable time.

The current discounted revenue which a mine owner or speculator can expect from the sale of a given amount of gold at any time in the future, is equal to its current market value. When the odds of government sales increase, the market value of existing stock falls. This serves to remind us that while the better prospect of additional supplies may be socially beneficial, the increased likelihood does injure owners of the existing stock. A country like South Africa, for example, would be injured by actions or announcement of world governments which substantially depress the gold price - just as it had benefitted substantially from previous international payments arrangements among nations which, in effect, constituted a commodity support programme for gold.

3.5 Divergence between private and social costs and benefits.

What has been called "the fundamental principle of the economics of exhaustible resources" is, among other things, a condition of competitive equilibrium in the sequence of futures markets for deliveries of the natural resource. In perfect competition, net price rising at the market rate of interest will result in Pareto optimality.[11] In particular, as Hotelling pointed out, the competitive equilibrium maximises the sum of the discounted consumer-plus-producer surpluses from the natural resource - provided that society wishes to discount future consumer surpluses at the same rate that mine owners choose to discount their own future profits.[12]

The question arises whether society ought to discount utility and consumption at the same rate as reflective individuals would discount their own future utility and consumption. This is an important question, as the discount rate determines the whole tilt of the equilibrium production schedule. If the market rate of interest exceeds the social rate of time preference, then scarcity rents and market prices will rise faster than they "ought to" and production will have to fall correspondingly faster along the demand curve. Thus, the resource will be exploited too fast and exhausted too soon.

On the one hand Hotelling states: "capital is productive, future pleasures are uncertain in a degree increasing with their remoteness in time, thus discounting is acceptable".[12] On the other hand, Rawls

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11. The resources price would reflect marginal social cost in terms of discounted consumer plus producer surplus.

12. Hotelling, p. 142

13. Ibid. p.143

extends the argument of the new welfare economists that interpersonal comparisons of utility are not justified - "from a moral point of view there are no grounds for discounting future well-being on the basis of pure time preference ..... this calculus of advantages which balances the losses of some against the benefits to others appears even less justified in the case of generations than among contemporaries."[14]

If the social rate of discount may exceed zero, the market rate is unlikely to exceed it because the risks facing individuals or firms may not be social risks, merely risks of transfer,[15] and because of the existence of taxes on income from capital - individuals care about after tax returns on investment and society, the before tax returns.

Other classes of reasons for expecting that private discount rates are too high and will distort intertemporal decisions away from social optimality denies that private time preference is the right basis for intertemporal decisions. Frank Ramsey argued that it was ethically indefensible for society to discount future utilities. Individuals might do so, either because they lack imagination (Pigou's "defective telescopic faculty") or because they are all too conscious that life is short. Moreover, in social decision making, time horizons should be very long.

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14. Rawls, J., A Theory of Justice, O.U.P., London, 1972, p. 287

15. Hanson, D.A., "Second Best Pricing Policies for an Exhaustible Resource", AER (P + P), February 1977. p. 354

Property rights may lead to externalities in the case of minerals to the extent that "ownership is a trust in a long sequence of ownerships from generation to generation for the good of the whole race for all time".[16] Since the resources are relatively divisible into independent productive units, where mineral rights are the property of the state and are leased to the mining companies, the full social cost can be covered by leasing to the highest bidder.

In conclusion, we know that, in general, even well-functioning competitive markets may fail to allocate resources properly over time. The reason is because, in the nature of the case, the future brings no endowment of its own to whatever markets actually exist. The intergenerational distribution of income or welfare depends on the provision that each generation makes for its successors. The choice of a social discount rate is, in effect, a policy decision about that intergenerational distribution. It is to the question of intergenerational equity and the principle of conservation that attention will now be turned.

3.6 The Principles of intergenerational equity and conservation of resources.

3.6.1 Introduction

Eventual exhaustion of natural resources is often regarded as a serious problem but the theoretical basis for this prediction remains somewhat inadequate. Every act of consumption of stock resources means that there is less remaining for future use. The potential

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16. P arkins & Whitaker, Our Natural Resources and their Conservation, John Wiley, London 1936. p.434

depletion of these resources gives rise to the need to consider whether market forces are leading to too rapid exploitation of these resources for the good of future generations and whether there is a need for government intervention to make greater provision for the future.

Economic efficiency both in the present generation and over time must be considered. Conservation does not imply lack of use, merely wise and careful use so that the utility derived from a resource may be maximised over time.

3.6.2 The Pure Theory of Wasting Assets

The pure theory of wasting assets (discussed earlier) considers the possibility that it is profitable to limit the current output of a natural resource so that greater supplies are available to future generations. Marshall showed awareness of the theory in his Principles, but only hinted at the results (1920, pp.438-39). A pioneering article by L.C. Gray (1914) presented the basic prepositions relating to the individual firm, he relied on an intuitive argument supplemented by numerical examples. Hotelling's 1931 article, however, provided the fullest treatment; he gave a more precise definition of wasting assets, developed a mathematical analytical framework, and outlined the analysis of several basic cases.

Subsequent work has concentrated on explaining portions of the earlier work. Herfindahl (1958) showed how cost curves could be used to simplify Gray's analysis. Scott (1965) developed a more general geometric approach that could deal with complications produced by forces such as shifts of costs and prices over time.

Herfindahl (1965) presented a graphical analysis of Hotelling's simple constant cost industry case. The comparative statics of the model were discussed, and the effect of differences among firms in costs was evaluated.

Wasting Assets theory is also closely related to two quite distinct broader areas - conservation and user costs. Clearly the pure theory of wasting assets deals with the problem usually considered central to conservation policy. Yet, the direct contact between the theory and conservationist writings has been limited. Barnett and Morse's (1963) review of natural resource scarcity assumes that the rate of exhaustion is exogenously determined. The role of the pure theory of wasting assets in explaining how the rate is selected is ignored. We do, however, obtain valuable insights into the crucial role technology must be given in any empirically relevant theory of exhaustion.

The automatic assumption that the pure theory of wasting assets is applicable to natural resource commodities involves a complete misunderstanding. Exhaustion is not necessarily desirable. Just as machines can become obsolete before they wear out, extraction of minerals can become unnecessary before the supply is depleted. Scrap availability might make mining undesirable, (e.g. copper), solar energy might displace mineral fuels. The pure theory only provides a test of whether exhaustion is profitable. If it were, the theory indicates that we would observe firms sacrificing current profits to increase future supplies. Since mineral industries generally do maximise future profits, i.e. present values, the theory actually seems to suggest that exhaustion of minerals is unlikely.

Thus, instead of providing rules of conservation policy, the theory suggests that conservationists are worried about a non-existent problem.

3.6.3. What is Conservation?

"Contemplation of the world's disappearing supplies of minerals, forests and other exhaustible assets has led to demands for regulation of their exploitation. The feeling that these products are now too cheap for the good of future generations, that they are being selfishly exploited at too rapid a rate, and that, in consequence of their excessive cheapness, they are being produced and consumed wastefully has given rise to the conservation movement."[17] These sentences appeared at the beginning of an article by the late Harold Hotelling, as far back as April, 1931.

Before going any further, it is necessary to clarify what is meant by "conservation" as it forms a central part of this discussion. The economist, Gordon, maintains that "it clearly makes no economic difference whether we save resources for tomorrow by not using them today in a process that does not yield direct satisfaction, but creates capital goods which yield their services tomorrow."[18]

Thus, the principle that determines the rate of investment, the rate of return on capital, must be used to govern the extraction of mineral resources.

Furthermore, Gordon points out that to conserve or postpone the use

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17. Hotelling, H., "The Economics of Exhaustible Resources", JPE Vol. 39, No. 2, 1931, p.137

18. Gordon, S., "Economics and the Conservation Question", JLE, Vol. I, 1958, p.114

of one resource usually involves the depleting or accelerating the use of another. It is meaningless to conserve all resources. To this the Petrick Commission into the coal resources of South Africa replies, "Conservation of a natural resource does not imply that recovery from it should be completely discontinued, but rather means husbanding the resource, controlling its depletion by avoiding waste in both recovery and utilisation and generally managing it with economy."[19] Conservation should thus be seen as the optimum use of resources from which will flow the maximum benefits for this and succeeding generations.

3.6.4 Intergenerational Equity

The question is whether current generations should invest more in conservation for the good of its descendants, in other words, to specify an optimal, intertemporal distribution of welfare to the extent that wasting assets contribute to this welfare. The appropriate consideration is whether every member of society over time has an equal claim to a quantity of a particular natural resource, or a right to equal satisfactions - equal gratifications of desire and not the objects that yield specific satisfaction. With some natural resources, such as deposits of minerals, their exploitation necessarily means that they are gradually used up, while others, e.g. fisheries, soil, can be made to bring a continuous return for an indefinite period. The usual complaint of the conservationists is that the former - the "stock resources", are used up too rapidly while the latter, the "flow resources" are not used so as to give as high a permanent return as they would be capable of. These

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19. Report of Commission of Inquiry into Coal Resources of RSA (Petrick), R.P. 63/1975, p.2, para. 9.

contentions are based partly on the belief that the private exploiter does not take a long enough view or does not have as much foreknowledge of future developments as the government and partly, on a simple fallacy which we shall see invalidates a great part of the usual conservationist argument.

There arises in this connection the problem of the neighbourhood effects, which may in certain instances lead to wasteful methods of exploitation because of the common property nature of the resource, (e.g. fisheries). In these cases the market fails to allocate resources efficiently and it is undesirable that where, for such technological reasons, we cannot have exclusive control of particular resources by individual owners, we must resort to alternative forms of regulation or government intervention.[20]

Most consumption of irreplaceable resources rests on an act of faith. We are generally confident that, by the time the resource is exhausted, something new will have been discovered which will either satisfy the same need or at least compensate us for what we no longer have, so that we are, on the whole, as well off as before. We are constantly using up resources on the basis of the probability that our knowledge of available resources will increase indefinitely - and this knowledge does increase in part because we are using up what is available at such a fast rate.

Conservationists take for granted that there is something particularly desirable about the flow of services that a given resource can provide at any one time, and that this rate of output should be

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20. Hayek, The Constitution of Liberty, Gateway, Chicago 1960 p. 372

permanently maintained. They do, however, recognise that this is impossible with regard to stock, although not to flow, resources.

Minerals and similar resources share with some of society's capital the property of being exhaustible, and if we want to maintain or increase our income, we must be able to replace each resource that is being used up with a new one that will make at least an equal contribution to future income. This does not mean, however, that if should be preserved in kind, or replaced by another of the same kind, or even that the total stock of natural resources should be kept intact. From a social as well as an individual point of view, any natural resource represents just one item of our natural endowment of natural resources and our problem is not to preserve this stock in its existing form, but always to maintain it in a form that will make the most desirable contribution to anticipated total income.

Given the fundamental nature of mineral resources and the likelihood of the discovery of new deposits and of technological innovation, the principle of intergenerational equity merely demands that "society channels its investment in such a manner that its aggregate income is made as great as the funds available for investment can make it."[21]

Since all capital is exhaustible and must be replaced, investment in the conservation of non-reproducible capital should not be seen as more desirable than in produced means of production, knowledge, technology and economic institutions.

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21. Hayek, F., The Constitution of Liberty, Gateway, Chicago, 1960 p. 374

As Hayek states: "To extend investment in conservation of a particular natural resource to a point where the return is lower than the capital it uses would being elsewhere, would reduce future income below what it would otherwise be. The conservationist who urges us to make greater provision for the future is in fact urging a lesser provision for posterity."[22]

Resource conversation, if not economically meritous, will reduce the economic value of output over time and may, by curbing research and capital formation, have a perverse effect on the future. "Emphasis on economic and social progress in the present is a much improved alternative to preoccupation with an indefinite and non-operational moral obligation to reserve natural resources for the economic benefit of future generations."[23] Since each generation cares for its immediate descendants, a series of short-term "just-savings"[24] schedules will tend to produce the long run optimum.

3.6.5. Divergence between Optimal and Actual Depletion Rates

If prices are correctly predicted we may conclude that resources are being exploited at an optimal rate. A brief outline of this argument is given here.

Resource conservation is an investment in the future. It requires us to give up present consumption for the sake of future benefits. It thus resembles other forms of investment which are undertaken in the economy (e.g. in plant or machinery). Efficiency requires that

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22. Hayek, F., p.374
23. Hayek, F., p.374
24. A notion introduced by J. Rawls, A Theory of Justice, p.284-293

the returns on all these forms of investment should be the same; otherwise we could increase consumption both now and in the future by expanding one type of investment and contracting others. A competitive firm will make the same sort of calculation. It will compare the returns from resource conservation and other investment opportunities and adjust the volume of each it undertakes, so that the returns from each are the same. If not, it could increase its profits by devoting more of its funds to the higher yielding investment. Consequently, the calculations made by a firm in deciding how rapidly to exploit an exhaustible resource will be the same as the one society would make if it were choosing an optimal depletion rate on the firm's behalf. However, in reality, actual and optimal depletion rates will diverge and it remains to consider the possible reasons for this bias.

i) Neglect of future generations

This issue has already been dealt with in some detail. It is a mistake to suggest that leaving resource exploitation to the market neglects the interests of future societies. If prices are correctly predicted, the demands of our children, grandchildren etc., are being taken into account by resource owners, who are saving up resources to sell to them when the time comes. However, there may be a general bias in the economy to consume now and leave too little to future generations. This would be reflected in high rates of interest and consequently a more rapid depletion of resources.

Conservationists take this view, pointing out that interest rates have been too high as a result of society's 'defective telescopic faculty' (Pigou), as mentioned earlier. However, if this were true,

it implies that we are undertaking too little investment of all kinds. As a result economic growth must be too low, and we must increase the investment ratio in an attempt to raise it. No doubt those who worry about excessively rapid resource depletion would be disinclined to accept the latter conclusion.

ii) Incorrect price predictions.

There is no guarantee that resource owners will correctly predict resource prices. If owners, on average, over-estimate future prices (as compared to equillibrium prices) they will supply less than the equilibrium amount now, while planning to supply more in the future. This will raise current prices. Since the extent to which resource owners want to deliver the resource currently depends on their price expectations (which cannot be very firmly based), there is scope for a wide divergence between actual and equilibrium prices. Although there may be forces causing a convergence of actual prices towards equilibrium, this adjustment need not be rapid. Oversupply may exist for many years before the drying up of major sources gives prices the upward push needed to bring about a revision of expectations.

What is important is to consider whether this bias in expectations will be upwards or downwards. This requires a more detailed examination of resource prices. Consider the owner of a stock of resources of total amount, R, and suppose that he believes the price for this resource at time, t, to be P_t. He has to incur exploitation costs $c(x,t)$ at time, t, if he is then extracting resources at the rate, x. Assuming that he wants to maximise the discounted sum of his profits, his rate of interest being i, he will relate the

marginal cost of extraction at t to the price at t by the equation

$$P_t = c_x(x_t, t) + Qe^{it}$$

$c_x(x_t, t)$ = marginal cost of extraction.

Qe^{it} = imputed cost of drawing on the stock of the resource. This cost rises at a rate equal to the rate of interest (the opportunity cost of holding money) because he has the option (at the margin) of lending at interest, i, instead of keeping the resource in stock. Q is the value, to the owner, of a unit of the resource (not yet extracted) at time O. Its level is such that he plans to just exhaust his stock. However, if P_t is too low, the owner will not plan to extract any of the resource at t and it is thus possible that $P_t \leqslant Qe^{it}$. For example, he may plan to exhaust his stock at some date T, because thereafter Qe^{it} is so large that it exceeds the difference between the price obtainable and the marginal cost of extraction.

Note that the form of the relationship expressed in the above equation is a very general one and does not incorporate all the important aspects of resource exploitation (for example, extraction costs, in general, depend upon the stock remaining).

Returning to the question of expectations - the term, Qe^{it}, will not be important when the total stock of the resource is still large; that is to say, the equilibrium price will not be much greater than the marginal cost. It seems unlikely that an actual price below the extraction cost could persist for very long. Therefore, if there is a bias, it must be in the upward direction. This would keep the price higher than it should be and thus bring about under-exploitation of the resource.

However, at a later stage, the price might be too low. As the stock diminishes, the term, Qe^{it} becomes important and the equilibrium price, having previously been constant or falling, should begin to rise. The rise would accelerate until the price is eventually growing at a rate approaching i (if the resource has not already ceased to be used). It is possible that people will tend to underestimate distant prices if, in fact, the rate of price rise is going to accelerate. In that case, there will be a bias towards overexploitation.

However, it seems that, on balance, the likelihood is for price extectations to be upwards, causing under-exploitation, rather than downwards.

iii) Risk aversion.

Uncertainty exists (as mentioned in Chapter 2) about future prices, resource supplies, etc. Consequently, a resource owner will be more uncertain about the price he can expect to obtain for his resource in the future, than about the price he can expect to obtain now. If he is risk-averse, he will tend to discount future prices (as he sees them) and deliver more of the resource now than he would have done if he had known for certain that future prices would be what he expects. It may, thus, be argued that the private owner's risk aversion implies an undesirable bias towards present depletion. However, a good deal of research needs to be done before one can be sure of the direction in which uncertainty biases depletion, far less its quantitative importance.

iv) Ownership uncertainty.

Uncertainty is important when the owner is uncertain about the future security of his rights to the resource or the profits from it. If he expects that the government may expropriate the resource from him with imperfect compensation, he has an incentive to deplete his stocks sooner rather than later. However, although political instability could thus, lead to over-exploitation, the transfer of ownership to the resource's nation might eliminate any bias to exploit the resource too rapidly.

v) Monopoly.

There is strong evidence of monopoly in resource exploitation, which may, of course, be exercised by implicit collusion or local government taxes. Thus, in cases where a natural resource, subject to explicit or implicit collusion, has a rather inelastic demand, there is a strong bias towards under-exploitation of the resource, as compared at any rate to the competitive outcome.

vi) Taxation.

Tax treatment of resource extractive industries is typically rather complicated, and as it forms the main section of a later chapter, discussion here will be limited.

Needless to say, the effect of taxation on the rate of resource depletion may be substantial. The simplest case is that in which resource owners are subject to a profits tax on receipts less operating expenditures, like other producers. In that case the tax will not affect the rate of depletion if it is expected to be applied

at a constant rate over time. But a profits tax will reduce the rate of return a firm obtains from its other investments and hence lead it to invest too much in conservation relative to other forms of productive investment. Since rates of profits tax are usually high, this effect may be substantial.

The tax, while not affecting the time profile of receipts, will reduce its size, and this will have a disincentive effect on exploration and development expenditure. Thus the existence of a profits tax may lead to a strong bias towards insufficiently rapid resource depletion: less of the resource will be discovered, less of what is discovered will be developed, and what is developed will be produced too slowly.

Governments of producing or consuming countries often impose revenue-raising taxes on the use of exhaustible resources. The effect of this is essentially equivalent to increasing the degree of monopoly in resource extraction, and as argued above, this will tend to lead to insufficiently rapid depletion.

3.7 Government Intervention - Regulation and Pricing

The concern of the conservationists has been that the free market is exploiting resources too fast and that the price has been too low so that full social costs have not been borne by producers and consumers in the current generation.

The chief arguments that have persuaded people of the necessity for central direction of the conservation of natural resources are that the community has a greater interest in and a greater fore-knowledge

of the future than the individuals, and that the preservation of particular resources raises problems different from those of the provision for the future in general.

It is also often claimed that future needs should be valued more highly (or discounted at a lower rate of interest) by the community than is done by individuals. If valid, this contention would definitely justify central planning of most economic activity. However, there is, as I shall explain, little or nothing to support this view.

There is no more justification in a free society for relieving the individuals of the responsibility for the future than there is for claiming that past generations ought to have made more provision for us than they did.

The argument that government is in a better position to take care of future needs because it is able to borrow at cheaper rates is also a false one. The advantage that governments have in this respect rests solely on the fact that the risk of failure in its investments is not borne by them, but by the taxpayer; in fact, the risk is no less, so far as judgement of the worthwhileness of the particular investment is concerned. But, since governments that can recoup themselves by taxation, if the investment does not bring the expected return, usually count only the interest they actually pay as costs of the capital they are using, the argument operates, in fact, against, rather than in favour of, government investment.

While individual mine owners may be criticised for not taking a long enough view of the future, there is no reason to suggest that the

political process can be relied upon to be more future orientated than the average corporation. The claim that government possesses superior knowledge raises a rather complex problem. It cannot be denied that there are some facts concerning probable future developments which the government is more likely to know than most of the individual owners of natural resources.

There will always exist, however, an even greater store of knowledge of special circumstances that ought to be taken into account in decisions about specific resources which only the individual owners will possess and which can never be concentrated within a single authority. This appears more clearly where the problem concerns the rate at which stock resources, such as mineral deposits, ought to be used up. An intelligent decision presupposes a rational estimate of the future course of prices of the materials in question and this, in turn, depends on forecasts of future technological and economic developments which the small individual owner is usually not in a position to make intelligently. This does not mean, however, that the market will not induce individual owners to act as if they took these considerations explicitly into account, or that such decisions should not be left to them, who alone may know many of the circumstances which determine the present usefulness of a particular deposit.

They will be influenced in their decisions by the knowledge of others who made it their concern to estimate such probabilities and who will be prepared to offer for the resources, prices which are determined by these estimates. If the owner can get a higher return by selling to those who want to conserve than by exploiting the resource

himself, he will do so.

There will normally exist a potential sale price of the resource which will reflect opinion about all the factors likely to affect its future value, and a decision based on the comparison of its value as a saleable asset with what it would bring if exploited now, will probably take into account more of all the available relevant knowledge than could any decision of a central authority.

Thus, the criticism that mine owners do not take a long enough view of the future is also incorrect, given the capital nature of minerals unless mine owners consume their profits and do not reinvest sufficient in the stock of reproducible capital. A tax on profits would serve the purpose of increasing investment and thus correcting any divergence between private and social interests, only if the government earmarked this revenue for investment. In the taxation of South Africa extractive industries this has not occurred. This principle is explained more fully in a later chapter on taxation in the South African gold mining industry. (Chapter 6)

In theory, perfectly competitive markets support socially optimal extraction patterns. In practice, capital markets are asymmetric and mineral markets are predominantly monopolistic or oligopolistic. The theory of monopoly suggests that a monopolist will tend to restrict output and charge a price higher than the perfectly competitive price. If this is the case, we ironically find that the conservationist would be a supporter of monopolistic practices. Hotelling[25] and Sweeney[26]

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25. Hotelling, p.152

26. Sweeney, J., "Economics of Depletable Resources, Market Forces and Intertemporal Bias", R.E.S., Vol.44, No.1, 1977 p. 136.

have shown that, in general, a monopolist will undersupply the depletable resource unless the market determined quantity is rising very rapidly during some period in time. Weinstein and Zeckhauser conclude that "there would seem to be no implication that in the second best situation, the imperfect market processes lead to too rapid a rate of resource consumption, or that government regulation would bring about a more efficient rate of utilisation."[27]

The view is given that, in the case of rare natural resources, exploitation by a monopoly is likely to extend their use over a longer period and that this is perhaps the only instance where such monopolies are likely to be formed and to persist in a free economy. However, I feel that it is a debatable point whether the greater degree of conservation which a monopoly would practice would be desirable from a social point of view. But for those who want more conservation because they believe that the market habitually underestimates future needs, the monopolies that are likely to develop spontaneously in such instances may provide the answer.

3.8 Conclusion.

One of the most important points in the previous section is that the price of a resource ought to be little more than the marginal cost of extracting and transporting it, unless the resource is rather close to exhaustion. Therefore, models which have used zero extraction costs are likely to be misleading.

In conclusion, the policy implications of the above arguments will be outlined.

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27. Weinstein & Zeckhauser, "Use patterns for Depletable and Recycleable Resources", R.E.S. Symposium 1974, p.87

a) It has been implied that resource depletion may take place too slowly because of monopoly power exerted by resource owners. Because of demand inelasticity it is likely that the losses arising from monopoly are very large, although it must be remembered that they are sustained chiefly by the industrialised countries, and those who make considerable use of resource-intensive products. The usual measures against monopoly are presumably desirable.

b) In many cases it is desirable to impose taxes on exhaustible resources, not because they are being depleted too rapidly, but as a means of taxing pure profits generated by the resource. These policies, if properly carried out, would not change rates of depletion.

c) Since most of the value of resource stocks is in the last few decades of their life, these taxes on resource use do not become significant until only a few decades of resource life remain (at then current rates of depletion). There is no particular argument in favour of taxing the use of natural resources as such when hundreds of years of reserves exist. (This is not to say there may not be other reasons for imposing commodity taxes on sales of exhaustible resources and commodities made from them, reasons of the same kind which lead one to favour taxes on jewellery, cars and cigarettes.)

d) Since there may be reasons for inadequate amounts to be spent on research into resources reserves (or methods of exploiting them), there is a case for governmental and intergovernmental subsidy of surveys and research in this area.

e) Since it is difficult for participants in resource markets to

predict resource prices correctly, governments and intergovernmental agencies can contribute to optimal resource use by gathering the information - about existing, proved and probable reserves, demand, including substitution possibilities, development of substitute sources, etc. - and developing econometric models to predict resource prices.

SECTION II

GOLD AND GOLD MINING

CHAPTER 4

DEMAND FOR AND SUPPLY OF GOLD

THE DETERMINATION OF PRICE

4.1 INTRODUCTION

Societies have often regarded some exhaustible natural resources as "critical", "essential" or "vital" to their development and hence their welfare.

In South Africa the resource that apparently fulfils these requirements is gold. For many years the gold price was determined by the International Monetary Authorities, ($ 35 per oz. for the period 1934-1968). It was believed that a fixed gold price was necessary for the conduct of the International Monetary System.

Ever since 1968, and the breakdown of the International Monetary System (I.M.S.), the price of gold has fluctuated considerably in response not only to economic but also to socio-political factors.

Unprecedented volatility has been experienced since mid 1979. The price rose from U.S. $ 227.61 per ounce (p.o.) in January 1979 to $ 875 p.o. in January 1980. It then declined and maintained a level of between $ 600 p.o. and $ 640 p.o. At the time of writing, (April, 1982), the price is fluctuating around the $ 330 mark, and still falling (see figure 4.1).

South Africa, as the largest producer of gold in the world, benefited directly from the rise in the average gold price. Thus she has been one of the most concerned parties in the volatile market. Such volatility is evidenced by the fact that each $ 10 increase in the price of gold raises the total earnings of South Africa by R170 m (given the present level of production).

CHANGES IN THE PRICE OF GOLD FROM JAN. 1944 TO JAN. 1982

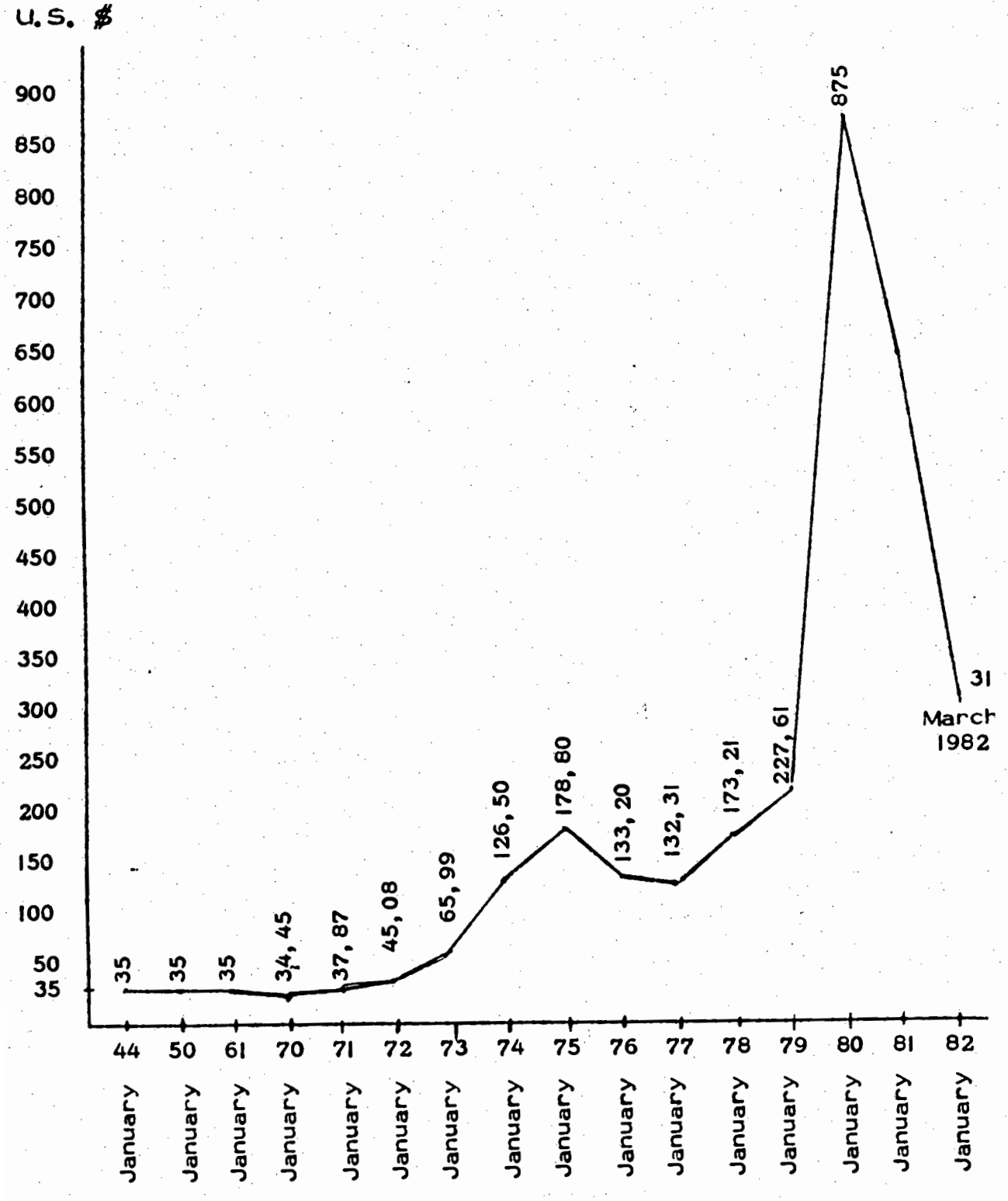

Fig. 4.1

Before discussing the demand for and supply of gold and the determination of its price, a brief history of the evolution of the International Monetary System will be presented.

4.2 Chronology of the International Monetary System and Gold Prices.

1934: President Roosevelt devalued the dollar by 60% and increased the price of gold from $20.67 p.o. to $35 p.o.

1944: A new I.M.S. was devised at the Bretton Woods conference. According to this system the dollar was the key currency which was convertible into gold and thus international payments could be made using the dollar. At this conference, two new international bodies were established, the International Bank of Reconstruction and Development, the International Monetary Fund (I.M.F.). The price of gold remained the same ($35 p.o.).

1945, 1946: The process of financial aid in time of peace began soon after the end of the War, with the large billion pound loan to Britain, which was granted on the condition that sterling was to be made convertible for foreign holders of sterling balances. Considering that in 1946 the world was starving for dollars and had a surfeit of unwanted sterling, the inevitable consequence of this arrangement was that the U.S.A. was really financing the purchase of American goods by the five continents - under British guarantee. This "aid not trade" move was followed later by the Marshall Aid, which was much more generous and much less business like. But it reduced the incentive

for beneficiary countries to make an adequate effort to work out their own salvation.

1949: All major European currencies were devalued against the dollar. The British pound was most affected, being devalued from $4.00 to $2.80. U.S. gold stocks continued to grow over the next three years and reached $25 billion.

1950-1958: In this period, world trade increased and the dollar was in great demand. Very few official gold transactions took place.

1958: For the first time the U.S. experienced a balance of payments deficit. Accordingly, there was increasing international liquidity in dollars and a relative decline in U.S. gold stock.

1960-1961: For the first time the demand for gold exceeded the supply, which created pressure to increase the price. To avoid any increase the international gold pool was established, which was centred in London.

1967: Foreign exchange markets were in disorder. Britain devalued the pound from $2.80 to $2.40.

1968: A major crisis in the foreign exchange markets developed in March, and the gold pool members were forced to abandon their informal stabilising price policy. A new international monetary order was introduced, termed the two-tier gold system. According to this system, gold could be sold on the free market, where the price

was determined by demand and supply.

1969: South Africa and the U.S. reached an agreement according to which South Africa was allowed to sell gold to the I.M.F. whenever the price was lower than $35 p.o. Thus a floor price of $35 was introduced. This agreement lasted for only 1½ years. In this year Special Drawing Rights (S.D.R.s) were introduced as a new reserve asset by the I.M.F. This was believed to mitigate the problems caused by an international trade system which suffered a shortage of liquidity. It was also the beginning of the so-called gold demonetisation campaign.

1971: A large balance of payments deficit was recorded in the U.S. The continuous heavy influx of the dollar into Europe forced the central banks of Germany, Switzerland, Belgium, Austria and the Netherlands to suspend their dollar support. On the other hand, to prevent a run on the gold stocks, U.S. President Nixon suspended the convertibility of the dollar to gold on 15th August. The price of gold was increased to $38 four months later. Ã new order for the I.M.S. was devised by the Smithsonian agreement.

1972: T he floating of the pound and other pressures on the dollar made the Smithsonian agreement ineffective.

1974: In June, for the first time, the U.S. congress passed a law according to which U.S. citizens were allowed to own gold and participate in the gold trade. This

liberalisation became effective in January 1975. The step was taken by American officials in an attempt to demonetise gold and to make it "just another commodity". In doing so, the U.S. Treasury announced on 3rd December 1974, that the Treasury would auction some of its own gold in order to meet the potential increase in the demand for gold in the free market. Two auctions were held in 1975 and a total of 1,3 million ounces of gold were sold. In 1978 a number of auctions were held. The last auction by the U.S. Treasury was announced in November 1979, and brought total sales since 1975 to 17,5 million ounces. This amount of gold would now be worth $10,6 billion at a price of $600 p.o.

1978: In April 1978, under the 2nd Amendment of the Articles of Agreement of the I.M.F., gold became formally demonetised. The Article reads: "Members are no longer required to pay gold to the Fund in connection with any transaction or operation ....."[1] In the second half of that year, a new proposal was provided by the then M.D. of the I.M.F. In this proposal a so-called Substitution Account was envisaged and all the official holders of the U.S. dollar outside the U.S. could invest their surplus dollars in exchange for S.D.R.s. Thus the temptation for holders of dollars to dump them on an already overburdened market, with the resulting adverse effects on exchange rates would be avoided.

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1. Quoted from Dr. C.L. Stals, "The international monetary role of gold". Address by Deputy Governor, S.A.R.B., Cape Town 14th February 1980.

1979: On 13th March 1979, the European Monetary System (E.M.S.) became operative. The main objective of the new system is a closer monetary co-operation between the members of the European Economic Community (E.E.C.). The participating countries are Belgium, Denmark, France, West Germany, Ireland, Italy and the Netherlands. It was envisaged that other members of the E.E.C., for instance Britain, would join the system later. The new currency was a composite of members' currencies. Furthermore, the European Currency Unit (the new currency) plays a central role in the system, as it is the reference for exchange rates and a common denominator for E.E.C. currencies.

In the new system, a European Monetary Fund was established (E.M.F.). All the Central Banks of the member countries were required to sell 20% of their gold holdings and 20% of their dollar holdings to the fund. The E.M.F. issued a total of 23 billion E.C.U.s. About 80 million ounces of gold were transferred to the fund.

The principal use of E.C.U.s is in settlements between E.E.C. central banks. This was the first formal step taken for re-monetisation of gold in the international context.

1980: In the last quarter of 1979 and first half of 1980, it was suggested that in order to strengthen the Substitution Account, a part of the I.M.F.'s gold assets should be transferred to the Account to provide further support for the S.D.R.s. Thus the new S.D.R.s, just like the

E.C.U.S, will be back by gold. Such a step, if taken, will be the first major official action on the road to the re-monetisation of gold since 1971.

4.3 The Demand for Gold

In attempting to analyse the future demand for gold, total demand has been divided into 10 different market segments. The first three are private investment, viz. large central bank investment, private investment and smaller central bank investment. Together these constitute "investment demand".[2] The remaining seven segments comprise industrial demand: there are four categories for jewellery (North America, Europe, Japan and the rest of the world) and one each for electronics, dental and "other industrial".

4.3.1. Investment Demand

A. Private Investment Demand

"Private investment demand" embraces the demand for official and 'fake' coins and medallions, as well as gold bullion bought by private citizens. The rationale behind the marketing of gold coins and medallions is worthy of examination.

i) The Marketing of Gold Coins

In the event that gold is completely demonetised and no longer acts as a base for the monetary system, the price of gold, as a commodity, would be determined in the market by the rules of supply and demand. This price, however, would be highly unpredictable due to the fact

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2. In most historically-orientated studies, central banks are regarded as supplying rather than demanding gold. In future, central banks are likely to be net purchasers of gold.

that there is an overhang in government stocks of more than 30 years annual production of gold. This substantial amount can at anytime be dumped on the market, causing a sharp decline in price. If expectations about the occurrence of a complete demonetisation of gold are probable, then the marketing policies of the main gold producers will play a crucial role in the life of the industry itself. In other words, the identification of alternative markets for gold becomes vital and imperative.

In the context of marketing only, the S.A. Chamber of Mines established a marketing organisation, the International Gold Corporation Ltd. (Intergold) in 1971. It concentrated mainly on the industrial and jewellery markets for gold, until October 1973 when it took on the responsibility for the marketing and promotion of the Krugerrand.

Table 4.1 shows the performance of Intergold between 1970 and 1979. It must be remembered, however, that the main marketing organisation for S.A.'s gold output is the S.A. Reserve Bank which is responsible for bullion sales. Nevertheless, the table illustrates the relative importance of Intergold with respect to is share in gold sales.

In 1980, Intergold diversified its coins and announced its intention of providing, half, quarter and 1/10th ounce coins as well as the original one-ounce Krugerrands. This policy aimed at spreading ownership to encompass small investors. Furthermore, the policy is intended to offset competition in the market. However, the Krugerrand's rivals are increasing. In 1981, Mexican authorities launched a $3 million marketing package in the United States where

KRUGERRAND SALES AND ITS RELATIVE SIGNIFICANCE

Year	Krugerrand Sales	Krugerrand Revenue Rm	Bullion Revenue Rm	Total Revenue Rm
1970	211018	6.6	824.6	831.2
1971	550200	16.6	882.4	899.0
1972	543700	24.6	1135.3	1159.9
1973	859300	53.8	1735.5	1789.3
1974	3203675	362.6	2257.2	2619.8
1975	4803925	589.3	1971.1	2560.4
1976	3004945	342.9	2037.3	2380.2
1977	3331344	451.2	2363.8	2815.0
1978	6012293	1044.6	2818.4	3863.0
1979	4940755	1330.3	4456.9	5787.2

Table 4.1

Source: Financial Mail, special Report, April 25, 1980. p.11

the Krugerrand was performing identically well. The Canadian Maple Leaf, the British Sovereign, the Russian chervonets, and the newly minted American medallions are other competitors.

ii) Determinants of Investment Demand

There are six critical determinants of investment demand for gold which can be identified:

- the price of gold,
- real interest rates, in particular those in Europe and the United States,
- real economic growth rates, particularly in the United States, Europe, Japan and the Association of South East Asian Nations (Asean),
- the level of political tension,
- the rate of inflation in non-communist industrialised countries,
- the relative strength of the U.S. dollar.

Two other recent developments, i.e. the beginnings of a move in Japan toward private investment in gold and the possible advent of large scale institutional demand in the U.S. should also be noted.

One can define two "polar scenarios" from the above information. The first of these is the "good-for-gold" scenario, and depicts the set of conditions under which experts would expect demand to be strong: high real economic growth (investors are richer), low real interest rates, high levels of political tension, high inflation and a weak U.S. dollar. The second is the "bad-for-gold" scenario, conditions under which investment demand would be very low: low

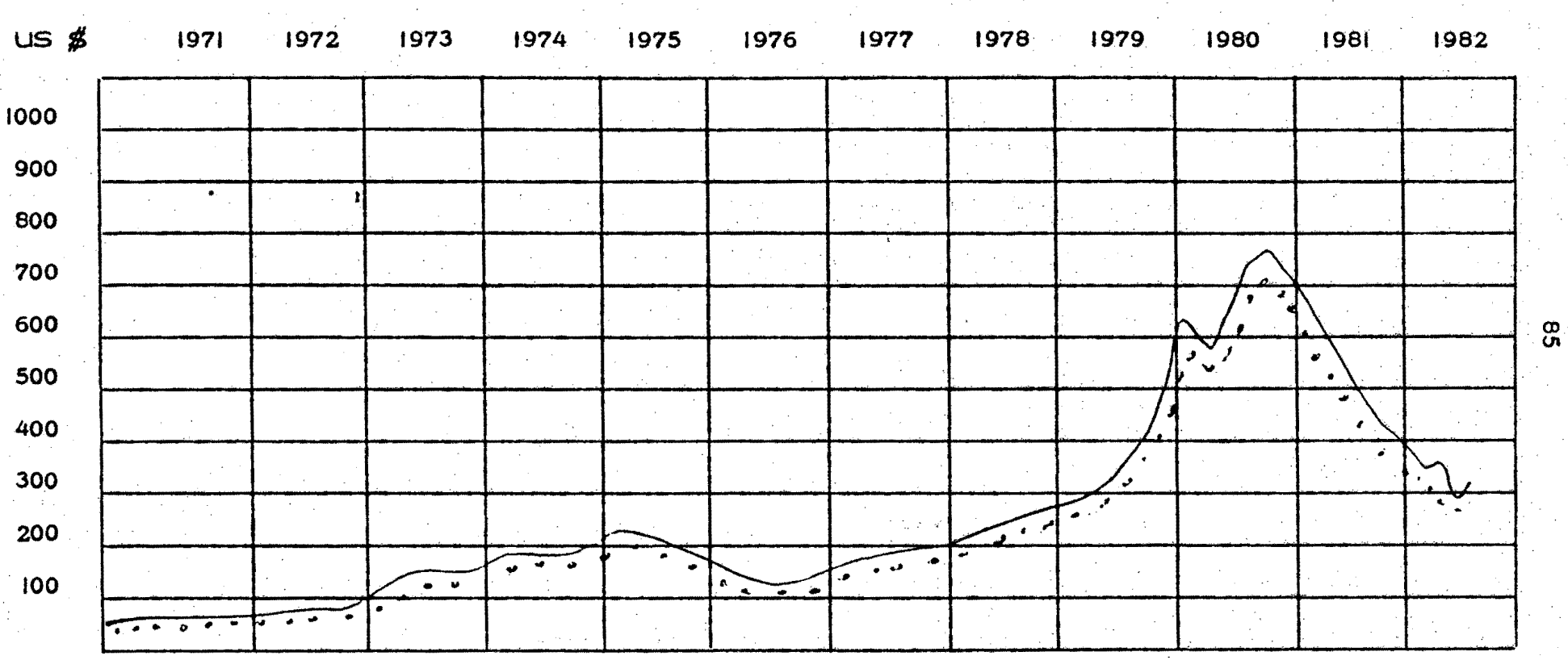

Fig. 4.2

Source: Executive Desk Diary, Modart (Pty) Ltd., Cape Town, 1982

real economic growth, high real interest rates, low levels of political tension, low inflation, and a strong U.S. dollar.

B. Large Central Bank Investment

Attention is now turned to investment demand from the large central banks - those of Europe and the United States - and the Saudi Arabian Monetory Agency (S.A.M.A.) which is big enough to be comparable in certain ways to the European and American central banks, and which is increasingly expected to behave in the same way as those institutions.

While the future role of the Central banks with regard to gold is uncertain, there are shared beliefs concerning some of the forces that will affect gold demand.

- The first belief is that on average, large central banks will be neither net buyers, nor net sellers; they will hold on to the gold they have, using the open market to augment or decrease their gold holdings only if circumstances force them, or the price of gold encourages them to do so.

- Secondly, those nations under pressure to mobilise their gold reserves will try to do this off the open market, for example through the use of gold as collateral for foreign loans, or through gold swops of the kind used by South Africa.

- Thirdly, while the U.S. treasury may, from time to time, resume sales of gold, it is very unlikely that they would be anywhere near as significant as those of the 1970s.

- Fourthly, if and when large central banks buy or sell on the open market, price will be the paramount consideration. Central banks are conservatively run, and it would be deemed irresponsible in principle to sell their nation's gold unless the price was considered relatively high, or buy unless it was low.

- Fifthly, central bankers now have an incentive to support a high gold price, or at least prevent a complete price collapse. This is particularly true of that majority of countries that value their gold reserves at something approximating market value, for a significant fall in the gold price could cause their central banks to re-value their gold reserves downwards. This implies in practice that certain banks, individually or in collusion with others, may be expected to support the gold price through open market purchases if the price falls too far.

- Finally, there is a reasonable chance that as the new decade unfolds, S.A.M.A. will officially begin to acquire gold reserves.

C. Small Central Banks.

When considering the smaller central banks, it becomes still more difficult to generalise about future investment demand.

However, there is reason to believe that, like all investment demand, "smaller central bank" net demand will be very price sensitive.

Secondly, it is likely that on average there will be net buying by these banks, as long as the price is not too high. There are several reasons for this view. Firstly, gold affords the secrecy that some Third World and O.P.E.C. governments value in their

official and quasi-official financial transactions. Additionally, the smaller central banks include those of nations such as Indonesia, Abu Dhabi and Kuwait which will have the surplus funds to acquire gold.

4.3.2. Jewellery Demand

A. European Jewellery.

Overall growth in European jewellery demand for gold will depend on such factors as rising real income, changes in fashion and promotional activities. The determinants of jewellery demand growth, like those of future investment demand, are highly uncertain.

Nevertheless, prospects do not appear to be very good for the next five years or so. Europe has been suffering from "stagflation", high oil bills (paid for in U.S. dollars that will continue to be expensive), exceedingly costly social welfare schemes, high interest rates and excessive deficit spending. Furthermore, there is little indication that these problems will disappear in the near future.

B. United States Jewellery.

The per capita consumption of gold in jewellery in the United States is very low at present. However, projections show that a combination of strong promotional activities, dramatic changes in retailing, and the influence of America's affluent younger generation could give rise to much higher purchases of gold jewellery.

C. Japanese Jewellery.

Certain differences of interpretation are called for in analysing Japanese jewellery demand. It is unnecessary to talk vaguely about

"future promotional efforts", it is possible to focus on definite plans for promotion of gold jewellery in Japan, due to start in 1982.

Moreover, in discussing fashion trends one is talking of the possibility of a completely new tradition of gold purchases for both fashion and investment in Japan. The enhanced awareness of gold in Japan has been due in part to the successful promotion of the Krugerrand, legal and institutional changes making it possible for Japanese citizens to buy and sell gold and evidence of increased concern about the implications of inflation for Japanese family retirement plans.

Consumption of gold jewellery by the Japanese has always been low, so there is the chance of a very significant percentage increase over the next few years.

D. Rest of World Jewellery Demand

This region consists of Asia , the Middle East, Africa and Latin America. Some portion of jewellery demand in certain areas of the world, notably the Middle East, is commonly viewed as falling into the private investment demand sector. In the absence of any detailed analysis of consumer motivation in this regard, it is almost impossible to make any predictions regarding future jewellery demand in these areas.

4.3.3. Electronics Demand

The determinants of electronics gold demand growth rate are respectively:

- the rate of growth of real income in the non-communist world,
- the additional growth rate of the electronics industry above that of real income,
- and the growth rate of substitutes for gold in electronics manufacture.

It must be borne in mind that in the short run at least, electronics gold demand is not nearly so price elastic as jewellery demand.

At present there are forces at work in the market, some of which favour, others which discourage the continued use of gold in electronics components. Among the forces favouring gold consumption are the very high reliability of gold-based components, the proportionately low cost (usually less than ten per cent) of gold in the typical connector component, and the extraordinarily high growth prospects for the electronics industry throughout the 1980s.

Offsetting these favourable trends is the fiercely competitive nature of the component industry which has led to cost-cutting, hence attempts to substitute other materials for gold, and the trend towards miniaturisation of components.

4.3.4. Dental Demand

There are several factors working towards a continuing reduction of demand for dental gold; indeed there are few which favour increased - or even sustained - demand.

Among the latter is the prospect of a defensive strategy by the manufacturers of gold alloys. On the negative side, however,

government-backed medical insurance schemes lack the funds necessary to pay the price commanded by gold, particularly when lower cost alloys are available as alternatives. Even in West Germany, where in 1975 expenditure on gold dental work was covered in its entirety by such a government scheme, coverage has now been reduced to 80 per cent.

In addition, it is reported that once customers have learned to use non-gold alloys, they do not return to gold even if the price drops.

4.3.5. Other Industrial.

The determinants of demand in this category are similar to those influencing electronics demand, viz. the price of gold, rate of growth of real income, additional rate of growth of the particular industry above that of real income and the growth rate of substitutes.

4.4. The Supply of Gold.

For the purposes of this section, gold is regarded as coming from three sources: "South African", "Communist" and "Other Western" countries.

4.4.1. South African Sales.

As far as South Africa is concerned, the four most important determinants of future sales would appear to be:

- price,
- quantity of gold produced (which depends on the former),
- the Sales policy followed by the S.A. Reserve Bank (through which all S.A. sales of bullion are made),

- the prospect of higher wages for black mine workers.

4.4.2. Communist Sales.

Sales from the communist bloc are completely dominated by the output of the Soviet Union, hence the following references to "Russian" sales and production.

Any account of future Russian sales must begin with consideration of the underlying philosophy that governs Russia's activities in the gold market. The strong consensus is that in the long run, Russia will sell only the amount of gold necessary to earn requisite foreign exchange.

There is evidence that this is the official policy. For example, in "Kommunist" No. 8 of May, 1980, V. Alhimov, Chairman of the Soviet Bank, Gosbank, writes that his government is committed to the preservation and growth of its gold stocks and claims that gold will be sold only when it is necessary to acquire foreign exchange. If this view is accepted, then any forecast of future Russian sales will hinge on two factors, production levels and foreign exchange requirements, both of which are kept secret.

It is believed that Russian annual production currently runs at about 260 tons and that it will rise to approximately 290 tons in 5 years' time. (See Table 4.2 for past Soviet Gold Statistics.)

In considering future foreign exchange requirements, it is important to comment upon the circumstances of natural gas, oil and agriculture. Perhaps the most important prospective development for Russia's

SOVIET GOLD STATISTICS

	1970	1971	1972	1973	1974	1975
Production (t)	347	360	379	398	421	407
Sales (t)	-3	54	213	275	220	149
Average Price $ *	35,9	40,8	58,1	97,2	159,1	161,1
Value of sales $ m	-	70	400	860	1125	770
S.A. production (t)	1000	977	909	852	759	708

* Based on London daily fixings

Table 4.2.

Source: "Gold Survey": Supplement to Financial Mail, 13th August 1976

foreign exchange position concerns the proposed construction of a natural gas pipeline to Europe. The implications of this could be significant for the gold market. Russia, presumably would have to sell less gold, because the pipeline would earn billions of dollars in hard currency or credits every year. However, it is not clear whether Russia would in fact see any net benefits to its foreign exchange position during the first few years of the project due to the need to repay construction and equipment loans, many of which would be incurred in western countries.

Oil exports have been very important to Russian foreign exchange earnings in recent years. It was believed that the Soviet Union would become a net exporter of oil by 1985, but this opinion has been revised, and the period extended. Indeed, the expected decrease in Soviet oil exports, taken with the likelihood of sluggish oil prices, implies a worsening of the country's foreign exchange position.

Agricultural prospects in Russia are very poor. The government's programme of expanding livestock herds to produce more meat requires a shift from grass to grain-fed animals. The required increase in grain supplies must be imported, given the poor productivity of Soviet domestic resources. All in all, annual imports of between 20 and 40 million tons are expected in the mid-1980s. Here again, Russia will face a serious shortage of foreign exchange.

4.4.3. Other non-communist nations.

There seems to be a very small chance that a major gold deposit will be discovered within the next five years. Furthermore, if the

GOLD BULLION SUPPLY AND DEMAND 1949 - 1979

Year	Free world Mine Production	Net Trade with Communist bloc	Total Supplied	Official Purchases or Sales*	Net Private Purchases
1949	733	-	733	396	337
1950	755	-	755	388	467
1951	733	-	733	235	498
1952	755	-	755	205	550
1953	755	67	822	404	418
1954	795	67	862	595	267
1955	835	67	902	591	311
1956	871	133	1004	435	569
1957	906	231	1137	614	523
1958	933	196	1129	605	524
1959	1000	266	1266	671	595
1960	1049	177	1226	262	964
1961	1080	266	1346	538	808
1962	1155	178	1333	329	1004
1963	1204	489	1693	729	964
1964	1249	400	1649	631	1018
1965	1280	355	1635	196	1439
1966	1285	-67	1218	-40	1258
1967	1250	-5	1245	-1404	2649
1968	1245	-29	1216	-620	1836
1969	1252	-15	1237	90	1147
1970	1274	-3	1271	236	1035
1971	1236	54	1290	-96	1386
1972	1184	213	1397	151	1246
1973	1121	275	1396	-6	1402
1974	1007	220	1227	-20	1247
1975	954	149	1103	-9	1112
1976	969	412	1381	-58	1439
1977	972	401	1373	-269	1642
1978	980	410	1390	-362	1752
1979	962	229	1191	-574	1765

* Definition of official sales has been extended from 1974 to include activities of Government controlled investment and monetary agencies in addition to central bank operations. This category also includes I.M.F. disposals.

Table 4.3

Source: Chamber of Mines 90th Annual Report, 1979. p.73

gold price remains fairly low, the lack of incentive for prospecting along with the closure or exhaustion of existing mines, will reduce production.

4.5 Causes of Changes in the Supply of Gold.

The relationship of the various factors determining the supply of gold is an exceedingly complex one. The treatment of this subject is not meant to be exhaustive, but is primarily designed to provide a link between the theoretical section on wasting assets and a later chapter on taxation of gold mines (Chapter 6).

In the Nineteenth Century, changes in the supply of gold were largely due to fortuitous discoveries of new ore resources and their exhaustion. Cost factors, other than exploration costs, were relatively unimportant as the basic capital equipment was often little more than a shallow pan or machinery of the simplest kind. For the last fifty to sixty years, accident has ceased to play a very important part in changes in the supply of gold. Gold mining has come to be undertaken by large units, mining at deep levels with expensive capital equipment. Improved techniques have reduced the risk factor in gold mining and prospecting. In short, it has become an industry which is just as sensitive to costs and prices as any other industry.

The existence of natural resources and their extent are of course important in determining the supply of gold. No amount of prospecting on a scientific basis will produce gold if it is not there. But economic factors can accelerate or delay the exhaustion of known

deposits of ore and promote or discourage new discoveries. In the absence of new discoveries and any change in the economic data, the supply of gold will gradually decline as the main resources of ore become exhausted. Exhaustion also has the effect of raising costs as the scale of operation declines and so accelerates the decline in output.

The relationship between a change in the cost of mining gold or its price and the supply of gold is not, however, a simple one. It is complicated by the fact that the supply of gold is not only a function of the tons of ore milled, but of the grade of ore mined as well. Because the grade of ore in a mine is not constant, a change in the tonnage milled need not lead to an equivalent change in the output of gold.

When looking at the effect of a change in costs (or price) on output, therefore, we must examine its influence both on the tonnage milled and the grade of ore mined.

Changes in costs can take two forms:-

1. It may take the form of a change in the amount or value of the yield of gold from each ton of ore of a given grade and at a constant cost per ton, due to a change in the rate of recovery or price of gold, or

2) It may take the form of a change in the cost of mining and milling a ton of ore.

The first will lead to an automatic change in the quantity or value

of gold produced, in addition to any indirect effect it may have via an induced change in the quantity or grade of ore milled. The second will affect the output of gold only through its influence on the quantity or grade of ore milled.

It has been the policy of the South African gold mining industry to mine ore of the average grade of payable ore in a mine. In most mines the grade of ore varies considerably. The composition of the ore of the Witwatersrand takes the form of a pyramid with a vast quantity of high grade ore at the apex. The quantity of payable ore (pay-streak) depends on the cost of mining and the price of gold. If costs fall or the price of gold increases, the quantity of payable ore increases so that average grade falls. This will cause the quantity of gold per ton to fall but it will induce an increase in the tonnage of ore milled. The grade of ore mined is not an independent variable in the determination of the supply of gold. It depends directly on changes in costs and price but it works in the opposite direction to a change in the tonnage milled induced by the cost and price changes.

The net effect on the supply of gold of these opposing tendencies depends on the proportion of high to low grade ore in a mine, the elasticity of supply of labour and capital, and the gestation period of mining investment.

4.6 Determinants of the Gold Price

It is generally agreed that there is an important link between inflation rates in the U.S.A. and fluctuations in the world gold price.[3]

3. I am indebted to Dr. D.J. Rees and Prof. B. Kantor for providing a lot of the information for this section. The theory of gold price movements offered here is, however, a rather tentative one.

Since 1971, when the United States could no longer maintain convertibility of dollars into gold at $35 p.o., the price of gold has risen six or seven times more rapidly than dollar prices generally. It is, therefore, clear that the world gold price is not simply determined by United States inflation rates. Other variables are involved.

It has been observed that a close ratio has been maintained between the gold price and the price of oil, silver, platinum and other non-perishable commodities.

An attempt will be made to explain why the stability of these relationships has important implications for the demand for gold rather than dollars, and therefore, for the determination of the gold price. Consideration will also be given to influence of changes in inflationary expectations on interest rates and on the demand for dollars and gold.

4.6.1. Interest Rates and the Future Price of Gold

When a currency is expected to lose purchasing power relative to other currencies, then for any given interest rate, borrowers will be more willing to borrow that currency (since they can repay the loan in devalued money) and lenders will be correspondingly less willing to lend.

Accordingly, interest rates in a currency that is expected to lose purchasing power will rise. The increase in interest rates effectively compensates the lender for the anticipated rate of inflation. The real interest rate, which is the difference between the nominal interest rate and the realised rate of inflation over the period of the contract will remain the same.

One can observe the situation in South Africa at present (March 1982) as far as inflation, interest rates and the Rand/U.S. dollar exchange rate are concerned.[4]

1. Inflation (as indicated by the consumer price index, C.P.I.)

Date	Quarterly change (Annualised)	Annual change (year-on-year)
October 1981	17	16
November 1981	17	15
December 1981	16	14

2. Short term Interest Rates (90 day acceptances)

	Current	Week ago	Year ago
21.12.81	15,25	14,85	7,00
3.3.82	17,25	19,50	9,25

3. Long Term Interest Rates (Long term Gilts)

	Current	Week ago	Year ago
21.12.81	13,29	13,28	11,80
3.3.82	14,18	14,28	12,80

4. U.S. $ / S.A. Rand Exchange Rate

3.3.82 Current 1,015 Year ago 1,275

1. The C.P.I. observations for October, November and December 1981 all indicate that the inflation rate is rising slightly. Prices are rising at an accelerating rate as, for each observation, the quarterly variable exceeds the year-on-year variable. This has been caused by the falling value of the Rand (in terms of U.S. dollars) over the period from January 1981. This phenomenon would have

4. Figures have been taken from the Financial Mail, 3.3.1982.

tended to push our inflation rate above the U.S. figure. On the other hand, U.S. inflation itself has dropped sharply, which could account for the very slight increase in our inflation rate.

2. Clearly, short term interest rates have been rising very steeply. Given an exchange rate which is more fixed than floating, this probably has little to do with increases in the anticipated rate of inflation and more to do with the unexpected tightening of liquidity (arising from balance of payments developments) as well as the high demand for credit arising from the gold-led boom, in South Africa.

3. Long term rates have been drifting upwards very cautiously. This entails either a higher rate of anticipated inflation (in the long term), or a higher expected real rate of return. However, it is very difficult for market agents to take a view on inflation and growth for the next 20 years.

4. Clearly the Rand has fallen against the U.S. dollar, both because of the weakening price of gold and the rise in the Dollar itself against most other currencies during the course of 1981.

These observations clearly support the assertion made above that interest rates in a currency that is expected to lose purchasing power will rise.

In a competitive market, all assets, including bank deposits denominated in different currencies and commodities like gold or gold futures, compete for a place in the wealth portfolios of investors at each moment in time. Expected real returns in the form of

capital appreciation plus expected income from any asset must, therefore, be equal to the expected returns[5] from all other assets simultaneously. The expected return is the nominal return agreed upon, multiplied by the probability of receiving that return.

Any real asset (e.g. gold) is only worth holding at any moment in time if it is expected to yield a rate of return equal to the return on competing assets. The return on holding gold comes entirely in the form of an increase in the price of gold. This is easily verified by observing the pattern of future gold prices on the gold futures market. At any moment in time the price of gold is always expected to increase by the prevailing dollar interest rates, (allowing a small charge for storage and arbitrage). Buying or selling of gold for delivery or acceptance of delivery at different points in time, while simultaneously borrowing or lending dollars at the same rate of interest maintains the relationship between the spot and future prices of gold and market interest rates.

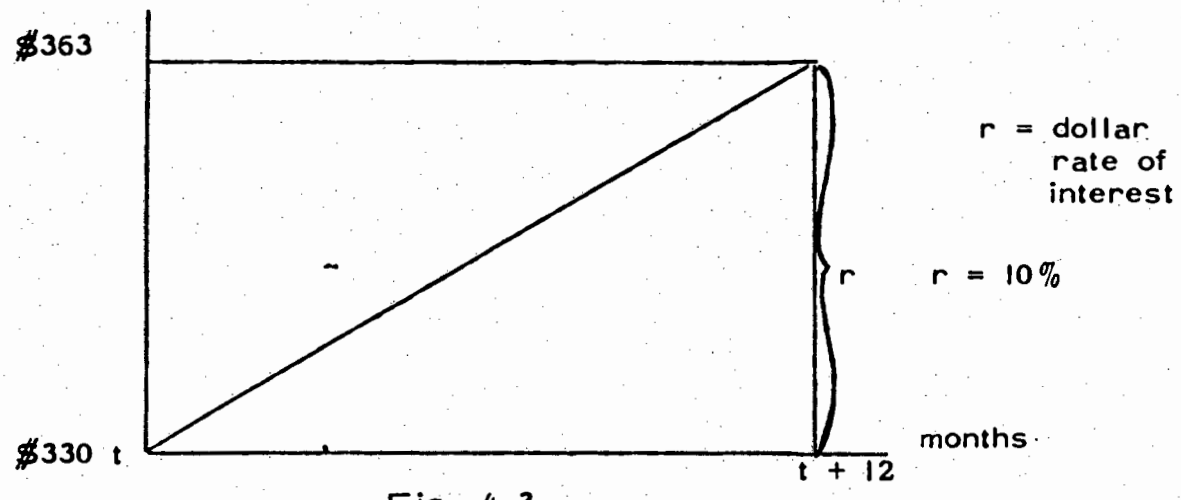

Fig. 4.3

In March 1982 (t) the spot price of gold is, say $330. The future (t + 12) price is $330 plus the rate of interest plus storage. Thus the slope of the line is approximately the dollar rate of interest.

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5. By specifying expected returns, the problem of different risks is taken into account.

4.6.2. Changes in nominal interest rates

If dollar rates of interest increase in response to an increase in the expected rate of inflation in the United States, then the expected future value of any dollar denominated asset must be higher. In other words, the slope of the line in Fig. 4.1 will get steeper. Consider for example, a United States government bond with a nominal value of 100, due to be redeemed in 12 months time. If the interest rate is 10% per annum, the nominal value of the bond is 90. When the interest rate rises to 15% per annum, the value of the bond falls to 85. However, would this same reasoning apply to an ounce of gold?

If the increase in interest rates reflected only an increase in the expected rate of inflation, the prices of real assets (gold, copper etc.) on commodity exchanges would rise in line with the higher interest rate.

$$\text{Present Value} = \frac{\text{Future Value}}{(1 + r)^n}$$

While the future value would be higher due to inflation, the increase in the interest rate would exactly compensate for this increase and the present value would remain the same. The rate of appreciation would equal the rate of discount and the current price of gold (unlike the price of the government bond) would remain the same. Only the slope of the triangle (Fig. 4.3) would change.

4.6.3 Changes in real interest rates

In practice, however, we observe that when dollar interest rates change, both the future and the spot prices of gold and other real assets change. This must imply that inflationary expectations are

not held with certainty and that expected real interest rates, i.e. the difference between the expected rate of inflation and the market (nominal) rate of interest change when the expected rate of inflation changes. There is much recent evidence to suggest that observed real interest rates do decline when inflation accelerates and increases when inflation declines. (The reasons for this will be considered later.)

The relationship between inflation rates and the real return on capital has been exhaustively investigated by Feldstein.[6] This literature suggested that in the United States the nominal interest rate rises by approximately the rate of inflation, so the real interest rates remain constant. This finding was consistent with the earlier work of Fama (1975).[7] More recent work of Fama's (1976)[8] finds a negative relationship between expected real returns and expected inflation rates. It would be recognised that the 1950s and 1960s in the United States were characterised by low and rather stable rates of inflation. The 1970s brought much higher and more variable rates of inflation.

Let us consider firstly, the consequences of a change in the real interest rate for the spot price of gold or any other non-perishable commodity.

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6 Feldstein, M., "The fundamental determinants of the rate of interest", Review of Economics & Statistics 52, 1970, pp. 363-375
"Inflation, income taxes and rate of interest: A theoretical analysis" American Economic Review 66, 1976, pp. 809-820

7. Fama, E, "Short-term interest rates as predictors of inflation" American Economic Review 65, 1975, pp. 269-282.

8. Fama, E., "Inflation, uncertainty and expected returns on treasury bills". Journal of Political Economy 84(3), 1976, pp. 427 - 448

Consider a situation with no inflation, which is expected with perfect certainty. The interest rate is 4% per annum and the time horizon is ten years. Now compare the price behaviour of one ton of consumable goods (e.g. apples) with the price of a real asset (e.g. gold). With no inflation the price of apples will be the same in ten years' time as it is today, whereas the price of an ounce of gold will be rising at 4% per annum.

If the gold price were not expected to rise at 4% per annum, wealth owners would sell gold until the price had fallen to such a level that it would provide a 4% per annum yield.

If at present 1 ton of apples cost $400, then in 10 years time the following equation holds true -

$$\frac{\text{1 oz gold}}{\text{1 ton apples}} = \frac{\text{1 oz gold}}{\$400} \times \frac{\$400}{\text{1 ton apples}}$$

In ten years time 1 ton of apples still costs $400 as required by our zero inflation assumption. The gold price will have increased by 4% per annum to $400 per oz., so that gold today must be $400 discounted by the rate of interest over 10 years, i.e. the current gold price is $270.23.

Alternatively, $270.23 accumulating at 4% will be worth $400 in 10 years' time.

Suppose we continue to assume no inflation but increase the rate of interest from 4% per annum to 5% per annum. The solution in 10 years time remains as before but the current gold price falls from $270.23 to $245.57. This is necessary if the gold price is

to increase at 5% per annum and if gold is to preserve its real purchasing power in terms of other commodities. An increase in the real interest rate is, therefore, associated with a fall in the current market price of gold as of all other assets.

Consider the effect of introducing a 15% per annum inflation rate. Real interest rates are 4% per annum, so nominal rates are approximately 19.6% per annum.[9] Then in 10 years' time we have

$$\frac{1 \text{ oz gold}}{1 \text{ ton apples}} = \frac{1 \text{ oz gold}}{\$1\,618.22} \times \frac{\$1\,618.22}{1 \text{ ton apples}}$$

Apples now cost $1 618.22 per ton, the effect of a 15% inflation rate. Gold which has been increasing in price at 19.6% per annum from a base price of $270.23, now costs $1 618.22.

Changes in the spot price of gold are, therefore, associated with changes in expected real interest rates. Changes in inflation in itself, whilst they affect the future price of gold are neutral with respect to today's price. It remains to consider why an increase in inflation is associated with a fall in the real interest rate.

4.6.4. Why real interest rates fall when inflation rises

Since it is reasonable to suppose that both borrowers and lenders share the same expectations regarding future inflation rates, one would expect inflation to be discounted at the same rate by both parties and that interest rates remain unchanged.

For any given market interest rate, borrowers would wish to borrow more and lenders would wish to lend less if they expected

9. As a result of compounded growth rates.

the rate of inflation to increase.

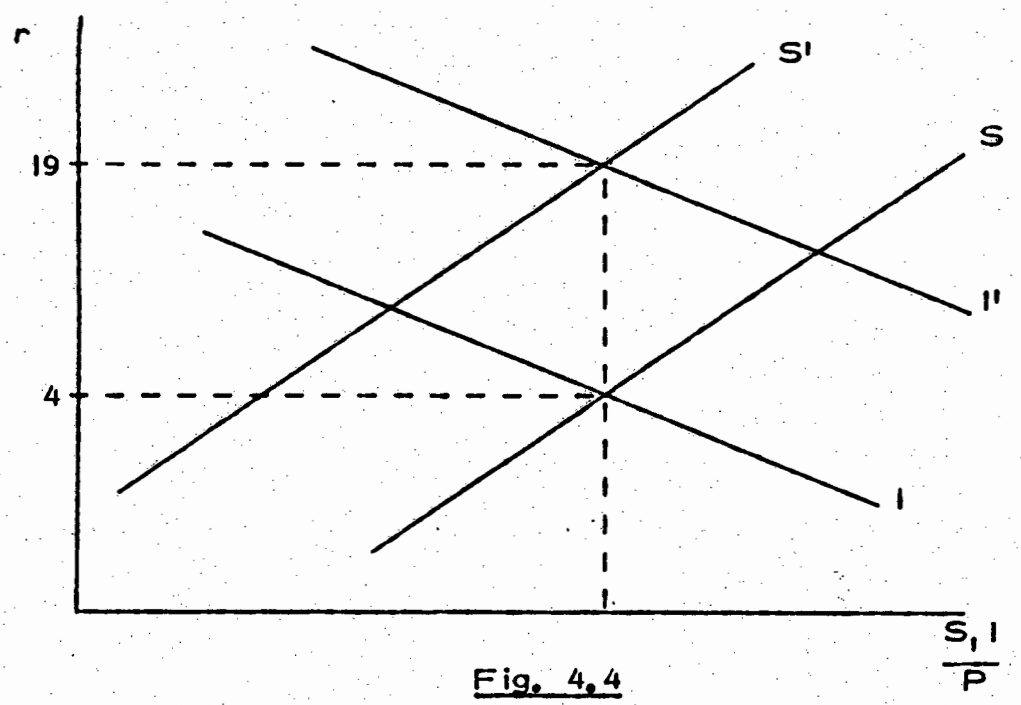

Fig. 4.4

Suppose with zero inflation the savings and investment curves were at S and I. Interest Rate is 4%. Now introduce a 15% inflation rate. Savings shift from S to S' Investment up from I to I'. The new interest rate is now approximately 19% nominal but remains at 4% (i.e. 19% - 15%) real. The real interest rate is, therefore, unchanged under inflationary conditions as long as savings and investment curves shift in equal proportions.

There are, however, strong reasons for believing that the real demand for loanable funds and real investment is likely to decline with increases in expected inflation. From the investor's perspective, the problem with inflation is not that prices rise but that different prices may rise at very different rates. A higher average rate of inflation conceals a much greater degree of variability of individual prices. The lender is concerned about the average rate of inflation. The borrower, who plans to invest in a clothing factory, is concerned

about the price of dresses relative to the price of material as well as of textile workers and this is usually more difficult to predict.

Households save in order to consume a wide range of consumer goods in future. The fact that relative prices of consumables may change is not nearly as important to them as to the producer of particular goods. Thus, even though borrowers and lenders may agree in their views on the anticipated average rate of inflation, the investment curve may shift less than the savings curve and real interest rates may fall. As argued above, when real interest rates fall, the current prices of assets, such as gold, rise.

A risk averse investor anticipating an inflation rate of 15% may act <u>as if</u> the anticipated inflation rate was 18%, i.e. as if the nominal interest rate was 19.6% - 3% = 16.6%. This is equivalent to a real interest rate of 1.6% (i.e. 16.6% - 15%).

The anticipated outcome in 10 years time will be

$$\frac{\text{1 oz gold}}{\text{1 ton apples}} = \frac{\text{1 oz gold}}{\$2093.53} \times \frac{\$2093.53}{\text{1 ton apples}}$$

In order for 1 oz of gold to increase in price at 16.6% per annum and be worth $2093.53 in 10 years time, the current price must be $450.71 per oz.

An increase in inflation rates if this is associated with increased uncertainty about the relative value of dollars is, therefore, likely to cause the current gold price to rise because the real interest rate falls.

In order to explain the inverse relationship between the spot gold price and real interest rates, it must be hypothesised that each investor allocates his budget between gold and other capital assets and consumables so as to maximise his utility through time.

Thus, given a certain stock of wealth, W,

$$W = PoAo + \frac{P_1A_1}{1+r} + \frac{P_2A_2}{(1+r)2} \text{ ----- } \frac{P_NA_N}{(1+r)N}$$

where P_1 = price of apples in time period 1.

A_1 = consumption of apples in time period 1.

r = rate of interest.

Utility maximisation requires that

$$P_1A_1 = P_2A_2 \text{ --------- } = P_NA_N$$

as long as $P_1 = P_2$ -------- $= P_N$, i.e. we assume <u>no inflation.</u> If we posit an infinite time horizon, this reduces to

$$W = P_oA_o + \frac{P_1A_1}{r}$$

However, the choice at present is not between consumption goods now and later, but between consumption now and gold or other assets. Hence

$$\frac{P_1A_1}{r} = P_gG$$

where P_g = gold price

G = quantity of gold held.

If we sum this over all consumers we can assume G to be constant (i.e. supply of gold is inelastic)

Hence $P_g = \frac{P_1A_1}{rG} = \frac{K}{r}$ where K (a constant) $= \frac{P_1A_1}{G}$.

Thus, one would expect an inverse relationship between the gold price and the real interest rate. In other words, low inflation rates would result in high expected real rates of return, or, conversely high inflation rates would result in low expected real rates of return.

This can be illustrated diagramatically.

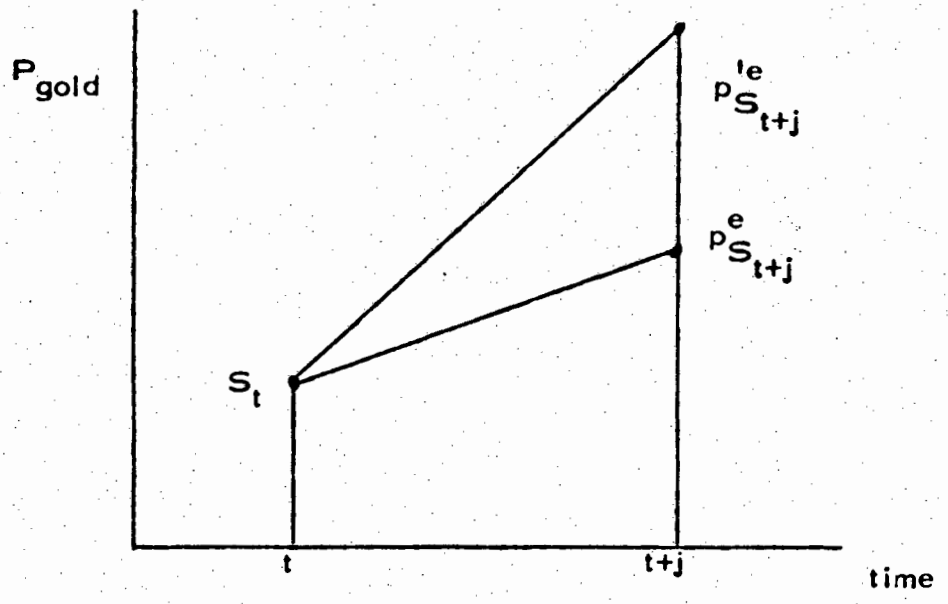

Fig. 4.5

Assume we have neutral inflation. The spot price of gold in period t is S_t and the expected future price of gold in period t+j is $^{p}S^{e}_{t+j}$. We also have

$$NR = Rr^{e} + p^{e}$$

where NR = nominal rate of interest

Rr^{e} = real expected rate of interest

p^{e} = expected inflation.

Assume now that NR increases while Rr^{e} remains constant. This results in an upward revision of inflationary expectations with no effect on the current spot price. However, the path of the expected

future price becomes steeper resulting in an expected future price in period t+j of $p'^{e}_{S_{t+j}}$. The slope of this line reflects the nominal rate of interest which has increased since the slope of the line has become steeper.

Alternatively, we may have the following situation

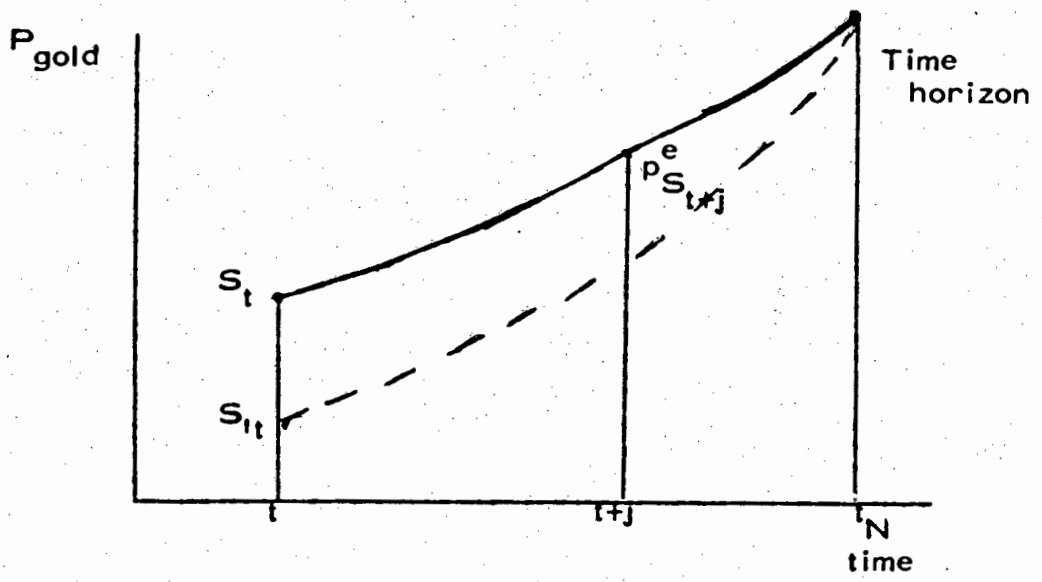

Fig. 4.6

Here we do away with the neutral inflation assumption.

We assume NR increases with inflationary expectations constant. Consequently, Rr^{e}, real expected rate of interest increases.

i.e. $NR \uparrow = Rr^{e} \uparrow + \overline{p^{e}}$

We must postulate a time horizon at some time in the future, t_N. This is a purely arbitrary choice as the time horizon can only be discovered empirically. The time horizon might just as well exist at t+j. Nevertheless, as a result of introducing the time horizon, the expected price path is revised downwards, along the dotted line, and results in a fall in the current (spot) price to s_{1t}.

4.6.5. Consumption Goods and Capital Goods

This explanation of commodity prices is entirely consistent with the explanation of the real rate of interest and the productivity of capital. There are two kinds of real goods in an economy - consumption goods and capital goods. Capital goods are created refraining from current consumption. Capital goods enable the society to produce more goods in the future. If the productivity of capital increases, i.e. the rate of transformation of current commodities into future commodities rises. This means that future consumption has become relatively cheaper. Less needs be sacrificed now in order to consume the same amount later. By the same token, current consumption has become relatively more costly. Purchasing capital assets, e.g. gold, is equivalent to purchasing future consumption goods. A rise in the real rate of interest, therefore, implies that these capital goods must fall in prices relative to current consumption goods.

Example:

Suppose we assume a 5 year time perspective. A current gold price of $315 per oz. is consistent with a real interest rate of about 5% and a price in 1987 of $402 per oz. Suppost now that the real interest rate changes, due to either a change in the productivity of capital or a change in the inflation rate. Under different interest rate assumptions, the effect on the current gold price can be shown.

Real Interest Rate	Current Gold Price ($ per oz.)		
	5 year (1987)	10 year (1992)	20 year (200
6%	300	287	261
5%	315	315	315
4%	330	347	382
3%	347	382	463

U.S. Inflation and Gold Price*

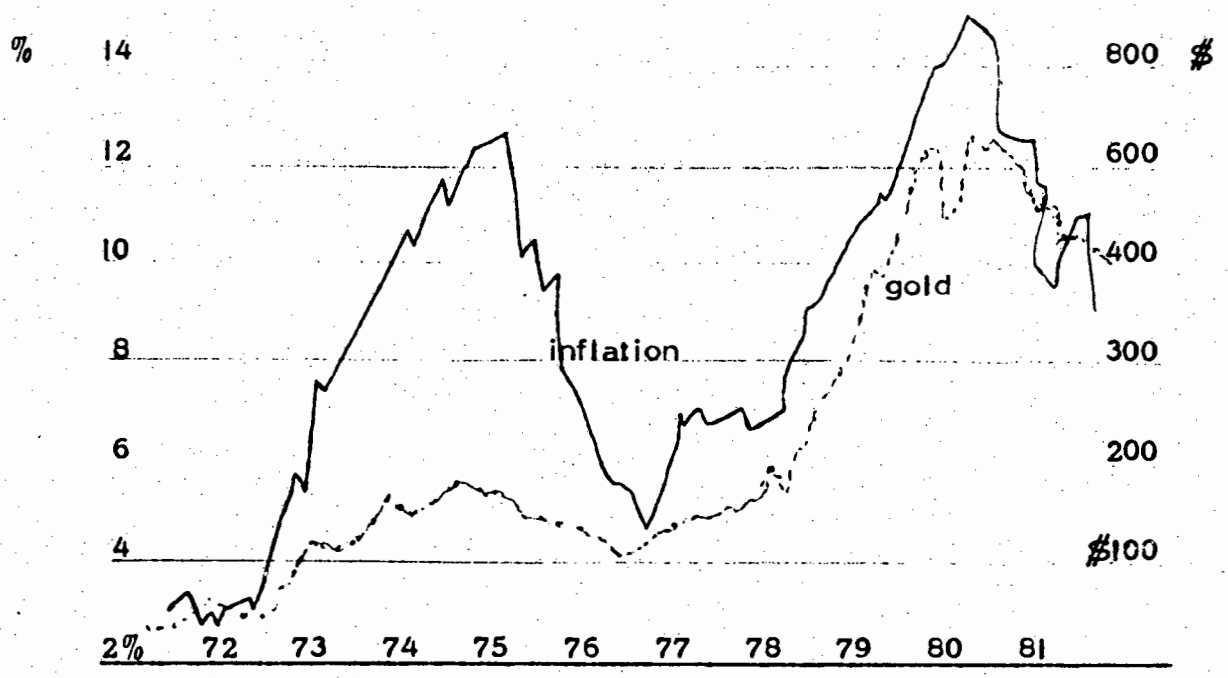

Fig. 4.7

Source: "The Hard Asset Investors Chronicle", Supplement to the Sunday Times, 14 Feb. 1982, p.3

* Nominal values.

Columns (3) and (4) show the effect of changes in the real interest rate if the market is working to a 10 and 20 year time horizon and a gold price of $513 per oz. in 1992 and $836 per oz. in 2002 respectively. Clearly changes in real interest rates have a much more dramatic effect on the current gold price as the time horizon increases.

4.7 Conclusion

It would seem apparent that during the 1970s, inflation and low real interest rates have not resulted in high rates of economic growth. Low real interest rates and lower rates of growth are caused by lower levels of real investment which can be attributed to inflation augmented uncertainties.

Wealth owners may have alternatives to undertaking real investment in the form of gold or other assets which possess a high degree of real value certainty, even during inflations.

This problem could be solved by reducing the risks associated with real investment (e.g. by providing a non-inflationary environment).

CHAPTER 5

THE HISTORY AND ROLE OF GOLD

IN THE SOUTH AFRICAN ECONOMY

5.1 Introduction

The discovery of gold on the Witwatersrand in 1886 changed the course of history of the people of Southern Africa. The gold mines pioneered the economic development of the country, setting the pace and providing the stimulus for the fuller growth of South Africa as a whole. Communication systems with their networks of road and rail, civic development and industrial and commercial advancement followed the expansion of gold mining activities along the Witwatersrand. Johannesburg became the hub of the country's transport systems. Secondary industry mushroomed to serve the ever-increasing demands of the gold-mining industry and the country's ports steadily enlarged their capacity to handle the consumer goods and the heavy machinery coming into the country as well as the growing tonnage of exports. The gold mines earn a considerable amount of foreign exchange and in addition the industry pays the government a substantial sum every year (R1 708 000 000 in 1979, some 48% of total profits and 82% up on 1978)[1] in taxation and lease payments. In 1979, South Africa produced 73.1% of the world's gold (excluding Russia). Next came Canada with 5.1%, the U.S.A. with 2.9% and Brazil with 2.7%.[2] (See Table 5.1)

5.2 South African Gold

5.2.1 Discovery and Location

An examination of the various events which culminated in the discovery of the rich gold bearing conglomerates of the Witwatersrand indicates conclusively that it was no fortuitous chance which led to their dis-

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1. The Economist, March 29, 1980, p.82
2. Chamber of Mines 90th Annual Report, 1979, p.71

PROPORTION OF ESTIMATED WORLD GOLD PRODUCTION PRODUCED BY S.A. 1887-1979

Year	S.A. %		Year	S.A. %	Year	S.A. %
1887	0,8		1918	45,4	1949	45,2
1888	4,2		1919	48,0	1950	43,9
1889	5,9		1920	50,7	1951	44,5
1890	7,7		1921	51,0	1952	44,6
1891	11,3		1922	45,5	* 1953	48,7
1892	15,1		1923	51,5	1954	51,1
1893	15,7		1924	51,0	1955	53,7
1894	20,6		1925	51,2	1956	56,2
1895	21,0		1926	52,0	1957	57,7
1896	20,7		1927	52,9	1958	57,7
1897	24,0		1928	54,6	1959	61,2
1898	27,6		1929	53,9	1960	62,3
1899	24,2		1930	51,3	1961	64,6
1900	2,8	S.A. war period	1931	48,6	1962	67,8
1901	2,0		1932	47,6	1963	70,3
1902	11,9		1933	43,5	1964	72,6
1903	18,7		1934	38,4	1965	74,1
1904	22,4		1935	36,4	1966	74,8
1905	26,7		1936	34,2	1967	76,7
1906	29,8		1937	33,5	1968	77,5
1907	32,3		1938	32,5	1969	77,6
1908	32,9		1939	32,5	1970	79,0
1909	32,2		1940	33,6	1971	79,1
1910	34,2		1941	34,9	1972	77,6
1911	36,7		1942	36,5	1973	76,8
1912	40,3		1943	48,0	1974	75,6
1913	39,0		1944	51,3	1975	74,6
1914	38,9		1945	53,1	1976	73,6
1915	39,9		1946	50,7	1977	72,2
1916	42,3		1947	46,9	1978	72,4
1917	44,9		1948	46,4	1979	73,1

* As from 1953, figures exclude U.S.S.R.

Table 5.1

Source: Chamber of Mines 90th Annual Report 1979, p.72

covery, but was only the final link in a long connected chain of circumstances. These events were not of any great importance or value and it would not be unreasonable to say that they merit attention only from the historical point of view.

The history of mining on the Witwatersrand may be said to have commenced in or about 1853.[3] Alluvial gold-mining was carried on in the Pilgrim's Rest - Lydenburg area in the early 1870s. The discovery of payable gold fields in other parts of the Transvaal had resulted in a large influx of newcomers from all parts of South Africa as well as overseas, to the district of Lydenburg, Pilgrim's Rest and other places where favourable indications of gold-bearing formation had been found. But it was not until the end of 1874 that a report reached Pretoria of the discovery of alluvial gold on the farm Blaauwbank, Rustenburg, about 43 miles west of Johannesburg. From that time on there is no lack of reliable evidence that the search for payable gold on the Witwatersrand was carried on without interruption, and with more or less intensity, until 1886 when the discovery of the Main Reef Series was made.

In magnitude this new gold field surpassed all others. The Kimberley diamond miners, whose discoveries in 1870 and 1871 had drawn the attention of the world, now looked towards the "Rand" as the new area was called. In January 1887, Rhodes wrote to his partner, Rudd, that "the opinion is steadily growing that the Rand is the biggest thing the world has seen."[4]

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3. Gray, J. Payable Gold, (C.N.A., S.A. 1937), p.15

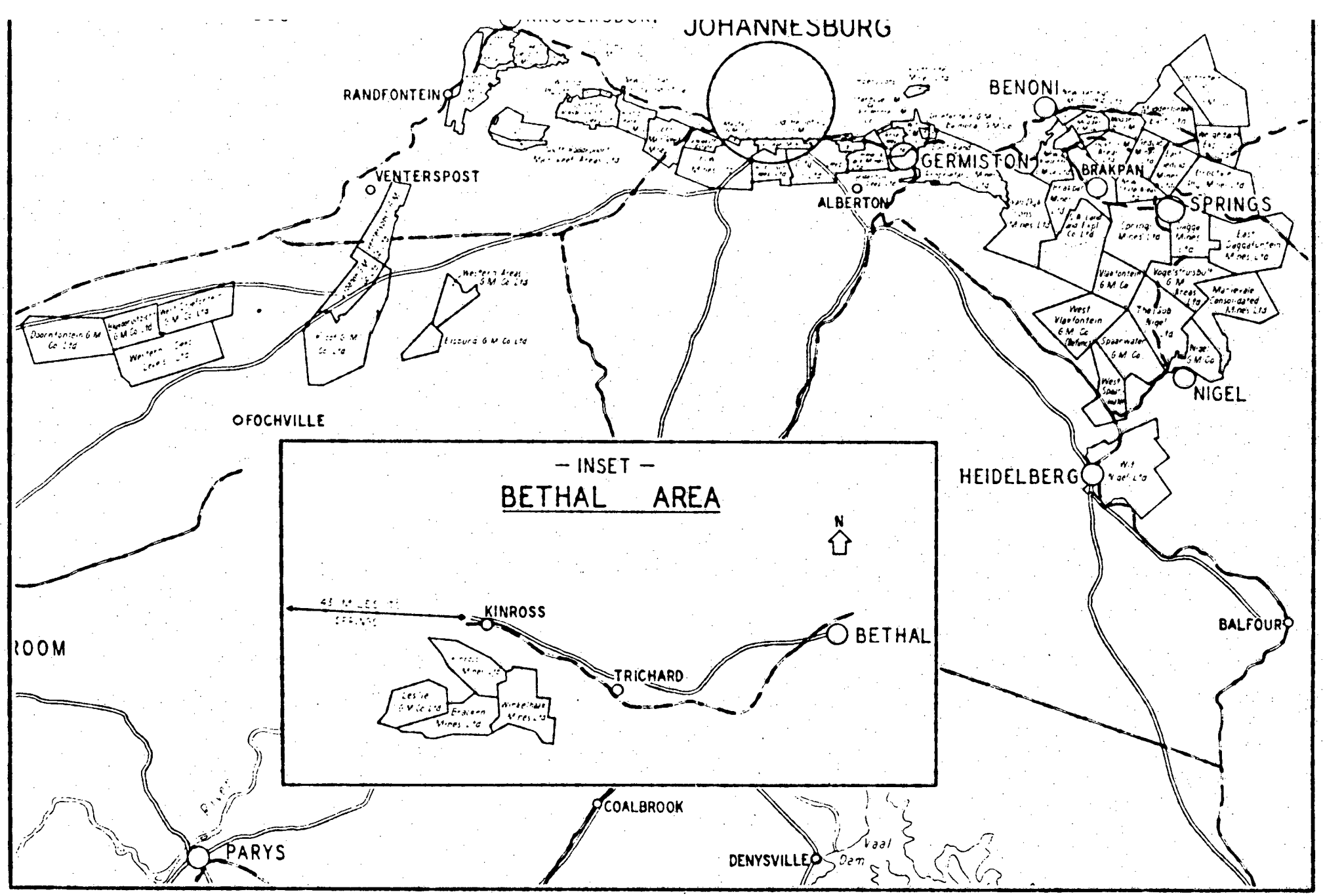
4. Letcher, O., The Gold Mines of Southern Africa, (Waterlaw & Sons, London, 1937), p.67

Extensions to the west and east of the original discovery were soon found and today the Witwatersrand gold field stretches about 130 km running generally east and west of Johannesburg. Subsequently, the Klerksdorp gold field was developed 160 km southwest of Johannesburg.

It is interesting to note the various divisions of the goldfields. The Central Rand extends from Roodepoort to Boksburg. In this area were laid down the foundations of South Africa's principal industry, but today there are only five producing mines and these account for a mere 3% of the country's output. The East Rand mines are grouped around the towns of Benoni, Nigel, Springs and Brakpan, with an extension southwards to Heidelberg. The West Rand mines are those near Krugersdorp and Randfontein. The extension of the field in a southwesterly direction towards Potchefstroom is known as the West Wits line or Far West Rand. It continues to the vicinity of Klerksdorp where there is another rich gold mining area. In 1947, the Free State Goldfields were added to the map and the towns of Welkom, Allanridge and Virginia grew up to the north and south of Odendaalsrus. Another development has taken place in the Winkelhaak-Kinross district to the east of Springs where the township of Evander has been established. Altogether there are about 50 major gold mines in the 500 km of South Africa's "golden arc" (see Fig. 5.1).

At present (1980/81), Anglo American is considering a new mine to the south and west of S.A. Lands and in the Erfdeel-Dankbaarheid block north of Welkom in the O.F.S. Observers guess that Gold Fields of South Africa (GFSA) will soon announce construction of the North Driefontein mine adjoining East and West Driefontein.

Anglovaal's Rand Leases, which stopped production in 1971 is thinking


JOHANNESBURG
RANDFONTEIN
BENONI
GERMISTON
BRAKPAN
SPRINGS
VENTERSPOST
ALBERTON
NIGEL
OFOCHVILLE
HEIDELBERG
BALFOUR
ROOM
COALBROOK
PARYS
DENYSVILLE
Vaal Dam
— INSET —
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KINROSS
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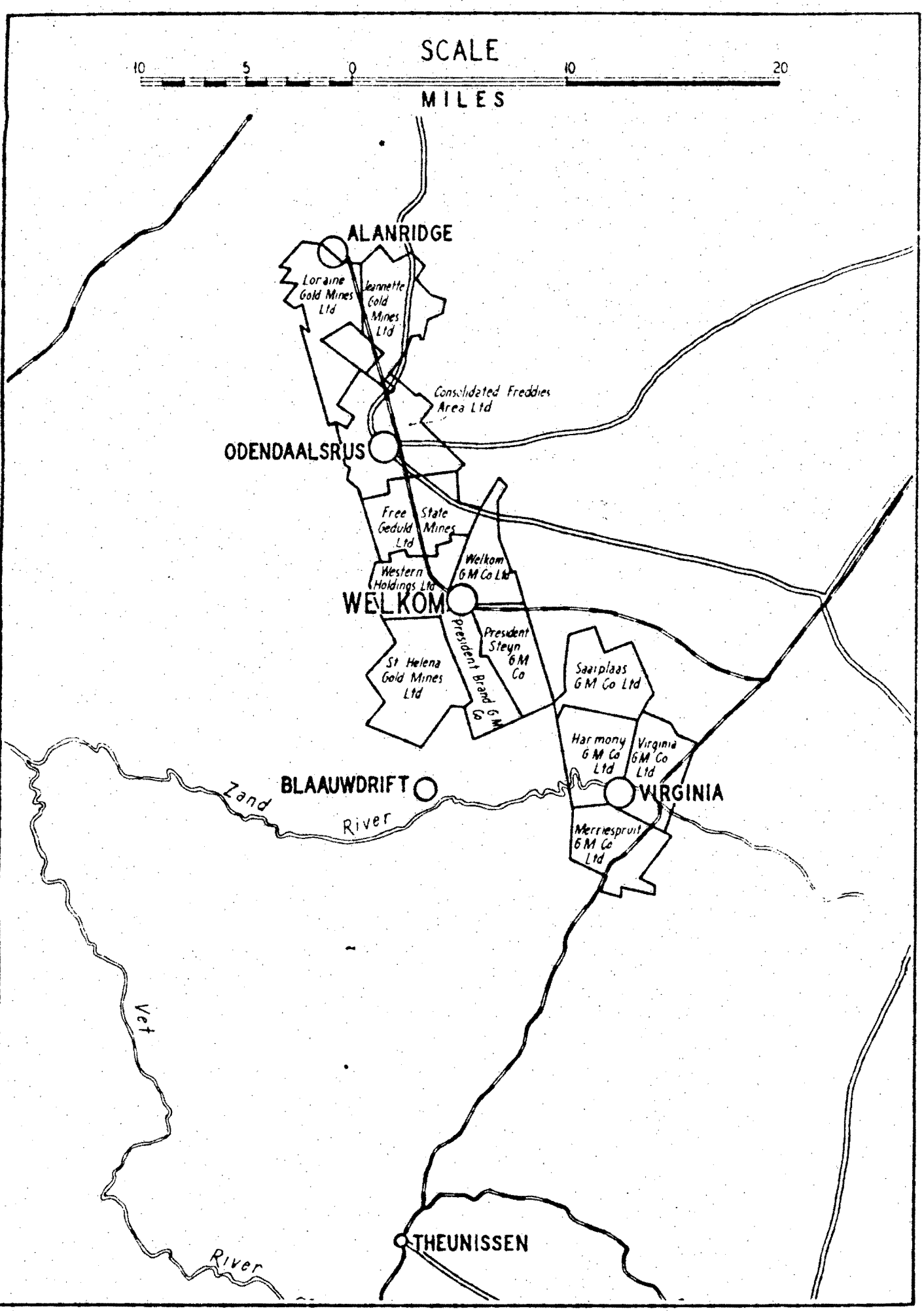
SCALE
10 5 0 10 20
MILES
ALANRIDGE
Loraine Gold Mines Ltd
Jeannette Gold Mines Ltd
Consolidated Freddies Area Ltd
ODENDAALSRUS
Free State Geduld Ltd
Free State Mines
Western Holdings Ltd
Welkom G M Co Ltd
WELKOM
President Steyn G M Co
President Brand G M Co
St Helena Gold Mines Ltd
Saaiplaas G M Co Ltd
Harmony G M Co Ltd
Virginia G M Co Ltd
VIRGINIA
BLAAUWDRIFT
Zand River
Merriespruit G M Co Ltd
Vet River
THEUNISSEN

Fig. 5.1 (a)

of re-opening, while Union Corporation has already started work on the new Beatrix mine, south of Welkom. All this comes on top of the three new mines which started production in 1979 - Unicorp's Unisel, Anglo's Elandsrand and GFSA's Deelkraal.[5]

5.2.2. Development

Certain factors encouraged the rapid initial development and considerable subsequent expansion of the gold mining industry in South Africa.[6] The most important factors were connected with

1) The geological formation of the deposit.
2) Technological advances in the mining and extraction of gold.
3) The proximity and cheapness of a power supply.
4) The availability of "cheap" unskilled labour.
5) The ability to raise large amounts of foreign capital.

A. Geoglogical formation

The gold on which the prosperity of South Africa depends occurs as tiny particles in a rock called conglomerate. In the early geological history of the country a sea covered what we now call the Witwatersrand. The rivers flowing into the sea deposited mud, sand and coarse gravel on the sea floor. These were consolidated into shale, sandstone and conglomerate. The layers of sedimentary rock were then covered by younger sedimentary rocks. In parts the rim of the saucer has been re-exposed by erosion. It was in one of these outcrops of metamorphosed conglomerate to the west of the present city of Johannesburg that the reef was discovered.

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5. The Economist, March 29, 1980, p.82
6. These factors are listed in Dr. M.H. de Kock's The Economic History of S.A. (P.S. King & Son, London 1936), Ch.7

Gold occurs in the matrix in very fine particles usually not visible to the eye. The great wealth of the Rand's ore cannot, therefore, be attributed to the richness of the deposit. The ore is relatively low grade. Its extent, uniformity and continuity is, however, unparalleled elsewhere in the world. Mining has been simplified by the surprising uniformity of the conglomerate but its hardness and the microscopic nature of the gold particles within it make the extraction of gold an expensive process. In fact, about 3-4 tons of ore have to be mined for every fine ounce (28 grams) of gold extracted from the conglomerate.[7]

The gold bearing reefs have been likened to the pages in a book[8] - "each page from a few inches to a few feet thick". To extend the analogy, the book is not only buried and tilted (dipping the reefs) but pages are crumpled, or torn (faulting the reef). Finally pages vary in quality (richness of gold content). The overall picture is a very consistent one, prompting some, perhaps over-optimistic, investors to liken the deposits to proven oil reserves.

B. Technological Advances

The great wealth of the Rand, and the subsequently discovered fields, were not easily accessible. Except for a very few mines, the average grade of the ore is low. (A mine is regarded as high grade if it recovers ½ an ounce of gold from every ton of gold-bearing ore. For every ton of gold-bearing ore it removes the mine will probably have to remove another ½ a ton of waste rock.) Securing a high extraction from such ore is a difficult process. The ordinary amalgamation process originally used extracted 50-60% of the gold. It was not

7. Nicholson, J. & Morton, J., Man's Environment, Shuter & Shooter Pietermaritzburg, 1975, p.250

8. Sutherland, C.M.V., Gold, Thames & Hudson, London 1959, p.167

until the introduction of the MacArthur Forrest cyanide process in 1890[9] that the problem was solved and recovery of 95% and more was achieved.

The reefs occur at great depths. In the Free State the reefs, which are all concealed, are badly faulted in places and are worked at depths varying from about 230 metres to 2000 metres. A factor that permits mining to such great depths is the hardness of the rock which lessens the danger of collapse. The deepest mine in the world is the Western Deep Levels, in the Transvaal. This has reached a depth of 3618 metres. The deeper the shafts go, the greater becomes the threat of rock walls bursting under pressure, and to minimise such dangers and improve methods of mining generally, a large research organisation has been established. To reduce the number of rock bursts, much feared by miners, engineers eventually developed a powerful hydraulic prop which, while yielding rapidly to the tremendous pressure exerted by a rock burst, continues to give strong support to the roof surface of the mine.

Another advantageous factor is the rate of temperature increase with depth, which is less than that experienced in most other parts of the world. This gentle geothermic gradient helps keep working conditions reasonable at great depths, but even with this slow temperature increase a reading of 43°C is reached at about 2750 metres in the Transvaal and at about 1700 metres in the O.F.S.

Large volumes of air are circulated (as much as 10 tons of air may be circulated through the mine for every ton of reef mined) and

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9. Letcher, p.100

underground air refrigeration plants are used.

In the mines where water is found, powerful pumps lift it to the surface where it forms small lakes. Some of this water is used to safeguard miners against the lung disease known as miner's phthisis.

Successful solutions to these and many other problems have enabled the industry to survive and flourish over an extended period of time.

C. Power Supply

A most important factor in the development of gold mining in South Africa has been the availability of coal resources in the Transvaal and Natal. Most of the coal is low grade but suitable for generating electric power or for converting into oil and gasoline. In South Africa the "cheap" energy policy leading to South Africa having some of the "cheapest" coal in the world, has been a result of the government regulation of internal prices.

D. Labour Supply

The existence of a large supply of labour drawn from South Africa and its neighbouring territories has been a crucial factor in the development of the gold mining industry. The position of the gold mining industry as the only alternative to the agricultural activities in early days has diminished due to the expansion of the industrial sector.

The absolute number of workers in the industry has been increasing but there has been a negative rate of relative growth. In 1910, there were 220 000 workers, in 1975, 370 000[10] and in 1979, 542 000

10 Hobart Houghton, D., The S.A. Economy, Oxford U.P., Cape Town, 4th ed., 1976, p.110

labourers were recruited for work on the gold mines.[11]

In 1974, President Hastings Banda of Malawi, put a stop to the recruiting of labour in his country for the S.A. mines. Malawians had made up over a quarter of the total black work force. And in 1975, the advent of a left wing government in Mozambique made the mining industry fearful that it might lose access to Mozambican labour. The number of black workers dropped alarmingly from 386 000 in 1973 to 333 000 in 1975. At one stage the industry was functioning on only 78% of its labour requirements.

The result was a recruitment drive amongst South African blacks with the aim of pushing their proportion up from a quarter to half the total work force. To make mining attractive, the industry had to increase its wages. Out of 511 000 blacks now employed, 298 000 were recruited in South Africa. The biggest foreign suppliers are Lesotho (110 000), Mozambique (39 000) and Malawi (22 000 - Dr. Banda lifted the ban in 1978).

The wage ratio between "white wages" and "black wages" is now 7 to 1 (as opposed to 18 to 1 in the early 1970s). The minimum wage for surface workers in the early 1970s was R14.30 per month. It is now R13.50 a week. The average black wage is now R155 per month. Blacks also get free accommodation, food and other services worth about R80 per month.[12]

In spite of the recent gold price upsurge, it seemed unlikely that mine workers would reap large benefits. The mining companies advocate that wage increases depend upon productivity and not

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11 The Economist, March 29, 1980, p.83

12 The Economist, p.83

profitability. They also insist that the pay increase should not exceed the cost of living increase (± 14% in 1981). This new productivity argument is most likely due to the excess supply of labour. According to the published data the industry's underground labour requirements in 1980/81 were entirely met and surface occupations were over-employed by 2%.[13]

E. Ability to raise foreign capital

The factors mentioned above - the geological formation, the solutions to technical obstacles, and the abundant supplies of both power and labour - coincided with the commencement of a unique period in international finance. "From 1870 to 1914, Europe and in particular Great Britain, played the role of the World's financier".[14] The great accumulated wealth in Europe as well as many other more complex factors, resulted in a new policy of "constructive imperialism" - the deliberate economic development of the Colonial Empire by the investment of capital. Cecil Rhodes defined this imperialism as "philanthropy plus 5%".

5.2.3. Expansion of the Industry.

In a speech to some visiting financial editors from Switzerland, the Chairman of one Mining Finance House made the following statement:

"This industry of ours, which is the spinal cord or our country's economy, is based upon a thin strata of gold carrying rock, which lies at depths varying to 3 300 metres below the surface and which

13. Rand Daily Mail, 17.1.1980

14. Frankel, S.H., Capital Investment in Africa, (Oxford University Press, 1938), pp.16-17.

contains gold in such minute quantities that we frequently only get 6 grams of gold from every 1 000 kg of rock we crush, but these quantities occur so consistently, and with such reliability, that our operation could be described as gold manufacturing when compared to mining operations elsewhere."[15]

Once the thin strata of rock has been removed (down to depths where mining remains economic) the mine ceases to manufacture gold, pays back the shareholders' capital and "dies". The industry, at any one given time, is made up of units in varying stages of life, all certain of ultimate death. And yet, because of the great extent of the present gold fields and the immense activity of the industry in exploration for new fields, this industry has never, since its inception in 1886, decreased its annual output of gold except during and immediately after the three wars (Anglo-Boer and two World Wars)[16] and after 1970.

The spate of new shafts and mines might suggest that South African gold production is increasing. Instead it is falling. From a peak of 1 000 tonnes in 1970, output has slipped down to 702.8 tonnes in 1979, despite a 16% increase in the tonnage of rock milled. In 1980 production was as low as 680 tonnes.

Mr. Dennis Etheredge, past president of the Chamber of Mines predicted that production will remain at around 700 tonnes a year until 1987.[17] After that, it may fall to around 350 tonnes at the end of

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15. Menell, S.G., Speech to Swiss Financial Editors, Johannesburg, 2nd January, 1959.

16. 4 other exceptions to this statement occurred in 1933, 1934, 1950 and 1951.

17. Chamber of Mines 90th Annual Report, 1979, p.3

the century. These predictions were based on what seemed in 1980 very conservative prices - $450 an ounce rising to $554 in 1984 and remaining constant until the year 2000.

South Africa's mines are expected to dig about 20 000 tonnes of gold out of the ground between 1982 and 2030, to follow the 36 370 tonnes mined since production started 97 years ago. Output is falling despite increased capacity because the mines are exploiting lower ore grades - in other words, having to dig up more rock to produce a given quantity of gold. Average grades declined from 12,7g/t in 1972 to 8.2g/t in 1979, a drop of 40%.[18]

The higher gold price made worthwhile the exploitation of low grade ores which would otherwise have been left in the ground. An average bullion price of $450 an ounce makes grades as low as 7.9g/t economic.

This has come as a result of South African Gold mining law which obliges a company to mine as close as is reasonably possible to the average grade of its economic reserves. Because this average grade is dropping sharply in direct inverse ratio to the rise in the gold price (after an adjustment for rising costs), as large areas of previously sub-economic (non-payable) ore become economic, the mines are dropping their mill grade. The cut-off grade or pay limit (the point below which it is not economic to mine ore) has fallen to about 2.5g/t compared with more than 8g/t before the collapse of the Gold Pool in 1971.

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18. Economist, p.83

Gold ore treated and fine gold produced, 1950-1979

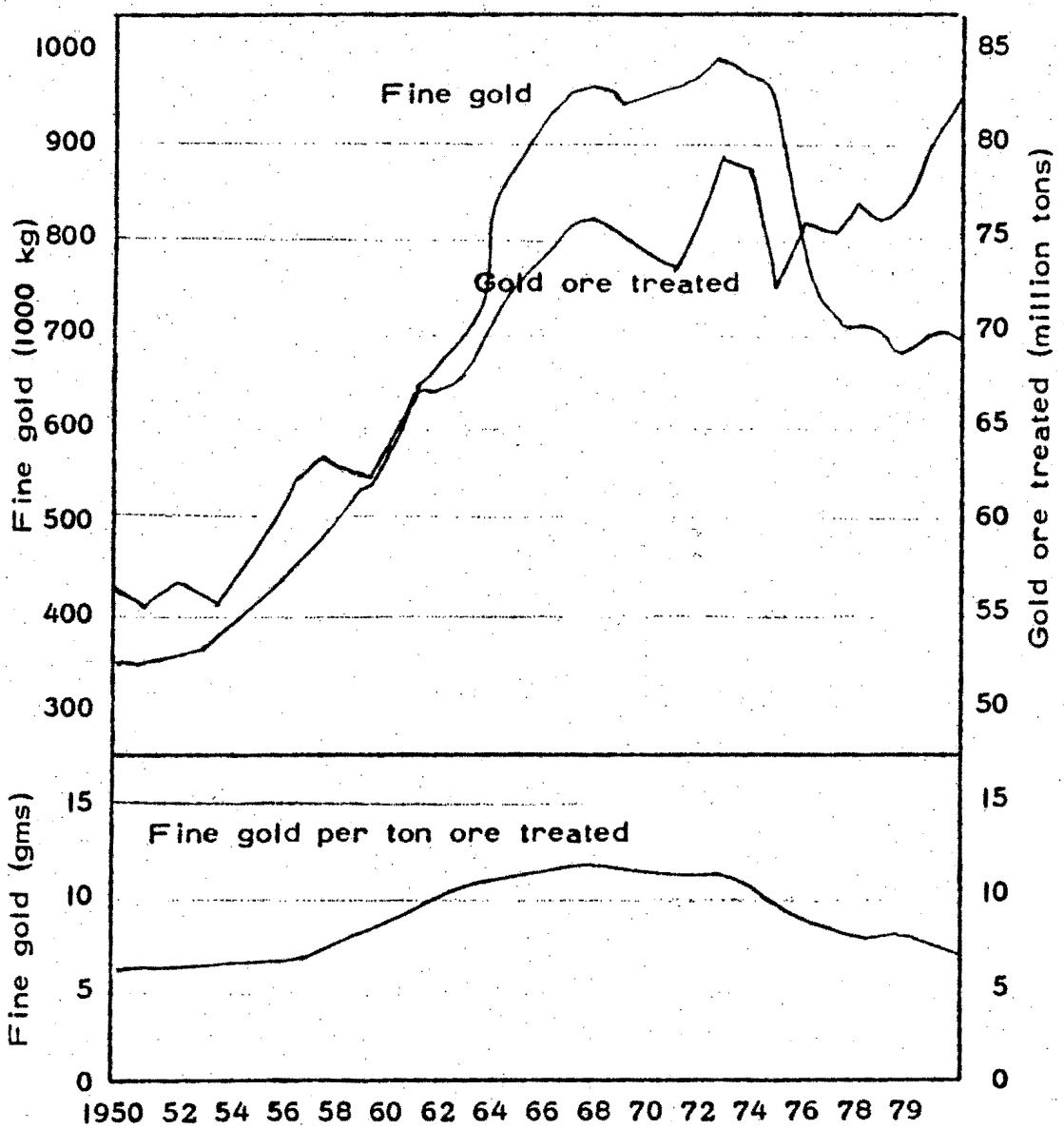

Fig. 5.2

Source: Chamber of Mines, Annual Reports

Relationship between grade of ore mined and the gold price

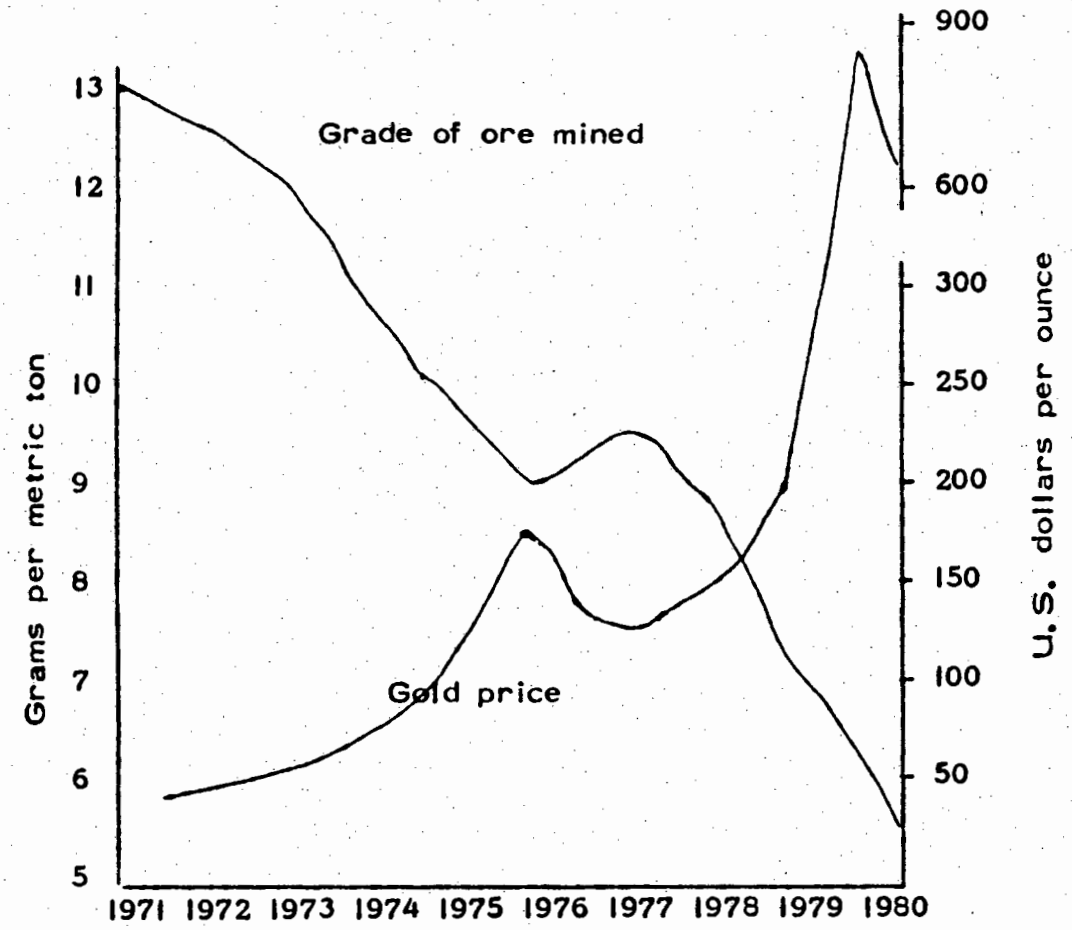

Fig. 5.2 (a)

Source: Chamber of Mines Annual Report; various issues

The effect of these two factors is to reduce profits (through lower grades) and lessen dividend distributions (through bigger diversions into capital expenditure) while extending considerably the life of the gold mining industry and maintaining its prosperity at higher levels for a longer period. This aspect will be dealt with more fully in the next chapter and is based on the theoretical foundations laid down in the chapter on Wasting Assets.

5.3 Organisation of the Industry - The Mining Finance Houses

The South African Mining Finance House is a unique institution. Some knowledge of its size and functions is of relevance to this thesis. It should be mentioned at the outset that certain important information in this field is not available to the public.

Initially, gold was worked by many individuals and small syndicates. Mining, Finance, Exploration and Land-owning companies sprang up. 396 such companies existed in South Africa (6 years before gold was actually discovered) in 1880.[19] By 1889 the figure had risen to 642. When the large scale nature of this new industry became apparent the successful rationalisation of the diamond industry was used as a basis for the gold mining industry. By 1897, the general organisation of the industry had taken a form which, though comparatively small in scale and imperfect in its workings, bore a resemblance to the so-called "Group System" of today.

There are 55 gold-producing companies in South Africa. Each of these companies is a separate entity with its own body of shareholders electing its own Board of Directors. But the administrative control

19. Frankel, S.H., pp. 80-81

Gold's Impact on the South African Economy

	Average Gold Price ($ / oz)	Gold Output (mn oz)	Current Account Surplus (deficit) ($ bn)
1972	59	29	(0,1)
1973	95	27	(0,1)
1974	159	24	(1,5)
1975	160	23	(2,5)
1976	125	23	(1,9)
1977	148	22	0,5
1978	193	23	1,5
1979	308	23	3,7
1980	613	22	7,5

Table 5.2

Source: Compiled from various issues of Chamber of Mines Annual Reports.

of all the companies (with one or two minor exceptions) is in the hands of one of a few large corporations possessing strong financial resources, long and intimate experience of mining enterprises, and efficient technical and administrative staffs.

The mining group has been likened to U.S. corporations such as General Motors and General Electric. But what in the United States is organised as a division is in South Africa organised as a corporate entity. In Professor Frankel's words, the mining finance house, or "Group" acts as "a combination of Controlling and Holding Company, Investment Trust, and Issuing and Promoting House."[20]

The Group holds a share interest in each subsidiary company under its aegis. This is seldom anything approaching a majority interest. It may, in certain cases, be a very small interest. Thus control is maintained without majority ownership.

This rather unique system evolved in a unique situation. The nature of the product, the consistency and wealth of the gold deposits on the Witwatersrand and the system inherited from the diamond mines at Kimberley, combined to create an industry structure which has remained unchanged for half a century. There has never been competition in the sale of gold bullion. Consequently, the Mining Groups in the industry have generally co-operated very closely on every sphere except the initial acquisition of a mine. This very strong oligopoly has made it possible for a Group to exercise actual control without "legal control". In addition, when mining approaches "underground manufacturing"; when it becomes not a gold-chasing but a

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20. Frankel, p.93

cost-minimising operation, it is then possible to employ very large expert technical, legal and accounting staffs in a Mining House's head office to service several individual mines with resultant economies of scale.

The seven S.A. Mining Groups are listed below (with the abbreviations to be used when referring to them in the text):

Anglo American Corporation of S.A. Ltd. (Anglo American)
Anglo-Transvaal Consolidated Investment Co. Ltd. (Anglovaal)
Gold Fields of S.A. Ltd. (GFSA)
Rand Mines Ltd. (Rand Mines)
Union Corporation Ltd. (Unicorp)
General Mining and Finance Corporation Ltd. (General Mining)
Johannesburg Consolidated Investment Co. Ltd. (J.C.I.)

Anglo American and its stablemate, De Beers, already own 49.9% of J.C.I. and their strategic holding of 25% of Consolidated Gold Fields will give them a powerful presence in GFSA. Consolidated Gold Fields itself owns 46% of GFSA. In addition, Anglo American has 3.5% of GFSA and its offshoot Amgold has another 11%. Between them they hold 23% in Hartebeestfontein, one of Anglovaal's two mines.

As table 5.3 shows, Anglo American is by far the biggest mining house in terms of profit and production even though its share of total output (including surface treatment operations) has declined from 41% in 1969 to 37% in 1979.[21]

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21. Chamber of Mines 91st Annual Report, 1980, p.65

General Mining is catching up fast. If it succeeds in taking up the outstanding 48% minority interest in Unicorp it will be a close second to Anglo American.

Had General Mining gained control of GFSA, as many suspect it would have liked to do, it would have overtaken Anglo American as industry leader. General Mining also has a 24% stake in Anglovaal's holding company but has so far made no attempt to increase it.

Rand Mines is part of the Barlow Rand Conglomerate in which Anglo American has a 7.2% stake. Rand mines may remain the one mining house outside Anglo American and General Mining spheres.

Several of the houses have interests in each other's mines. GFSA holds 15% of Anglo American's Elandsrand mine and a sizeable amount of Rand Mine's Blyvooruitzicht. Although Anglovaal administers Hartebeestfontein, it owns only 6.7% of the stock while Anglo American has 23%. Anglo American also has 16.4% of GFSA's East Driefontein, 14.2% of West Driefontein and 23.6% of General Mining's Buffelsfontein.

All the Gold Mining Houses have fingers in other mining pies and, with the exception of GFSA, large industrial interests. Almost 1/5th of Anglo American's investment income came from industry last year and 36% from gold. General Mining derived almost half its investment revenue from gold and uranium, 14% from base metals and 12% from commerce and industry.

Mining Houses share of gold profits and production

1979 figures

	Output tonnes	% of total	R'000	Operating profit % of total
Anglo American	262.0	38.2	1 274 352	41.1
GFSA	162.7	23.7	951 957	30.7
Rand Mines	69.4	10.1	115 441	3.7
Union Corporation	60.2	8.8	304 487	9.8
J.C.I.	46.6	6.8	160 554	5.2
General Mining	46.4	6.8	133 557	4.3
Anglovaal	37.9	5.5	159 003	5.1
Independent	1.2	0.1	1 347	0.1
Total	686.4	100.0	3 100 698	100.0

Table 5.3

Source: Business Brief, The Economist, March 29, 1980, p.82

Because of the absence of competition in the sale of gold, it is to the Group's mutual advantage, through the Chamber of Mines (an industry association) to pool their knowledge, to formulate common policies where necessary, and to share services and facilities. The Chamber of Mines is most active in the following spheres:

a) Labour recruitment and transport.

b) Refining of the individual mine's gold bars.

c) Recovery of traces of precious metals from mines' gold plants.

d) Workmens' Compensation Insurance scheme for all mines.

e) Materials testing and buying policies.

f) Dietary standards.

g) Accident prevention.

h) Treatment of Pthisis.

and in other spheres of mutual interest.

Functions performed by the Groups.

The Mining Finance House's functions can be summarised as follows:

a) The Group's prospectors locate a likely area and carry out a drilling programme, subsequently applying for a mining lease (if the results justify it).

b) The Group arranges a syndicate that guarantees to subscribe or find subscribers for the entire capital to reach production. The Group then takes a participation in this syndicate, in addition to its vendor's consideration which repays the Group for its pre-floatation expenses.

c) The Group assumes technical and administrative control of the mine; and subsequently takes care of any financial requirements,

making temporary loans where necessary, or arranging long term loans to bring the mine to production and to ensure operations during its life.

Finally,

d) The Group may finance and manage other types of mines and a variety of industries, ranging from paper manufacturing to food processing.

5.4 The Role of Gold and its importance to the S.A. Economy.

As a major industry, gold mining has had a major impact on the South African economy as a whole.

The industry is in fact an integral part of the economy and its direct structural importance can best be measured by the industry's net contribution to national income relative to other sectors of the economy and that proportion of the total working population employed in the industry. According to the latest published input-output table of the S.A. economy (1975), 38 out of a total 51 sectors in the economy were in some way involved in providing intermediary inputs for the gold mining industry. The most important of these were: electricity, gas and steam 17.7%; mechanical machinery 18.2%; metal products 11.7%; agriculture, forestry and fishing 9.2%; paint and chemical products 7.1%.[22]

The analysis of the role of gold will be divided into two sections, namely the period 1886-1978 and the period 1978-1982. This has been done in order to pinpoint the monetary role of gold and its varying effects under a system of fixed exchange rates (prior to 1978) and

22. Nedbank Economic Round-up, March 1980

the effects of the massive increase in the price of gold and the exchange rate proposals of the De Kock Commission[23] (post 1978).

To this extent, I have not considered such issues as the importance of gold as a source of government revenue; as an earner of foreign exchange and as a supplier of jobs. I have rather concentrated on one specific aspect in detail, although the role of gold as an earner of foreign exchange is implicit in the analysis. Furthermore, the role of gold as a source of government revenue via taxes and leases is discussed at length in the next chapter.

5.4.1. The Period 1886-1978

Before 1870, South Africa had been almost entirely an agricultural country. Farming, particularly in the interior, was largely of a subsistence character.

The discovery of diamonds at Kimberley in 1868 began the transformation of the economy from one that was predominantly based on subsistence agriculture to a capitalistic agriculture - mining economy. By the 1880s diamonds equalled agricultural products in the country's exports. This process was greatly accelerated by the discovery of the Main Reef of gold on the Witwatersrand in 1886. Six years later, the output of gold had already exceeded the output of diamonds in value.

The period 1886-1910 has understandably come to be known as the "Gold Era" because of the profound dynamic effect the discovery of gold and rapid development of the industry had on the growth and the determination of the economic structure of the country.

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23. Commission of Inquiry into Exchange Rates (De Kock Commission) 1978.

It greatly accelerated the rate of immigration into the country, which reached its peak just before and after the Boer War.

Gold mining determined the location of many new cities, chief of which is Johannesburg. It also determined the pattern of South African railway transport, which in its early stages of development was designed to link the Witwatersrand with the sea. Without the discovery of gold it is unlikely that the largest centre of industry and population would have been situated in the interior of South Africa.

Gold soon became South Africa's most important export and gold mining acted like a magnet which attracted foreign capital to South Africa. Ever since its inception in 1886, the industry had been a major force in the South African economy, but amongst all, its contribution to the economy as a strong stabilising factor was the most considerable. Because of its fixed-price nature at the time it acted as a contracyclical force in times of declining business activity.

5.4.1.1 Gold Mining and the Trade Cycle.[24]

Theory suggests that gold output should move anti-cyclically. The price of gold under gold standard or semi-gold standard conditions is normally constant over long periods of time. Between 1717 and 1914 the price of gold in terms of sterling was £4.24773 per fine ounce, or what is the same thing, one gold sovereign contained $113\frac{1}{623}$ grains of fine gold. Dr. Busschau maintains that before 1914 gold did not have a price in the strict economic sense of the

24. This scenario exists under a system of fixed exchange rates and a fixed gold price.

word. He prefers to call £4.24773 per fine ounce the "measure" of gold rather in the same way as pints are a measure of water.[25] While the nominal value of gold is constant its "real" value changes with movements in the price level. When the price level falls, the "real" value of gold increases and vice versa.

Fluctuations in the level of activity are normally accompanied by movements in commodity prices, wages and interest rates. In a depression, therefore, with falling prices, wages and interest rates, the production of gold should become more profitable and so gold output should expand. In a boom the opposite should be the case.

If gold output moves in this anti-cyclical manner, the gold mining industry should have a stabilising effect on fluctuations in a gold mining country. Gold mining is in a special position as a trade cycle stabiliser. Unlike the continuous demand industries[26] (which have an anti-cyclical effect on the economy during a depression and by raising the "floor" beyond which output will not decline, they accelerate recovery) it should act as a stabiliser in both directions. That is to say, it should not only curb the depression, but restrain an inflationary boom as well.

It also differs from those industries that have played a stabilising role in cycles, in that anti-cyclical fluctuations in gold output would be integrally related to fluctuations in the general economy via movements in costs and the price level, and not only due to trend

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25. Busschau, W.J., "Gold Mining Investment" SAJE, March 1937 and The Measure of Gold, C.N.A. Ltd., S.A. 1949, p.1

26. Industries that have continued to expand in spite of depression in other sectors of the economy, e.g. the Rayon industry continued to expand during the depression of the 1930s.

factors and structural changes that persist in spite of, rather than because of the cycle. The gold mining industry would act as a kind of "built-in" stabiliser. Other things being equal, cycles in a country with a large gold mining industry should be of smaller amplitude than in a country without a gold mining industry.

A gold mining industry can act as a stabilising force on the economy of a gold producing country in two ways. Firstly, via its effect on income and employment and secondly, via its effect on the monetary system.

We will first consider the direct income or real effect of the gold mining industry on the country's cycles. The following assumptions will be made.

1) All prices are flexible in both directions. Only the price of gold is fixed.
2) Gold output is flexible with respect to changes in costs.
3) Factors of production are mobile.

To begin with, we will consider what happens in the upswing phase of the cycle. In the early stages of the upswing, while there are still unemployed resources in the economy and prices are constant, gold production may continue to expand. As the economy approaches the full employment "ceiling" however, commodity prices and wages begin to rise. Gold mining costs also rise. But in the case of the gold mining industry, a rise in costs can not be compensated by a rise in the price of gold. As costs rise, therefore, gold output is curtailed. Marginal mines are forced to stop production. Workers are dismissed, less stores are bought by the industry and profits fall.

In addition, the decline in the profitability of the industry leads to a falling off of gold mining investment. A rise in interest rates will further accentuate this fall in mining investment. This decline in gold-mining income, employment and investment through the operation of the multiplier-accelerator mechanism will tend to slow down the rate of growth of income in other sectors of the economy and accelerate the coming of the down-turn.

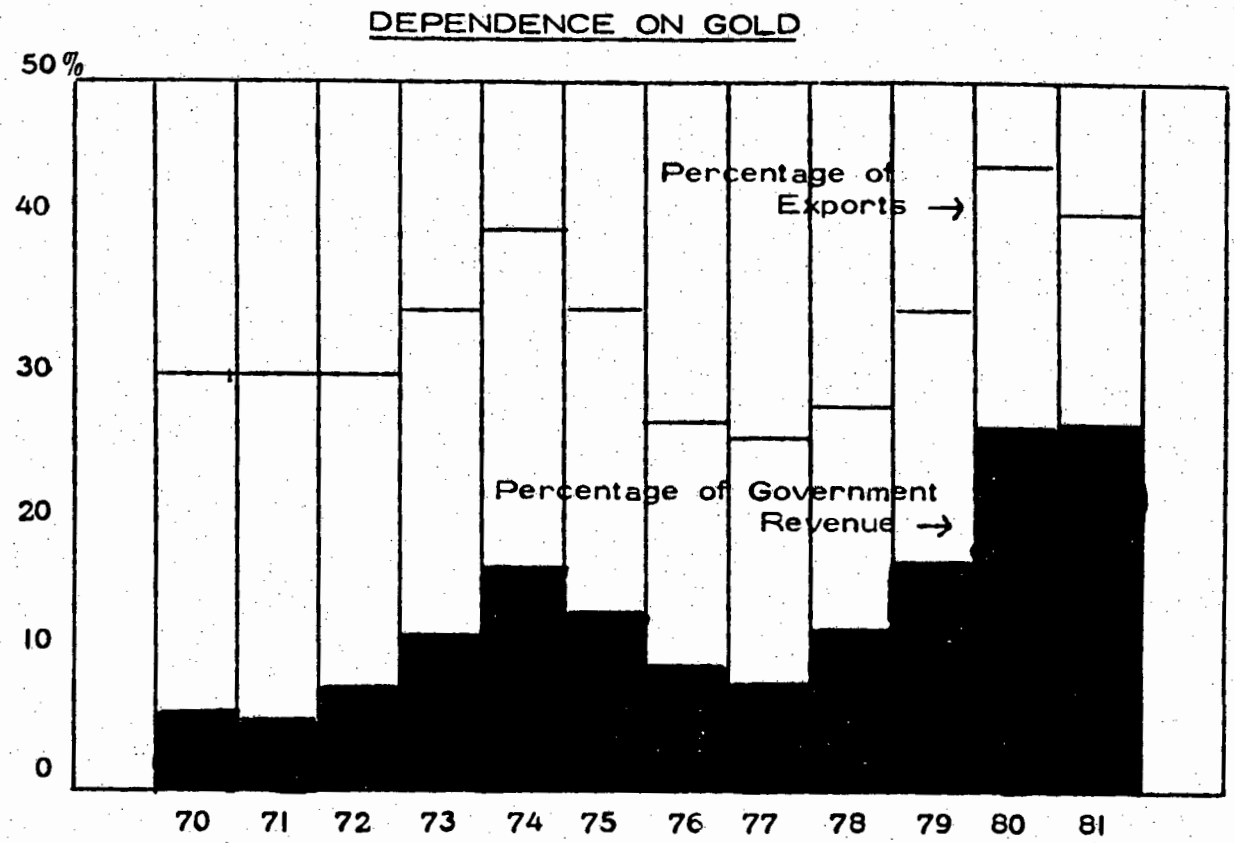
In the downswing, the process is reversed. As output and prices decline, gold production is stimulated. Gold bearing ore rendered unpayable in the previous rise in costs can now be profitably mined. The fall in costs and interest rates and rise in profits will also lead to increased investment in gold mining. The greater the fall in the price level, the more will gold production and investment be stimulated. The industry will absorb some of the unemployed workers from other sectors of the economy and increase its outlay on stores. This increase in employment and income in gold mining will have a multiplier effect on employment and income in other sectors and so tend to offset the deflationary forces at work in the economy. In certain industries very closely linked with the gold mining industry, the increased gold output will not only offset a fall in demand from other sectors but lead to an increase in demand. In this way, some investment will be induced in industries other than the gold mining industry. The net effect of the expanding gold mining industry will be to limit the extent of the decline in income and employment and accelerate recovery.

The monetary effects of a gold mining industry will tend to work in the same direction as its "real" effects. If our economy is on a full gold standard, anti-cyclical fluctuations in gold output will have an

added stabilising influence. As gold output declines in the upswing the supply of new "real" money will contract. This will tend to cause interest rates to rise and credit to be curtailed. This would add to the "real" deflationary effect of the gold mining industry in the upswing. The reverse process would take place in the downswing.

When gold is a major export item, as in the case of South Africa, fluctuations in its output can have an important indirect monetary effect via the balance of payments situation. A decline in gold output and exports in a boom, if it is compensated by an increase in the export of other commodities, can lead to an adverse balance of payments situation. This deficit can only be met by increased foreign lending or an outflow of gold held in reserve for international payments. If the economy is on the gold standard, a fall in gold reserves should lead to a deflationary monetary policy. In a depression, with a fall in the demand for imports and an increase in gold output, a favourable balance of payments position may develop, and result in an easing of credit conditions. When, however, the gold standard is not in operation and fluctuations in the balance of payments are dealt with by means of movements in the rate of exchange or direct import controls rather than by monetary measures, the indirect monetary effect of fluctuating gold output will be limited. The income effect, however, will still remain.

While it may not eliminate cycles, an anti-cyclical gold mining industry should, nevertheless, narrow the extent of the fluctuations. How effective it will be will depend on its size, the length of the time lags and the strength of the destabilising forces in the economy. The smaller the industry, the longer the time lags and the stronger



A vast share of the State's Revenue is supplied by taxation on the gold mines. This graph shows the high combination of the gold mines in the past gold boom which enabled South Africa to maintain a high rate of growth while western economies were in recession.

Fig. 5.3

Source: Cape Times, March 25, 1982, p. 24

the destabilising forces, the less effective will the industry be in its stabilising role.

So far I have assumed that gold output itself moves anti-cyclically. When, however, the assumptions on which the anti-cyclical behaviour of gold output is based are relaxed and the factors that in practice modify its inverse relationship with the trade cycle are introduced, its stabilising influence is still further reduced. In practice, gold mining costs tended to be fairly rigid and the price of gold has not remained constant. While gold output may be sensitive to changes in costs, the relationship between costs and output is not a simple one. It is complicated by the fact that gold output is not only a function of the tonnage milled but of the grade of ore mined as well. While a fall in costs may lead to an increase in the tons of ore milled, it also leads to a fall in the grade of ore mined. As a result, gold output may not increase to the extent that tonnage milled increases. Similarly, when costs increase, an increase in grade may offset the effect on gold output of a fall in tonnage milled. There are also lags in the response of gold output to a change in costs due to the imperfect mobility of factors and the long gestation period (usually 3 to 4 years) of gold mining investment. Finally, the availability of unexploited reserves of ore is another limiting factor.

5.4.2. The Period 1978-1982

The scenario which I have discussed above exists only under a system of fixed exchange rates and fixed gold price. Since the proposals of the De Kock Commission (late 1978) a system of fixed exchange rates has ceased to operate in South Africa. The exchange rate

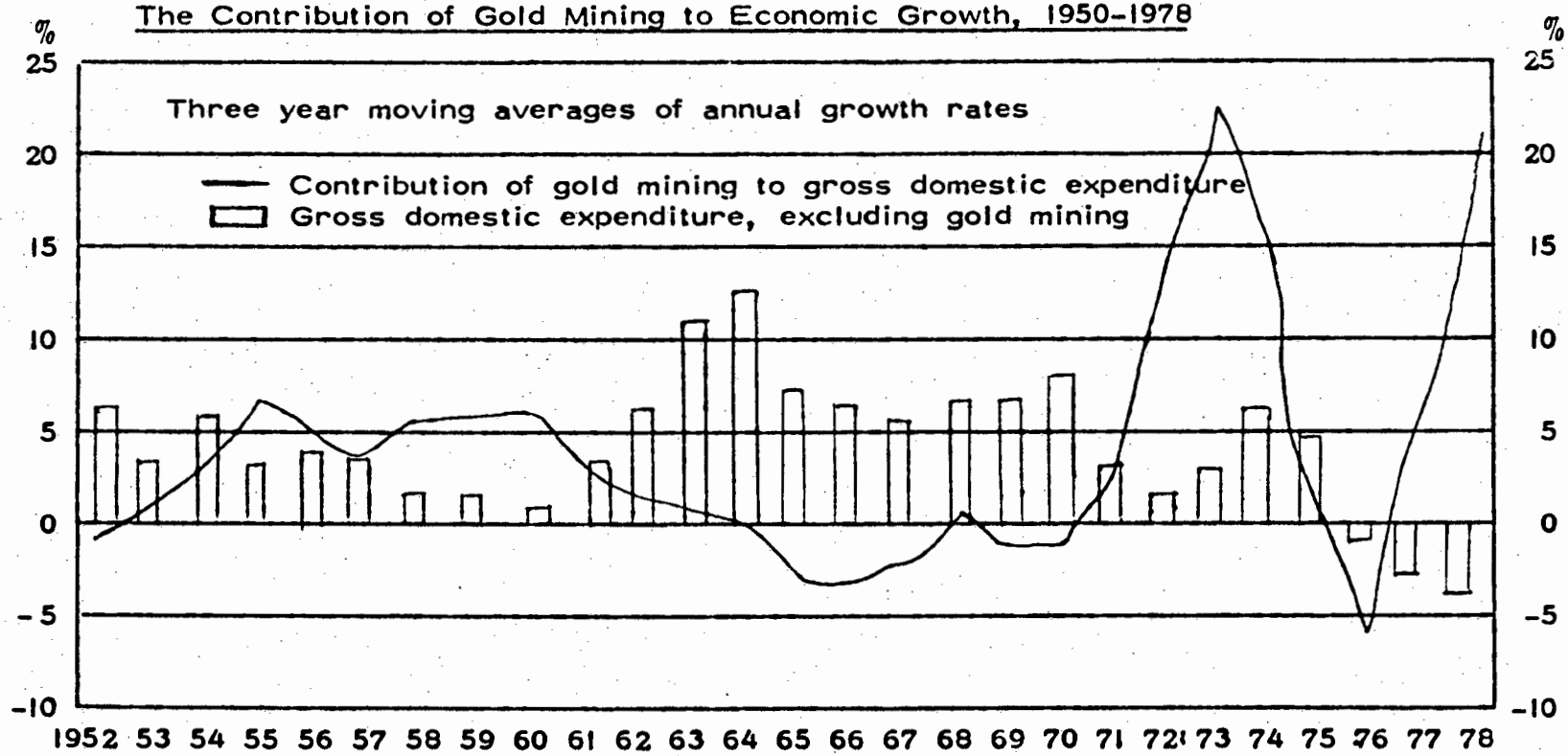


Fig. 5.4

The time trend of annual growth rates in the contribution of gold mining to domestic expenditure, correlated with the trend of the growth rates in total domestic expenditure excluding the contribution of gold mining, suggests some lagged functional relationship, between expansion in gold mining and expansion in the rest of the economy.

Source: Based on data obtained from the Quarterly Bulletin of the S.A. Reserve Bank.

system now in operation is one of a "managed float" rather than freely floating exchange rates. Under a system of fixed exchange rates there exists a more or less automatic link between increases in world prices and increases in rand prices.

Because South Africa buys and sells as much as 30% of her G.D.P. on world markets, assuming no change in the rand value of the dollar, prices in South Africa must rise at roughly the same rate if selling to and producing for the domestic market is to remain competitive with foreign markets. It is only by means of an appreciating exchange rate that a country may avoid the average rate of inflation of its trading partners. Under fixed exchange rates, monetary and fiscal policy become balance of payments dependent, i.e. when the balance of payments is favourable and central banks accumulate foreign exchange reserves and the banks' additional cash reserves, the money supply grows at a faster rate. Interest rates may come down and the fiscal authorities may be encouraged to spend more and tax less.

Under a policy of floating exchange rates, a country can run its monetary and fiscal policy independent of the balance of payments. The supply and demand for foreign exchange is equalised by changes in the rate of exchange as determined in the foreign exchange markets.

The Authorities set their monetary and fiscal policies and the exchange markets establish the rate of exchange consistent with these policies. Until the De Kock Commission, South Africa operated a highly balance of payments dependent monetary policy.[27] What has happened since the recommendations made by the Commission will be briefly described

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27. See Kantor, B., "S.A. Monetary Policy after the De Kock Commission", U.C.T., Cape Town, 1979, pp.1-5

The gold price and costs, 1971-1979

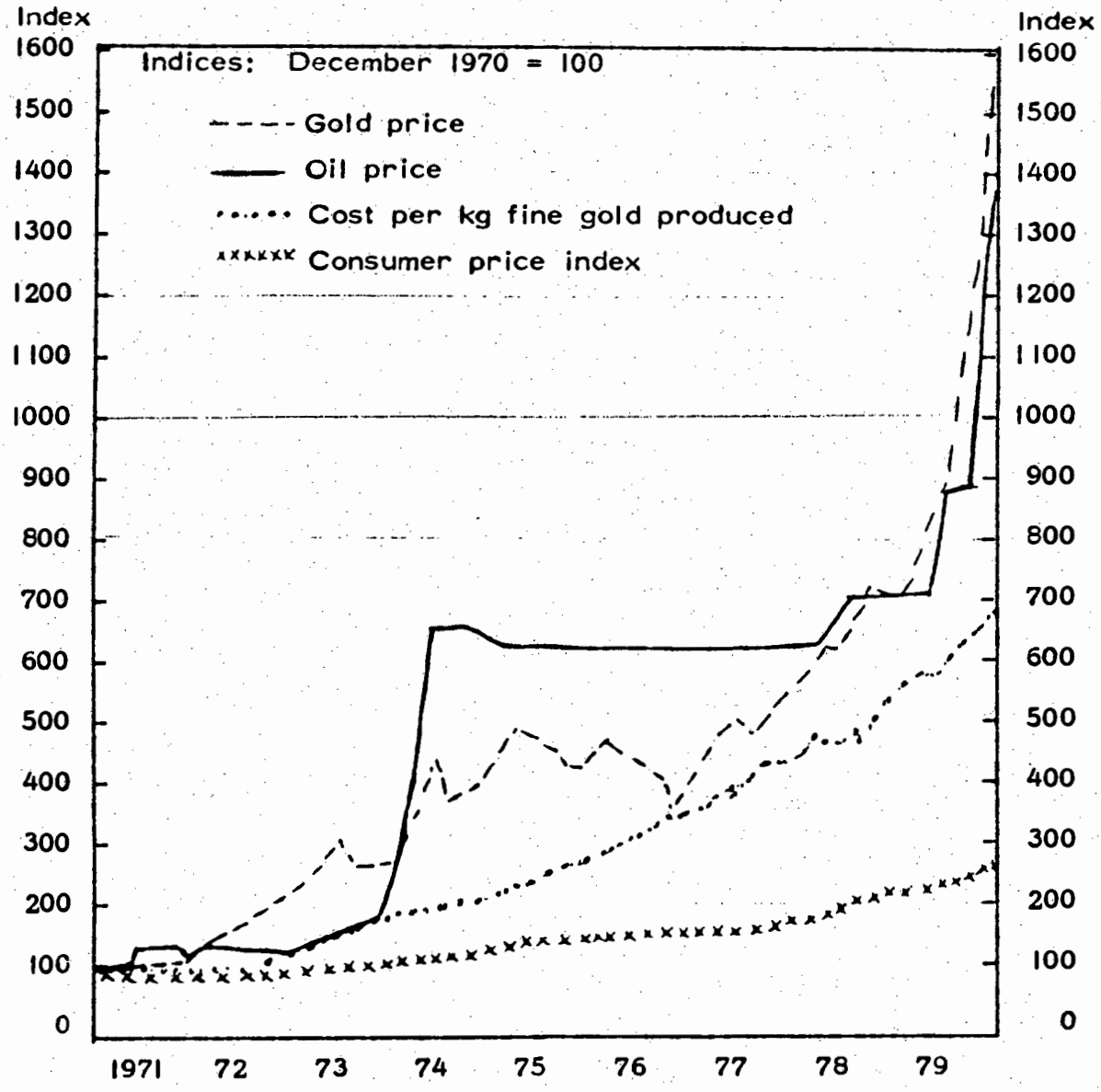

Fig. 5.5

On balance the gold mining industry was not adversely affected by the domestic and international inflation of prices and costs in the nineteen seventies. Unit cost of gold production increased much less than the price of gold. Moreover, gold being the main export commodity of South Africa, its price explosion enabled the country as a whole to withstand the impact of the oil price hikes since 1973. After the first quarter of 1973 the price of oil increased almost four-fold in less than a year. The price of gold only caught up with this rise by the middle of 1978. Since then the rise in the gold price has been somewhat faster. It should, however, be noted that the value of gold exports is considerably larger than the cost of oil imports.

Source: S.A. Reserve Bank, Quarterly Bulletin, Chamber of Mines and unpublished data supplied by the Chamber.

here.

The price of gold declined from an average of $613 per ounce in 1980 to one of $460 per ounce in 1981 and an average so far this year (1982) of $364 per ounce. In view of the depreciation of the rand in terms of the U.S. dollar since January 1981, the price of gold expressed in rands has naturally declined by much less than the dollar price over this period. Thus, compared with the decline of 25% in the average dollar price of gold between 1980 and 1981 the rand price declined by only 16 percent.

Similarly, compared with the further decline of 21 percent in the dollar price of gold between the end of 1981 and 19 March 1982, the rand price declined by only 14½ percent. The depreciation of the rand has, therefore, softened the impact of the gold price decline on the South African gold mining industry and the economy in general.

Despite this cushioning effect, however, the rand value of South Africa's net gold output still declined; other exports were adversely affected by the stagnant conditions in world markets and imports, as a direct result of buoyancy in the domestic economy, increased by 28 percent in value and 15 percent in volume.

The net effect of these and other changes was that the surplus of R2,8 billion on the current account of the balance of payments in 1980 was transformed into a deficit of nearly R4 billion in 1981.

Although South Africa's present balance of payments difficulties stem predominantly from the decline in the gold price and other external

developments, they must also be attributed to the inordinate rise in total monetary demand during 1980 and 1981. Under the impact of the huge increase in gold earnings, this rise in turn was fuelled by an excessive rate of increase in the broadly defined money supply (M_2) which accelerated from an annual rate of 17 percent in the first quarter of 1980 to 46 percent in the first quarter of 1981.

The basic cause of this monetary expansion was the co-existence of a large surplus on the balance of payments current account and exchange control. Exchange control measures artifically trap money within the country's borders - money which would normally flow to areas outside the country where it could earn the highest return, thus easing internal problems of excess liquidity. Furthermore, during 1980, since the inauguration of the managed float, despite current account surplusses, De Jongh, past governor of the Reserve Bank, refused to allow the rand to appreciate. Thus it seemed apparent that the opportunity provided by the De Kock Commission to break the dependence of the money supply on the balance of payments was being forsaken. Furthermore, the rise in the money supply brought about an increase in the cash reserves and other liquid assets of the banks, which later enabled them to create large amounts of money by-expanding their credit to the private sector.

A further consequence of this situation was the sharp decline of interest rates during 1979 and throughout the first three-quarters of 1980.

From October 1980, however, following the abolition of credit ceilings, the declining tendency of the gold price and the downward trend in the net gold and other foreign reserves, the monetary and interest

rate situation began to change fundamentally - a process which has continued up to the present. The present governor of the Reserve Bank, De Kock, has been committed to a policy of slowing down the rate of increase in the money supply and has met with a fair amount of success in this endeavour.

5.5. Conclusion

In order to help stabilise the economy, when the gold price rises we should avoid rapid accelerations in money supply growth. When the gold price falls, we should be able to avoid a rapid fall in money supply growth. However, we did not avoid a rapid increase in the money supply in 1980 and early 1981. Since then, money supply growth has slowed down considerably, although it picked up somewhat in the final quarter of 1981.

Under the prevailing monetary policy arrangements, the Reserve Bank is made responsible for determining the spot and forward exchange rates and, therefore, by implication of interest parity, the levels of short term interest rates in South Africa are also Reserve-Bank determined. For close control of the money supply as well as interest and exchange rates, the Reserve Bank would have to be able to forecast precisely the demands for credit at the chosen interest rate, which it is unable to do.

At present, monetary reforms have only resulted in a closer relationship between different short term interest rates. Without market determined exchange rates, interest rates cannot be determined by the market either. Without a true market in foreign exchange and credit South Africa will not achieve appropriate and consistent money supply objectives.

The level of short term interest rates in South Africa will, therefore, continue to depend upon the Reserve Bank's view of the balance of payments. South African interest rates will remain high relative to foreign interest rates for as long as the balance of payments remains in substantial deficit.

During the course of 1982, the South African economy will come to make adjustments to the lower gold price, the balance of payments deficit and the high interest rates. Slower money supply growth will cause a decline in real domestic expenditure growth.

The lower exchange rate will help relieve the pressure on the gold mines, balance of payments and interest rates. This does, however, imply little relief from inflation, even though the trend in World Inflation rates is, at present, downwards.

CHAPTER 6

GOVERNMENT INTERVENTION

IN THE

GOLD MINING INDUSTRY

6.1 Introduction

Extractive mineral deposits fall into the category of resources which have the character of a fixed stock that is non-replenishable in its existing form. Therefore, every act of consumption of these stock resources means that there is less remaining for future use. Minerals, such as gold and platinum, can be classified differently by speculators and mine owners. From the point of view of speculators and other holders of gold, this mineral can be regarded as an everlasting asset in that it is not destroyed in consumption (unlike oil and coal). However, from the point of view of mine owners and the state, gold is classified as a wasting asset which is non-renewable in its existing form. Every act of extraction means that reserves are continuously depleted. The potential depletion of these resources gives rise to the need to consider whether market forces are leading to an exploitation of these resources which is too rapid for the good of future generations and whether there is a need for government interference to make greater provision for the future.

As the former problem has already been dealt with, attention will now be addressed to the latter issue, viz. government intervention in the gold mining industry. In this chapter, the various regulatory mechanisms adopted by the government (leases, subsidies and taxation) will be examined from both theoretical and practical points of view. The aims of government intervention and its effect through time on optimal resource allocation will also be considered. The concern of conservationists has been that the free market is exploiting resources too fast and that the price has been too low. Thus the full social costs have not been borne by producers and consumers in the current generation.

In theory, perfectly competitive markets support socially optimal extraction patters. In practice, capital markets are asymmetric and mineral markets are predominantly monopolistic or oligopolistic. The theory of monopoly suggests that a monopolist will tend to restrict output and charge a price higher than the perfectly competitive price. Weinstein and Zeckhauser conclude that "there would seem to be no implication that in the second best situation the imperfect market processes lead to too rapid a rate of resource consumption, or that government regulation would bring about a more efficient rate of utilisation."[1]

While individual mine owners may be criticised for not taking a long enough view of the future, there is no reason to suggest that the political process can be relied on to be more future-orientated than the average corporation. However, this criticism is irrelevant given the capital nature of minerals, unless mine owners consume their profits and do not reinvest sufficient in the stock of reproducible capital. A tax on profits would serve the purpose of increasing investment and thus correcting any divergence between private and social interests, only if the government earmarked this revenue for investment. In the taxation of South African extractive industries this has not occurred. Furthermore, a tax on dividends may be a more direct way of dealing with this divergence between private and social interests.

6.2 Property Rights and Mineral Resources

Property Rights are understood to be the sanctioned behavioural

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1. Weinstein & Zeckhauser, "Use Patterns for Depletable and Recyclable Resources", RES Symposium, 1974, p.87

relations among men that arise from the existence of goods and pertain to their use. What, then, are the respective public and private claims in regard to the economic potentialities of natural resource endowments? On equity grounds, there can be no purely objective criteria for arriving at conclusions. As a legal matter, most nations separate surface rights and mineral rights, with the latter being retained by the nation.

But within the boundaries of an individual nation, the legal arrangements may be of controlling importance. Since the earth's crust is opaque, exploration of minerals will not occur in those nations which retain subsurface mineral rights unless it is done by the state (directly or under contract) or unless incentives are given to private agents, such as discovery bounties, concessions conditioned on royalty payments, or permission to purchase mineral resources directly.

In nations where surface and subsurface rights can be purchased jointly by private citizens, ignorance of the existence of mineral deposits will usually result in placing a price near to zero for such deposits. Subsequent discovery of minerals will create windfall gains for property owners, particularly if they employ none of their own resources in making the discovery. But, if individuals purchase land within which the likelihood of the discovery of minerals is considered high, part of the land payment will explicitly or implicitly cover mineral rights. In such cases where mineral rights are purchased at their market value, there may be a stronger case in equity for allowing the land buyer (not the original seller) to receive the income from minerals exploitation. But the position of landowners and prospectors is quite different, except in the rare case where the

same individual serves in both capacities.

Property rights may lead to externalities, in the case of minerals to the extent that "ownership is a trust in a long sequence of ownerships from generation to generation for the good of the whole race for all time".[2]

Since the resources are relatively divisible into independent productive units, where mineral rights are the property of the state and are leased to the mining companies, the full social cost can be covered by leasing to the highest bidder.

6.3 Natural Resource Taxation: Resource Allocation and Distribution Implications.

How should extractive industries be taxed? This question is, of course, merely a part of the more fundamental question regarding the general problem of taxing all economic agents in such a way as to implement a wide range of public policy goals. These goals presumably include concern for neutrality in resource allocation and equity in income distribution, but may also extend to partially conflicting goals such as economic growth, conservation and security. But certain of the characteristics of extractive industries are such as to warrant particular study of the probable consequences of various tax policies.

On efficiency grounds, there might seem to be a plausible case for confiscatory taxation of all revenues from exploitation of minerals in excess of the supply price of the necessary productive factors.

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2. Parkins & Whitaker: Our Natural Resources and their Conservation, John Wiley, London 1936. p.434

And, under highly restrictive conditions, such a case can be made.

Assuming perfect competition, perfect foresight, homogeneous capital, mineral lands of heterogeneous quality, and complete knowledge of the location, extent and extraction costs of all minerals, then it follows that if tastes, technology and resources are given as of a point in time, the output of an economy can be maximised by the elimination of rents and quasi-rents and the consequent payment to all factors of production of no more than their competitive supply price.

Rents and quasi rents would be taxed away in full and the proceeds used by the state to employ factors at competitive supply prices to perform public services.

Assuming that these restrictive assumptions were met with, the interests of economic efficiency would be served, in that production from a given set of inputs would be maximised.

On equity grounds, many welfare economists would prefer an income distribution which is not influenced by windfall gains from mineral discoveries, but instead depends solely upon the amounts of factor services supplied at competitive rates.

But there is a very great difference between this abstract model and the world around us. There are a number of factors to be considered: the distinction between pure Ricardian rent and the various returns to mineral exploitation, the absence of perfect knowledge and foresight, the imperfection of competition in many markets, and the fact that established land tenure systems may create situations in which

economic efficiency may be achieved only at the cost of disruptions and possible inequities.

6.3.1 Rents and Returns to mineral exploitation.

When examining the issue of mining taxation it is essential to determine the tax paying capacity of the various incomes received from mineral production (i.e. operating company net profits, lease bonuses, lease rentals and royalties) and how they differ from pure Ricardian rent.

On one point we may be perfectly clear: Ricardo himself has emphasised that payments of the former type are not in the nature of Ricardian rent, which refers only to payments for the use of the "original and indestructible powers of the soil". Such powers are non-depletable and non-augmentable, whereas individual mineral deposits are by definition depletable, and the total supply is usually augmentable or renewable in some degree through further exploration efforts.

From the standpoint of economic efficiency the tax paying capacity of pure Ricardian rents is such that they may in principle be confiscated in full, although on equity grounds this may discriminate against current landholders who have paid prices for land which reflect the capitalised value of expected future rents.

In a world of ignorance, uncertainty and lack of foresight, the tax paying capacity of mineral deposits must surely be reduced. In fact, the various elements of net income from mining are more akin to Alfred Marshall's definition of "quasi-rent". These quasi-rents accrue

to owners of supramarginal factors whenever higher cost marginal factors determine the equilibrium price. But in contrast to Ricardian rent where such incomes may be received in perpetuity by a factor in absolutely fixed supply, mineral quasi-rents represent a sort of per-unit liquidating dividend, the receipt of each instalment of which reduced the stock of resources which ultimately yield up the total quasi-rent.

About 50 years ago there was a controversy[3] in this area which is of relevance here. The question was asked: How much of the net return to mineral extraction should be regarded as the rent of the land and how much as the return on capital invested? Orthodox marginal analysis would suggest that, given a purely competitive capital market (and in the absence of differential risk), the imputed rate of return on capital invested in the mine would be equal to the market interest rate. Hence a sum equal to the product of this rate and the amount of capital invested would represent the equilibrium return to capital. The surplus of net returns above this imputed interest return would represent rent.

But in the short run, all revenues above current outlays for operations are quasi-rents, whether imputed to capital or land. If part of these quasi-rents are to be imputed to capital in the manner suggested above, this treatment will not produce an imputation of factor returns which is consistent with long run equilibrium unless it is assumed that the same amount of capital as that which forms the basis for the interest-income computation can be readily reinvested in such a way as to duplicate the original mining operation when the reserves of the initial mine are exhausted. However, this may not be true.

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3. Gray, L.C.; "Rent under the Assumption of Exhaustibility", Quarterly Review of Economics, 28 (May 1914), pp.464-489

If exploration risk is present, such that more funds need be spent in searching for new mine sites than can be attributed directly to those sites actually discovered, then the interest return to the total capital actually necessary to insure operation of mining facilities as going concerns is understated, and the rent to land is overstated. In such circumstances, if depleted properties are to be replaced, some of this "rent" to land must be used to provide the needed capital.

To avoid understating the implicit return to capital necessary to accomplish replacement, the return must be computed either by the use of a higher total capital investment cost, reflecting the costs of the unsuccessful as well as the successful ventures necessary to discover a given volume of reserves or the actual outlays must be multiplied by a higher rate of return, reflecting the risk of mining investment.

The issue of replacement costs does not seem to have entered directly into the controversy. There was, however, some feeling that either capital costs, or the value of the minerals in place, ought to be recovered through a royalty which would be an appropriate reduction from the total surplus of receipts above current outlays. These royalties would be implicit royalties to mine owner operators, the receipt of which would be necessary to maintain capital intact. Such implicit royalties differ in nature from the explicit royalties which may be received by landowners. If a mine operator merely obtained his right to work a given mine by payment of an equilibrium royalty equivalent to the excess of unit revenues over the competitive supply price for the service he supplied, the question remains: What is the status of the income to the recipient of the royalty (or lease payment)?

And if the recipient of the royalty bought his land at a price reflecting the capitalised value of minerals in place, what was the status of his payment to the original landholder? It is apparent that at some point a landholder has received a windfall gain because of the discovery of mineral deposits, the extent of which was capable of ascertainment. Such quasi-rents which accrue to wholly passive landholders who make no contribution to minerals exploration or production could, on efficiency grounds, be taxed away without resource misallocation.

Under conditions of uncertainty regarding location, extraction costs and extent of mineral deposits, resources are likely to be located by prospectors and acquired at lower average prices. In many cases, the prospector may suffer heavy losses, but a few lucky prospectors may receive very large quasi-rents which greatly exceed the moderate receipts of the landholder.

How much of the prospector's quasi-rent may be taxed away without adverse effects on resource allocation? This depends on the need for further exploratory effort. Paradoxically, if the prospector has unearthed an absolutely inexhaustible deposit, his quasi-rents might be completely confiscated. But if the costs and difficulties of exploration are very great, and the deposits discovered relatively few and soon depleted, the insuring of adequate supply may require not only the exemption of quasi-rents from taxation, but in some cases the payment of actual subsidies. One could then agree with Marshall that quasi-rents have a positive effect on the allocation of resources especially in risky pursuits.[4]

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4. Marshall, A.; Principle of Economics, 8th ed., Macmillan & Co., New York, 1920, p.424

Quasi-rents earned by a few individuals will attract possibly less competent people into these fields. It is only necessary that the size of the inducement be commensurate with the need for additional supply, and that the receipt of such inducements be limited to those who actually participate in efforts to increase supply. Hence, no general case can be made for the confiscatory taxation of the quasi-rents of mineral prospectors on the grounds of efficiency.

Even the case for confiscatory taxation of landowners' royalties is qualified when the existence of risk, uncertainty and ignorance are recognised. If prospectors are allowed to retain the bulk of their mineral quasi-rents, while those of landowners are taxed away in full, it can readily be predicted that landholders will soon organise to conduct exploration operations of their own lands. This may entail some loss in efficiency, to the extent that it removes this function from experienced specialists and transfers it to the initially inexperienced. This argument applies only if taxation is completely confiscatory in the tradition of Henry George. Less than confiscatory rates may present inefficiencies from arising, but this in turn will compromise the equity basis for such taxation.

6.3.2 "Ideal"[5] Basic Principles in Mining Taxation

i) The first basic principle is that all expenditures (capital and working costs) incurred directly or indirectly for mining purposes should be allowed for tax purposes. There is no valid reason why the cost of necessary surface rights and of mineral rights should not be deducted directly or indirectly through allowances. It might be

5. The word "ideal" is perhaps misleading. The tax system advocated here may be ideal from the company point of view and possibly the industry point of view, but it may be less than ideal from a taxpayer or a public-interest point of view.

appropriate to add that this principle does not justify allowance of anything more than cost.

ii) Secondly, it should be recognised that, in mining, the distinction between capital expenditure (usually allowed via depreciation or redemption allowances) and current working costs (immediately deductible) is largely artificial. A mine, unlike other industries, does not have an unlimited life and, furthermore, its life always remains of uncertain duration and its profit expectations highly risky and largely outside its control. Whereas the logical time account for other industries can be accepted as a year, the only true time account for a mine should cover its whole life and in such an account the cost of all capital work and equipment would be items of working expenditure. There is justification, therefore, not only for allowing all mine capital expenditure immediately as and when incurred, but also for the carrying backward of losses incurred in any year, so that past tax payments can be refunded when operations turn unsuccessful. Any loss not used up in this way will then be carried forward as allowed as present. (This might be coupled with similar carry backward-and-forward provisions for profits just to keep the taxpayer and tax collector on an equal footing).

iii) Thirdly, in view of the direct and indirect benefits of mining to the State (economic and strategic), the State should ensure that, as far as possible, taxation does not raise the current cost of production and hence the operating mine cut-off grade; if this is not done, the exploitation of ores or new mines will be rendered uneconomic.

It is often contended that these requirements, together with those

ensuring the encouragement of new investment in a sector subject to high risk, can best be met by special allowances on gross revenue (e.g. the U.S.A. depletion allowances and the South African tax formula) and on capital expenditure (e.g. investment allowances on new capital expenditure, or a compound-interest allowance on unredeemed capital expenditure, as for new South African gold mines).

However, I see no way of deriving from the legitimate assertion that operating costs chould not be raised by taxation, the dubious conclusion that this principle can best be met by special allowances on gross revenue. Percentage depletion allowances may compensate for risk, but it is arguable that in so doing they err in the opposite direction; that is, they unduly lower marginal costs and, therefore, encourage inefficient investment and production.

iv) Finally, the tax rate for mines should not exceed that of other industries (at least extractive industries). In terms of effective rates (taxes paid in relation to income), this principle is sound, but neither should effective rates be lower, and there are indications that this is in fact the case in some countries today.[6] More attention is devoted to this contentious issue in the next section.

6.4 Taxation of South African Gold Mines

6.4.1 The Aims of the State

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6. See Bucovetsky, M.W.; "The Taxation of Mineral Extraction", No. 8 in the Studies of the Royal Commission on Taxation, Queen's Printer, Ottawa, 1966. See also the considerable testimony concerning oil and gas presented at the Hearings of the Antitrust and Monopoly Subcommittee of the United States Senate in the Spring of 1970.

The concern about the future of gold in South Africa lies in the fact that the industry provides employment for a large number of workers and that gold is a valuable source of foreign exchange. The price of gold has also become increasingly affected by political as well as economic factors.

The government has thus undertaken a duty to ensure that the life of mines is extended as far as possible and that secondary industry is developed to take the place of gold mines in providing employment on the decline of the gold mines. The Holloway Committee (1946) described the principle of government intervention as follows: "As representative of the community, the State has the duty of ensuring that the natural endowment in a wasting asset is not exploited in such a way that the community is left in an impoverished condition when the mineral resources have been exhausted. It is the duty of the State to prevent the dissipation of the country's patrimony."[7]

Furthermore, the Committee stated that "any action which depresses gold deposits below the pay limit deprives the country of its natural assets, reduces its capacity for employment and has the same effect as living on capital."[8]

With regard to taxation, the Holloway Committee explained: "We are concerned with the question of the share of the tax burden which can reasonably be imposed on the wealth producing capacity of the country's gold endowment without, in an almost literal sense, killing the goose that lays the golden eggs ..... we are, therefore, of the

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7. Report of the Committee on Gold Mining Taxation (Holloway) UG 16/1946, para. 125(c).

8. Holloway Report, p.3, para. 8.

opinion that, wherever possible, taxes which increase costs should be repealed and where it is necessary to recover the same amount of revenue this should be raised from taxes falling on profits."[9]

The wasting assets theory is more forcibly stated and becomes a a matter of principle in paragraph 129 of the Report which states "that it would be wrong in principle for the State to limit its taxation of the surplus product of a wasting asset to the same level as it extracts from industries with a more or less indefinite life." Thus the Inter-departmental Committee concluded that the fundamental consideration governing special taxation is whether an activity is a "wasting" activity.

Up until 1946, the main arguments supporting the special rate of tax for the gold mines dealt either with the "unearned" character of natural resources or with a fortuitous happening. It was significant that both the Inter-departmental Committee and the Social and Economic Planning Council rejected these arguments in their entirety. The Inter-departmental Committee, however, replaced these with a new argument - the wasting asset theory.

However, the Committee made no real attempt to define a "wasting asset" and in paragraph 131 of its Report, it shifted the argument in a direction which served further to confuse rather than clarify the position. In this paragraph, the Committee attempted to justify an abnormal tax rate, not on the grounds that mining income is derived from a "wasting asset" but on the grounds that such income is a "residue over the necessary costs in the wider sense."

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9. Holloway Report, p.3, para. 9

Perhaps the Committee's conception of the wasting asset theory can be stated thus:-

If a country is largely dependent on a mineral deposit for its existing prosperity then, unless it is prepared to face a cataclysmic fall in its standard of living when that mineral is exhausted, it must establish alternative sources of living. South Africa must, therefore, transmute its gold resources into capital works like dams, roads, educational facilities and the like. These arguments do not apply to farming because that goes on indefinitely; nor do they apply in such force to coal and diamonds because the country is not so dependent on them as it is on gold. If gold extraction is dealt with on the same basis as other activities and merely subjected to the ordinary tax rate, when the gold mines are worked out, there will be nothing to show for them but some holes in the ground.

There is force in this argument. It is, in fact, the basis of the Gold Law under which the State expropriates 75 per cent of all proclaimed land and places the proceeds to the Loan Account through which capital works are financed. Taxation of the industry has increased so greatly that the yield from this 75 per cent expropriation - and hence the amounts which have been made available for capital works - is fractional compared with the tax yield which is utilised for the ordinary administration of the country.

In 1945, of a total revenue of £18,412,000 from gold mining, less than £2,415,000 was placed to Loan Account.[10] In other words, the transmutation of gold resources into capital works was, and still is to an extent, theoretical.

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10. Holloway Report, p.4, para 14.

From this standpoint, then, the wasting assets theory is in direct conflict with a high rate of gold mining taxation because high taxation may result in the diversion of gold mining profits from the Loan Account to current expenditure. Furthermore, high taxation has the effect of causing prospects which would otherwise be payable to be written off; so that from this aspect, too, the wasting assets theory supports low taxation.

The argument that extra taxation is justified on the grounds that gold is a wasting asset and that the national capital should be maintained would only be valid if it could be shown that the shareholders of the gold mining companies were not in fact maintaining the country's capital intact and if the proceeds of the extra taxation were used for capital investment. On these conditions, discriminatory taxation may be justified but it is doubtful whether an inequitable tax should be based on such questionable assumptions. Furthermore, the effect of discriminatory taxation on the future volume of new investment from abroad should not be forgotten.

While the Committee's contention may be true, provided that the revenue is channelled into the development of industry, the different rates of taxation on gold mines and on other extractive industries cannot be justified. In the taxation of South African extractive industries the former has not occurred - taxes paid in excess of the rates of company tax have not been placed in a separate fund for investment purposes. They have been placed in a general revenue fund.

Furthermore, the State has undertaken to ensure that mine owners do not "pick the eyes of the mines" by extracting only the high-grade

ores nearer the surface and then closing the mine leaving the high-cost ores behind. Once a gold mine is closed, it cannot be readily re-opened. The regulatory mechanisms that have been adopted by the Government have been the terms on which mineral leases are granted and the taxation of gold mining profits.

6.4.2.1 Structure of Lease and Tax Payments

A gold mine's direct contribution to the State is determined in two ways, i.e. lease and tax. The lease formula which is the State's first participation in profits is determined when the entrepreneur initially applies for a lease area. The tax formula determines the State's second participation in profits. (For revenues from S.A. Gold Mining Taxation, see Table 6.1 and Fig. 6.1)

By the Mining Taxation Act No. 6 of 1910, mineral leases and taxation were governed by the ratio of profit to recovery. The lower the grade of ore extracted, the lower the rate of recovery of gold from the ore and the lower the payment to the government.

Mineral leases $$y = a - \frac{b}{x}$$

Income Tax $$y = c - \frac{d}{x}$$

where y = % profits payable to government

x = ratio of profit to average recovery expressed as a percentage

a, b, c and d are constants. a and b vary from mine to mine. a and b were fixed in the leasing agreements such that the lessor was the highest bidder in terms of sharing profits with the state.

Year	Gold Mining Tax & Lease Payment R m.	Total Revenue R m.	Gold Mining Revenues as % of Total Revenues
1973-74	456	4162	11,0
1974-75	757	4916	15,4
1975-76	641	5626	11,4
1976-77	408	6196	6,6
1977-78	448	7054	6,4
1978-79	862	8181	10,5
1979-80	1501	9882	15,2
1980-81	3633	13388	27,1
1981-82*	2400*	15858	15,1*

* estimated.

Table 6.1

Source: Chamber of Mines Annual Reports, S.A. Reserve Bank Quarterly Bulletins

Government Revenue from Gold Mining
1971-1979

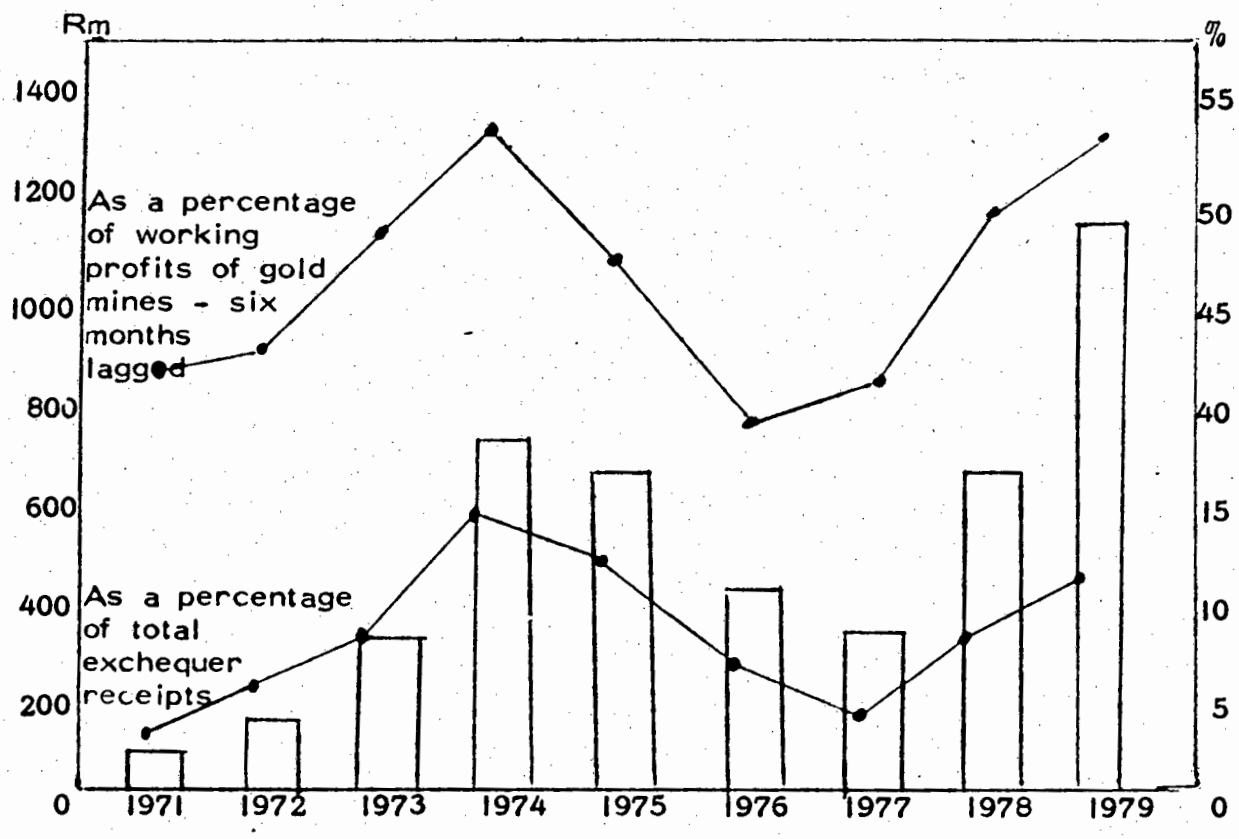

Fig. 6.1

Source: Based on data supplied by the Department of Inland Revenue, the S.A. Reserve Bank and the Chamber of Mines.

Since 1936, gold mining tax has been determined by a sliding scale formula. Up to 1945, the basic tax was 15% plus the formula of

$$y = 40 - \frac{500}{x}$$

In 1946, following the Holloway Report, the basic tax was discontinued and total tax was determined by the formula

$$y = 70 - \frac{420}{x}$$

X became the ratio of profit to gross revenue expressed as a percentage. The minimum ratio of profit to recovery was fixed at 6% so that each mine was forced to work its average grade by law. c and d were fixed such that the tax payable by gold mines far exceeded tax payable by other companies - this persists today (see Table 6.2).

The form of this formula has basically remained the same but has been changed as follows:-

1947 $y = 63 - \frac{378}{x}$

1948/50 $y = 60 - \frac{360}{x}$

1951/55 $y = 63 - \frac{378}{x}$

1956/65 $y = 60 - \frac{360}{x}$

1966/82 $y = 60 - \frac{360}{x}$ + 5 per cent surcharge

and $y = 60 - \frac{480}{x}$ for post 1966 mines

Changes in the S.A. tax system have placed mines into 4 categories.

1) Old mines prior to February 28th, 1946.

2) Mines between 1st March 1946 and 1st August, 1966.

3) New mines post August, 1966.

4) State Assisted mines.

Formulae in operation as of February, 1982.[11]

1) Lease $y = 15 - 90/x_1$

2) Income Tax $y = 60 - 360/x_2$ (Pre 1967)

x_1 = ratio of profit (less redemption allowance) to revenue as percentage.

x_2 = ratio of profit (less lease payment and less redemption allowance) to revenue.

There is also a 5% surcharge added to income tax.[12]

Additional non-mining income is taxed at the company rate of 40% + 5% surcharge.[13]

Other Categories

1. Old Mines: unless classed as a deep level mine or receiving State aid, these mines are now treated on the same basis as the Income Tax example above as a result of changes in the 1973 budget.

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11. Mining Journal, Quarterly Review of S.A. Gold Shares, February 1982, Vol. 25, No. 4.

12. This has been increased to a surcharge of 15% as a result of the 1982/83 Budget proposals (March 1982).

13. Also included in the 1982/83 Budget proposals was an increase in company taxes to a basic rate of 42% + 5% surcharge + 10% loan levy, thus increasing the effective tax rate from 42% to 46,2%. (See Table 6.2)

COMPANY TAX 1974 - 1983

Financial Years ending during Year ended	Basic Tax %	Surcharge %	Loan Levy %	Total %
31.3.74	40	1	2	43
31.3.75	40	1	1	42
31.3.76	40	1	2	43
31.3.77	40	3	6	49
31.3.78	40	3	6	49
31.3.79	40	2	6	48
31.3.80	40	2	4	46
31.3.81	40	2	0	42
31.3.82	40	2	0	42
31.3.83	42	4,2	0	46,2

Table 6.2

Source: Cape Times, April 3rd, 1982, p.22

2. New Mines: For any post 1966 mine, taxation is based on

$$y = 60 - \frac{480}{x} + 5\% \text{ surcharge.}$$

(viz. East Driefontein, Randfontein, Deelkraal, Elandsrand, Unisel and Ergo.)

3. State Assisted Mines:

$$y = 68 - 601/x$$

If x is less than 8.84% then y becomes negative and assistance is payable to the mine. There is no surcharge.

In all the above cases the 10% loan levy has been done away with. (For a worked example of lease and tax payments according to the formulae, see Appendix A. For taxation and lease formulae for individual mines, see Appendix B.)

6.4.2.2 Basis for Gold Mine Taxation

1) Taxable Income (gold mining)

Taxable Income for gold mining is income derived from gold mining less the following deductions:

a) Expenditure actually incurred in the production of income (working costs including lease payments).

b) Capital Expenditure Redemption Allowance.

2. Capital Expenditure Redemption Allowance

In the case of gold mines which were granted leases or were established prior to 28th February 1946, the capital redemption

allowance was calculated by either dividing the unredeemed balance of capital expenditure by the life of the mine or by taking 26,5% of the balance, whichever gave the greater amount. This meant that there was always an unredeemed balance.

According to Act 65 of 1973, a "transition year" was defined as the first tax year ending after 31st December 1973. Where a mine commenced production before the beginning of the transition year, the balance was to be redeemed in equal amounts over the life of the mine or five years, or four years in the case of a gold mine, whichever was the shorter period, respectively.

In the case of diamond mines and "new gold mines" (after 1946), all capital expenditure up to the close of the first year of production was allowed to be deducted from income in that year and thereafter the expenditure incurred during each succeeding year.

These deductions are in lieu of wear and tear of machinery etc. and payments for the use of patents, land, buildings, expertise, machinery etc.

The sum of any amounts received from the sale of assets, the cost of which has previously been recognised as capital expenditure, must be deducted from the capital expenditure incurred in the year in which the sale takes place.

6.5 A qualitative Analysis of the Effects of South African gold mining taxation and leasing policies on optimal extraction patterns.

South African governments, early on in the life of the gold mining

industry, developed a specialised leasing system of considerable economic significance. The system was established under the Transvaal Act No. 35 of 1908 and by Act No. 30 of 1918 the mineral leases board was made a Statutory Body.

This system is in effect a method of leasing the right to exploit gold resources to the highest bidder. Under this system the state assumes the rights of a shareholder in sharing in profits, but makes no contribution to capital expenditure for developing mines or for new exploration and prospecting.

The objectives of the system, which were apparently intended to obtain for the state the inherent rental value of the mineral deposits, were based on confusion as to the economic nature of this "rent". The system failed to distinguish between "pure" Ricardian rents and quasi-rents, a question which I have already discussed (see Section 6.3.1.). The system, therefore, did not take sufficient account of the effects on the supply of capital for new exploration activities.

With the imposition of much higher rates of income taxation on gold mines than were envisaged when the system was first inaugurated, and with the increasing costs and risks of developing new mines at increased depths, the share of profits which bidders could afford to pay to the state for new leases has shown an overall decline as the proportion of profits taken by the state has increased.

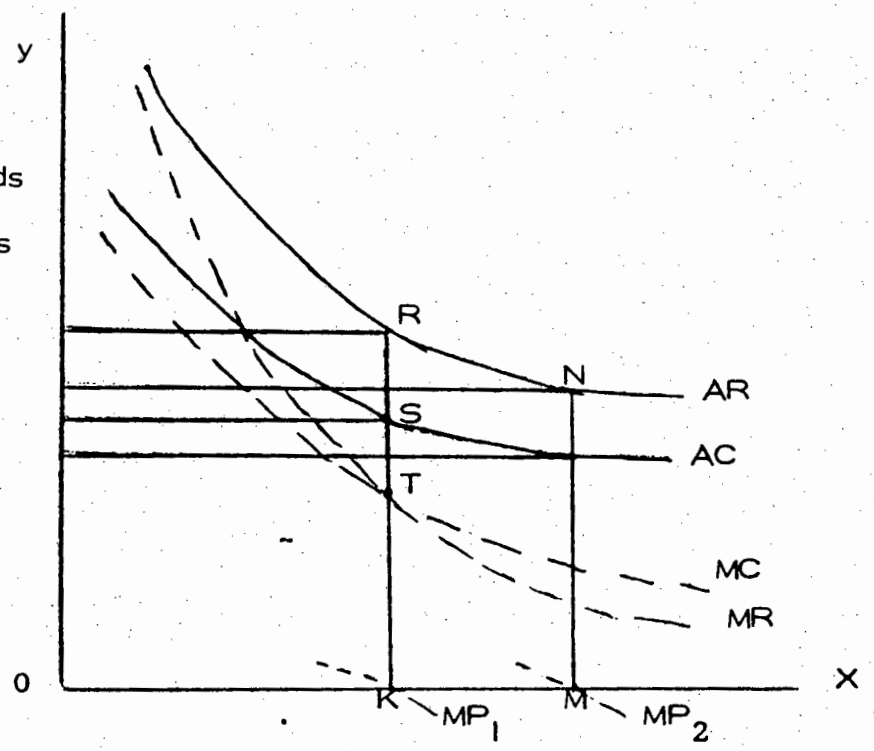
The general form of sliding scale adopted in these mining leases is $Y = a - \frac{b}{x}$, where y is the percentage of profits payable to the government, x is the ratio of profit to recovery expressed as a percentage and a and b are constants agreed to in the

lease. This type of formula has remained in force since then with only slight variations as discussed previously.

One of the general effects of this type of formula is to induce the producer to lower the grade of ore per ton which is milled. This is regarded as desirable by South African governments in order to lengthen the lives of the mines. The following section examines the effect of such sliding scales in detail.

6.5.1 The effects of a sliding scale formula.

The influence of Government participation in profits may be seen more clearly with the use of the following diagram (Fig. 6.2)



AR = Average Revenue
AC = Average Cost
MC = Marginal Cost
MR = Marginal Revenue
MP = Marginal Profit

Fig. 6.2

Suppose all gold bearing rock consists of X tons of a certain average grade and that annually operations are directed to a block of ore of x tons (i.e. the ore actually milled, plus that discarded by sorting or left unmined = x). Life is equal to $\frac{X}{x}$ tons.

As life is fixed, the annual amount to be provided for depreciation is constant for any rate of output.

Where the government has no share in the profits, the MC and MR curves intersect at T. It is desirable, therefore, to work tonnage OK with a gold content per ton giving a yield of RK per ton.

Total profit = OK x RS.

If government participation is introduced and this is based on the usual formula, then if such Government share adds to costs, one obtains a new marginal profit curve. The old marginal profit curve cuts the X axis at K. The new marginal profit curve will cut the X axis at a point to the right of K. Let this be point M.

The producer does not carry on his business to maximise his share and the Government's together. He will, therefore, now find it desirable to mine a tonnage of ore with a gold content equal to a yield per ton of NM. This means that it will now be desirable to lower the average grade of ore worked, and where capacity remains unchanged, life will be lengthened.

These twin objectives, viz. lowering the grade of ore and increasing life, have always been regarded by South Africans as desirable. One must take into account, however, the effect of such a policy on the country's economy as a whole.

Firstly, it is clear that the total profit (the company's share, plus the government's share) diminishes. Total profit prior to Government participation is equal to a rectangle of the size OK X RS; with Government participation the rectangle of total profit is OM X NC.

This means, on the assumption of a fixed life, that the annual profits are diminished in total.

The value of any mine to the country at any moment is its value as capital, where capital equals the present discounted value of the total profits.

The effect of Government participation with a sliding scale formula of the type examined is to reduce the series of annual profits over the fixed life, i.e. to reduce the PV of future profits, and so to cause a diminution in the amount of capital, i.e. the real wealth, that the leased mines represent at any moment.

Removing the assumption of fixed life one can see that with a given capacity a lower average grade of ore is desirable. The total profit over life, i.e. the sum of annual profits is reduced, and the spread of this total profit is over a longer time. In the discounting process, then, the PV of future profits is reduced by virtue of both these changes.

The fact that the formula makes a lower average grade desirable means that the producer will now include ore he would otherwise have discarded, since without Government participation the marginal yields of this additional ore are below its marginal costs. In the diagram this is represented by the inclusion of tons lying between K

and M, and these, in terms of the diagram, would, in the absence of Government participation, have a total yield less than total costs, giving a loss equal to the difference between the rectangles OK X RS and OM X NC.

However, once the Government participates, it is in the gold producer's own interests to make the loss on additional low grade ores. He does so because the reduction in profit will lower the Government's share while on balance increase his own share.

An algebraic example may also serve to prove this point.

If, in producing OR tons, the total yield (OK X RK) is R20 000 and the total costs (OK X SK) are R8 000, then total profit is R12 000. If, in producing OM tons, the total yield (OM X MN) is R22 000 and the total costs (OM X MC) are R12 000, then total profit is R10 000. If the Government's share in the former case if R6 000 and, in the latter case, R2 000, the figures on which the producer bases his choices are

	Case 1	Case 2
Total yield	R20 000	R22 000
Total cost	8 000	12 000
Total profit	R12 000	R10 000
Government's share	6 000	2 000
Producer's share	R 6 000	R 8 000

It is in the producer's special interest to make the loss on the additional ore of R2 000 (additional yield = R2 000, additional cost R4 000) because the saving on payment to the Government is R4 000 and on balance the producer gains R2 000.

If the Government's share of profit, whether under a lease or under taxation, is determined on a sliding scale falling with the profit/recovery (P/R) ratio, it encourages producers to perform uneconomic actions which produce a conflict between individual and social interest. This tends to be the case with the South African taxation system for gold mines.

Furthermore, as previously discussed, it has never been made clear why gold-mining should be singled out for special taxation. Granted, the income that accrues from gold mines comes from an extractive industry or wasting asset. However, there is no reason why the same taxation principles should not apply to all extractive industries such as coal and diamond mining.

Why gold mining income should be taxed at a greater rate than other income has been explained by South African governments on the grounds that this differentiation has existed since the time of Union.

It is also possible that a rise in the profit/recovery ratio need not necessarily mean a rise in profitability. Two mines may earn the same profit on the same capital, working with the same tonnage. There would be the same profitability, but if the one had a high yield per ton and a high cost per ton, and the other a low yield per ton and a low cost per ton, the profit per ton would be the same, but the rate of taxation on profits with the sliding scale formula would vary greatly.

In the course of my research I often posed the time-honoured question: "Why should gold mines be taxed at a higher rate than other companies?" The responses this illicited were numerous and varied.

In some instances it was felt that greater rates of taxation were not necessarily due to greater profits in the gold mining industry but rather that gold mining income accrues in large amounts during production and hence the mines have large amounts of cash available. Hence they are more easily accessible to high tax rates. It is interesting to note, however, that gold mines, over the years, have not made excess profits. S.H. Frankel has illustrated this point. He showed that in 1963, the average rate of return on investment in gold mines was 4.3% as opposed to 7% in U.K. equities.[14]

Other arguments have centred around the high degree of risk and speculation involved in gold mining. This is considered to be justification for the heavy taxation of gold mines. High degrees of risk may result in larger returns and profits, in which case the argument for a higher rate would be justified. However, the speculative element can be no reason for increasing taxation.

The former is an argument for increasing the rate of tax with increases in income whatever the source of income. It provides no justification for taxing two companies (engaged in different industries) at different rates whatever the relative size of their incomes, or the relative profitability of their operations. Furthermore, the fact that mining operations are speculative does not justify a higher rate on both the relatively successful and the relatively unsuccessful gold mining companies.

An American tax authority actually used this "speculative" or "risk"

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14. Frankel, S.H.: Investment and the Return to Equity Capital in the South African gold mining industry (1887-1965) Basil Blackwell, Oxford 1967. p.12

argument from the opposite angle.[15] He concluded that unless mines received recognition of the risks involved in mining investment, mining operations might diminish.

It seems to me that the argument of risk is invalid when used for either higher or lower taxation. As the tax is on income there seems to be no reason to consider the risks of the operations from which this income was derived.

It has also been suggested that the relationship of the State to mining gives it some justification for taxing such income at a higher rate. This would, at least, not seem to account for the difference between the rates on coal, diamond and gold mining. Whatever attitude a Government adopts towards the ownership of gold mines, there does not appear to arise out of this attitude any reason for a differential rate of tax. Although many arguments have been advanced from time to time in justification of the principle that mining should occupy a relatively favourable position in a country's taxation structure vis-a-vis other sector's, it is also true that just as many arguments have been advanced in justification of the principle that mining should bear a higher tax burden than other industries.[16]

The question of the State's interest in the exhaustion of minerals generally is a complex one, often involving purely nationalistic motives.

15. Graton, L.C.; "Federal Taxation of Mines" in Transactions of the American Institute of Mining and Metallurgical Engineers" vol. for 1919.

16. An interesting example can be found in the Garnsey-Lentz controversy: M.E. Garnsey, "Fair Taxes for Mining", The Colorado Quarterly, vol. 7 (Winter, 1959) pp. 229-240; O.H. Lentz, "Mineral Economics and the Principle of Equitable Taxation", Quarterly of the Colorado School of Mines, vol. 55 (April 1960).

Whether there is a good case for State interference in increasing or decreasing the supply of an exhaustible resource, and what form this intervention should take will be discussed in the concluding chapter.

6.6 Quantitative Analysis of the effects of Taxation and Lease policies on the extraction of gold.

6.6.1 General Expression for the Tax Formula

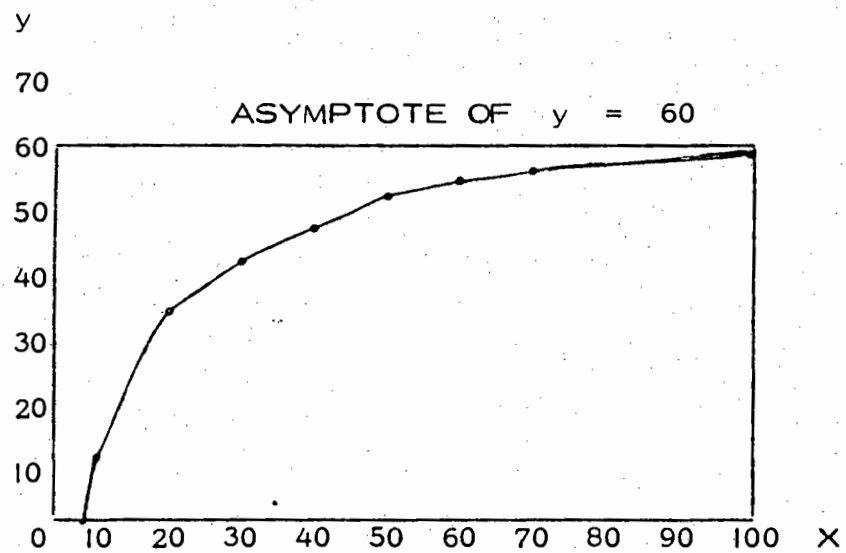
$$y = a'\left(1 - \frac{b'}{x'}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where

x' = ratio expressed as a percentage which the taxable income from gold mining bears to income from gold mining

a' = 60 (typical current value)

b' = 8 (typical current value for post 1966 mines)



Ratio of Taxable Income to Income as Percentage

Fig. 6.3 $y = 60\left(1 - \frac{8}{x'}\right)$

Also applied to the tax is a surcharge percentage s', currently

equal to 5%.[17]

The above formula has been used in the gold mining industry for well over 30 years. Its selection was governed by the purely mathematical concept of a suitably shaped curve to satisfy the following conditions.

i) The richer the mine (as reflected by its x' value) the higher the taxation.

ii) The tax rate should approach a maximum.

iii) The tax rate should not be the cause of inefficient mining.

It is evident from Fig. 6.4 that objectives i) and ii) are met. Whether objective iii) is met, however, is more difficult to ascertain. This question will be examined later.

To interpret the implications of the tax formulas, we define the following symbols:

I = Income derived from gold mining.

E = Expenditure used in producing the gold.

R = Taxable Income (i.e. $R = I - E$)

R^* = Net Income (after tax has been deducted)

T = Tax payable.

$s = 1 + \frac{s'}{100}$

$a = \frac{a'}{100}$

$b = \frac{b'}{100}$

$x = \frac{x'}{100}$ (ratio of taxable income to income)

$y = \frac{Y}{100}$ (fractional tax rate)

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17. 15% surcharge as a result of 1982/83 Budget proposals

Using the above definitions and (1) we have:

$$T = syR$$

$$= sa\left(1 - \frac{bI}{R}\right) R$$

$$= sa\,(R - bI) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$= sa\left[I\,(1-b) - E\right] \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$R^* = I - E - T$$

$$= I - E - sa\left[I\,(1-b) - E\right]$$

$$= I\,(1 - sa + sab) - E\,(1 - sa) \quad \ldots\ldots\ldots \quad (4)$$

$$= (1 - sa)\,(I - E) + sabI \quad \ldots\ldots\ldots\ldots \quad (5)$$

$$\frac{R^*}{I} = (1 - sa + sab) - (1 - sa)\,\frac{E}{I} \quad \ldots\ldots\ldots \quad (6)$$

For the post 1966 case (pre 1966 in brackets)

$a' = 60$ i.e. $a = .6$

$b' = 8\ (6)$ i.e. $b = .08, (.06)$

$s' = 5$ i.e. $s = 1.05$

We have

$$T = .63\,(R - .08I) \quad \ldots\ldots\ldots\ldots\ldots \quad (2')$$

$$(.63\,(R - .06I))$$

$$T = .63\,(.92I - E) \quad \ldots\ldots\ldots\ldots\ldots \quad (3')$$

$$(.63\,(.94I - E))$$

$$R^* = .4202I - .37\,E \quad \ldots\ldots\ldots\ldots\ldots \quad (4')$$

$$(.4078I - .37\,E)$$

$$R^* = .37\,(I - E) + .0504I$$

$$(.37\,I - E) + .0378I) \quad \ldots\ldots\ldots\ldots \quad (5')$$

$$\frac{R}{I} = .4204 - .37\frac{E}{I} \quad \text{.....} \quad (6^1)$$

$$(.4078 - .37\frac{E}{I})$$

6.6.2 Interpretation of the Effects of the Tax formula

i) Condition for no taxation

Using equation (3), we have for $T > 0$

that $sa\left[I(1-b) - E\right] > 0$

i.e. $I(1-b) > E$

or $(I - E) > bI$ ..... (7)

For post 1966 mines $b = .08$, hence the mine will not pay tax if the taxable income $R = I - E$ is less than $.08\,I$.

For pre 1966 mines, $b = .06$, hence such a mine will be free of tax provided $R \leq 0.6\,I$.

ii) Special variable allowance and fixed tax rate

Using equation (3) we can interpret the tax formula as one giving a fixed tax rate of $sa \times 100\%$ on an adjusted taxable income $(R - bI)$, where the true taxable income, R, is reduced by $b \times 100\%$ of the income, I.

Currently, then, using (2^1), we have that there is a fixed taxation rate of 63% on the taxable income reduced by 8% of the income (6% in the case of pre-1966 mines).

Example:

Income	4 000 000
Expenditure	3 000 000
Tax. Income	1 000 000
8% of Income (Allowance)	80 000
Adjusted Tax Income (A.T.I.)	920 000
Tax (63% of A.T.I.	579 600

iii) Net Income per unit Income

Net Income per unit of Income as a function of Expenditure per unit of Income is given by equation (6)

$$\frac{R^*}{I} = (1 - sa + sab) - (1 - sa)\frac{E}{I}$$

This relationship is plotted in Fig. 6.4 for the following cases:

a) In respect of taxable income derived from mining for gold, the percent tax rate (Y) is determined by

$$Y = 60 - \frac{360}{x}$$

or $$Y = 60\left(1 - \frac{6}{x}\right) \quad \ldots\ldots\ldots \quad (8)$$

where x represents the ratio expressed as a percentage which the taxable income from gold mining bears to the income from gold mining.

The rate Y is, however, limited to

$$Y = (20 + w)\left(1 - \frac{6}{x}\right) \quad \ldots\ldots \quad (9)$$

where w represents the number of completed times R 2 500 is contained in the taxable income less R40 000. Note w = 0 if taxable income is less or equal to R42 499.

A surcharge of 5% must be added to the tax as determined above.

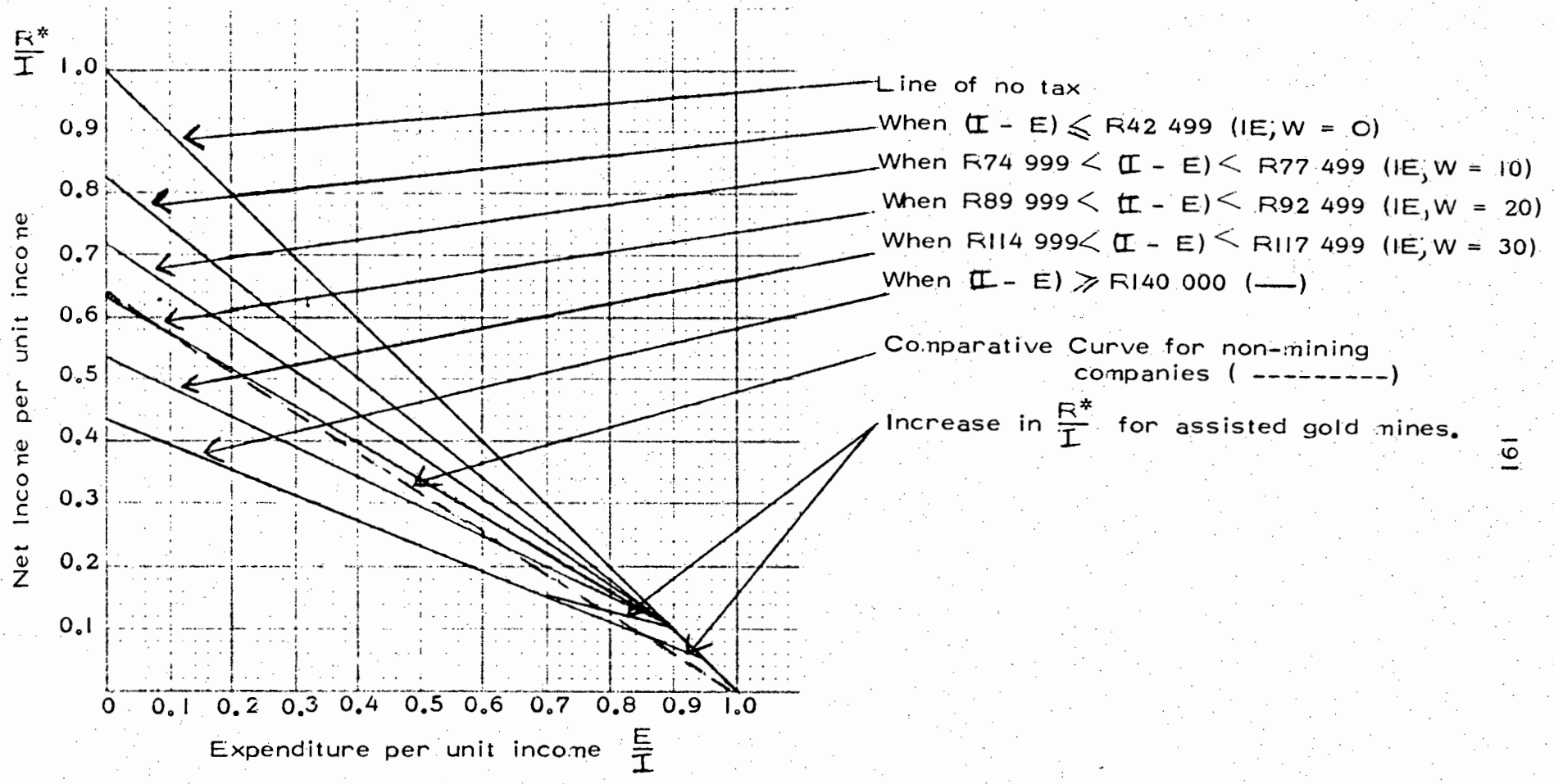

Fig. 6.4 $\frac{R^*}{I}$ $(\frac{E}{I})$

In the case of an assisted gold mine the rate of tax is limited to

$$Y = 68 - \frac{601}{x} \quad \ldots\ldots\ldots\ldots \quad (10)$$

and where this formula applies, the 5% surcharge is not added.

b) For post 1966 gold mines the same provisions apply as in a) except that formula (8) is replaced by

$$Y = 60 - \frac{480}{x}$$

or $$Y = 60 \left(1 - \frac{8}{x}\right) \quad \ldots\ldots\ldots\ldots \quad (11)$$

and formula (9) is replaced by

$$Y = (20 + w) \left(1 - \frac{8}{x}\right) \quad \ldots\ldots \quad (12)$$

The relationship $\frac{R^*}{I}$ expressed by equation (6) is plotted in Fig. 6.5 for the normal case as well as for the special cases where taxation is limited by formulae (9) and (12). Also plotted on Fig. 6.4 is the $\frac{R^*}{I}$ ratio for a non-mining company.

This shows that $\frac{R^*}{I}$ is greater for a gold mining company provided that $\frac{E}{I} > .84$. Hence if a mine uses more than R84 in expenditure in producing R100 worth of gold, it receives a more favourable treatment than a non-mining company.

Because of formula (9), this favourable treatment also

applies to all mines whose taxable income is less than R92 499 per annum.

Examining the $\frac{R^*}{I}$ curves, it is evident that if income, I, is constant, then the net profit will always be improved if expenditure E is reduced. More precisely, using formula (6), if a mine which is taxed according to factors a, b and s has an income of I and an expenditure of E, we have that

$$\frac{R^*}{I} = (1 - sa + sab) - (1 - sa)\frac{E}{I}$$

If the mine decreases its $\frac{E}{I}$ ratio by $\Delta\left(\frac{E}{I}\right)$, then the increase in its net profit income ratio, $\Delta\left(\frac{R^*}{I}\right)$ will be as follows:

$$\Delta\left(\frac{R^*}{I}\right) = \Delta\left(\frac{E}{I}\right)(1 - sa) \quad \ldots\ldots\ldots \quad (13)$$

which currently for a normal tax mine

$$= .37\,\Delta\left(\frac{E}{I}\right) \quad \ldots\ldots\ldots\ldots \quad (13')$$

hence, if $\frac{E}{I}$ was 0.5 and $\frac{R^*}{I}$ = 0.22 and $\Delta\left(\frac{E}{I}\right)$ = .05

then $\Delta\left(\frac{R^*}{I}\right)$ = .37 x .05

= .0185

and so the new $\frac{R^*}{I}$ = 0.22 + .0185

= 0.2385

hence a 10 per cent decrease in expenditure per unit income results in a 8.5 per cent increase in net profit per unit income.

Looking at the tax formula from the above point of view,

we see that the tax formula does discourage inefficiencies, at least in expenditure.

iv) Mining of unpayable ore

If we examine a mine whose R^* is given by formula (4), i.e.

$$R^* = I(1 - sa + sab) - E(1 - sa)$$

and decide to spend an additional expenditure of ΔE to increase I by ΔI, then we will increase P^* by ΔP^*, we will then have

$$(P^* + \Delta P^*) = (I + \Delta I)(1 - sa + sab) - (E + \Delta E)(1 - s$$

or $$\Delta P^* = \Delta I(1 - sa + sab) - \Delta E(1 - sa)$$

for $\Delta P^* > 0$, i.e. an increase in net income, we have to have

$$\Delta I(1 - sa + sab) - \Delta E(1 - sa) > 0$$

or $$\frac{\Delta E}{\Delta I} > \frac{1 - sa + sab}{1 - sa}$$

$$= \left(1 + \frac{sab}{1 - sa}\right) \quad \ldots\ldots\ldots\ldots \quad (14)$$

For a pre 1966 mine with the normal tax formula

$$\frac{\Delta E}{\Delta I} > \frac{.4078}{.37} = 1.1$$

Hence, provided we spend less than R110 for every R100 of additional income produced, we will increase our net income.

If $\Delta I = \Delta E$ (i.e. costs = income), we have

$$\Delta R^* = \Delta E \text{ (sab)}$$
$$= \cdot 0378 \, \Delta E \text{ (for the normal tax mine)}$$

hence if $\Delta E = \Delta I = R100$

$\Delta R^* = R3.78$

In this situation we have mined gold worth R100, spent R100 to mine it, and received a net income for the effort of R3.78.

This shows that there is an incentive to mix payable and unpayable ore in the overall production plan.

Considering that mining costs are rising by about 15 per cent per annum and that money has a time value associated with it of 17 per cent (nominal short term interest rate as of March 1982) per annum, the rich ore, if left unmined for some time depreciates in value.

For example, if the R100 was spent to produce an income of R150 by mining rich ore instead of unpayable ore, we would have

$$\Delta R^* = 150 \, (1 - .63 + .0378) - 100 \, (1 - .63)$$
$$= 150 \, (.4078) - 100 \, (.37)$$
$$= R24.17$$

If that same ore was mined a year later, then

$$(\Delta R^*)^1 = 150 \, (1 - .63 + .0378) - 115 \, (1 - .63)$$
$$= R18.62$$

However, to take into account the time value of money, we have

to divide $(\Delta R^*)^1$ by (1.17)

i.e. $$\frac{R18.62}{1.17} = R15.91$$

hence the value of the gold has depreciated by

$$R(24.17 - R15.91) = R8.26$$

In the above example, it might then be profitable to spend the R100 to mine the unpayable ore rather than spending the same amount for mining the richer ore, provided that there were no effects other than a one year delay on mining the same amount of the richer ore. This is unlikely as this action would usually set in motion a chain reaction of delays in mining rich ore down the life of the mine.

In general, the best decisions can only be obtained by balancing over the life of the mine factors such as taxation, time value of money and yields from low and high grade ores.

v) Certain misconceptions

It is sometimes thought that better financial results can be obtained (particularly for marginal and semi-marginal mines) if the mine restricts operations so that no tax will be payable.

It is shown below that if working costs can be expressed as

$$E(z) = C_1 + C_2 Z \qquad C_1 > 0,\ C_2 > 0$$

or

$$E(z) = \alpha z^n \qquad \alpha > 0,\ 0 < n < 1$$

(where z = tons mined per annum)

then there is no better mining policy than to mine to maximum mine capacity, and incur maximum tax.

Case (I) Linear Working Costs

Assumptions:

i) Working Costs $E(z) = C_1 + C_2 Z$ ..... (15)

where $C_1, C_2 > 0$

C_1 = annual overhead costs.

C_2 = marginal cost/ton.

C_1, C_2 are not functions of time.

Z = tons mined.

ii) Total available ore = T tons.

iii) Income from mining z tons is

$$I(z) = r(z) \quad \text{.....} \quad (16)$$

where $r > 0$

iv) There is no capital expenditure allowance.

v) a tax formula $Y = a'(1 - \frac{b'}{x})$ applies where

$0 < a', \quad b' < 100$

$$a = \frac{a'}{100}, \qquad b = \frac{b'}{100}$$

A policy such that the mine will not pay tax restricts by (7) the value of I and E and Z, such that

$$I(Z) - E(Z) \leqslant b\, I(Z)$$

i.e. $rz - (C_1 + C_2 Z) \leqslant brz$ ..... (17)

i.e. $Z \leqslant \frac{C_1}{r(1-b) - C_2}$

Suppose $z = \frac{C_1}{r(1-b) - C_2}$ ..... (18)

then a maximum annual tonnage will be produced subject to the provision of no tax.

Annually we shall have a net profit of

$$R(z) - E(z) = rz - (C_1 + C_2 Z)$$

$$= (r-C_2)z - C_1$$

$$= \frac{(r-C_2)C_1 - C_1}{r(1-b) - C_2}$$

$$= \frac{brc_1}{r(1-b) - C_2} \quad \ldots\ldots\ldots \quad (19)$$

The mine will go on for

$$\frac{T}{C_1}\left[(r(1-b) - C_2)\right] \text{ years} \quad \ldots\ldots\ldots\ldots \quad (20)$$

hence the Total Profit is equal to

$$Tbr \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (21)$$

(note: if b = .06, then Total Profit = .06rT)

If tax is paid, we have

$$Z > \frac{C_1}{r(1-b) - C_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

and life $= \frac{T}{Z}$ ..... (23)

Total net profit will then be, using (4) with s = 1

$$\left[I(z)(1 - a + ab) - E(z)(1 - a)\right]\frac{T}{Z}$$

$$= \left[rz(1 - a + ab) - (C_1 + C_2Z)(1 - a)\right]\frac{T}{Z}$$

$$= T\left[r(1 - a + ab) - \frac{C_1}{Z}(1-a) - C_2(1 - a)\right] \quad \ldots\ldots\ldots \quad (24)$$

We would like to show

$$Tbr > T\left[r(1 - a + ab) - \frac{C_1}{Z}(1 - a) - C_2(1-a)\right] \quad \ldots\ldots (25)$$

i.e. that the non tax policy is better than some tax policy.

However (25) implies that

$$br > r(1 - a + ab) - \frac{C_1}{Z}(1 - a) - C_2(1 - a)$$

i.e. $$br(1 - a) > r(1 - a) - \frac{C_1}{Z}(1 - a) - C_2(1 - a)$$

i.e. $$br > r - \frac{C_1}{Z} - C_2$$

i.e. $$\frac{C_1}{Z} > r(1 - b) - C_2$$

i.e. $$Z < \frac{C_1}{r(1 - b) - C_2} \quad \ldots\ldots\ldots\ldots \quad (26)$$

which is in contradiction to (22)

i.e. $$Z > \frac{C_1}{r(1 - b) - C_2}$$

Hence, every tax paying policy produces a greater total net return than the maximum annual tonnage policy which does not pay tax.

We further need to know if there exists a policy where the

mine will pay tax but will prolong its life without decreasing its total net profit.

Suppose that under policy 1, the annual milling rate is Z_1 and under policy 2, the annual milling rate is Z_2 with

$$Z_1 < Z_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (27)$$

i.e. policy 1 leads to a longer life.

Using expression (24), the Total Net Profit for

policy (1) $P_1 = T\left[r(1 - a + ab) - \frac{C_1}{Z_1}(1 - a) - C_2(1 - a)\right]$ ... (28

for policy (2) $P_2 = T\left[r(1 - a + ab) - \frac{C_1}{Z_2}(1 - a) - C_2(1 - a)\right]$.. (29

we require $P_1 \geqslant P_2$

i.e. $$-\frac{C_1}{Z_1}(1 - a) \geqslant -\frac{C_1}{Z_2}(1 - a)$$

i.e. $$Z_2 \leqslant Z_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

which is a contradiction to (27)

Hence, under the assumption of linear costs, there is no better policy than to mine maximum tonnage.

In the second part of the proof we have not considered the case where the taxable income under the two policies is less than R140 000 and tax formula (9) with different values of 'a' for the two policies may apply. In such cases it may be profitable to restrict mining - this, however, is doubtful particularly if we also take into consideration the time value of money (interest rate) and rising costs.

Case (2) - Curvilenear Working Costs

If we change assumption i) in the previous case to

$$\text{Working costs} = E(z) = \alpha z^{n} \quad \ldots\ldots\ldots\ldots \quad (15')$$

$$\alpha > c$$

$$c < n < 1$$

(i.e. costs per ton gradually decrease with tonnage)

then for the mine not to pay tax we require

$$z^{(1-n)} \leqq \frac{\alpha}{r(1-b)} \quad \ldots\ldots\ldots\ldots\ldots \quad (17')$$

If we than assume annual production at

$$z^{(1-n)} = \frac{\alpha}{r(1-b)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (18')$$

we will obtain Total Profit over the life of the mine equal to

$$Tbr \quad \ldots\ldots\ldots\ldots\ldots \quad (21')$$

If tax is paid, then

$$z^{(1-n)} > \frac{\alpha}{r(1-b)} \quad \ldots\ldots\ldots\ldots\ldots \quad (22')$$

and total net profit is

$$T\left[r(1 - a + ab) - \alpha (1-a) z^{(n-1)}\right] \quad \ldots\ldots\ldots \quad (24')$$

We want to show that the non-tax policy is better than some tax policy, i.e.

$$T br > T\left[r(1 - a + ab) - \alpha (1-a) z^{(n-1)}\right] \quad \ldots\ldots \quad (25')$$

i.e. $$z^{(n-1)} > \frac{r(1-b)}{\alpha}$$

or $$z^{(1-n)} < \frac{\alpha}{r(1-b)}$$

which is in contradiction to (22').

Hence, again there is no better policy than to mine maximum tonnage and incidentally to incur maximum tax.

6.6.3 Objectives

It is generally accepted that the main objective of a company's management is to maximise the profits of the owners, the equity shareholders. That this principle is well accepted within the gold mining companies in South Africa is doubtful.

Other objectives are frequently used to determine the policy of a gold mine. For example:

i) the selection of a policy which maximises the life of a mine within the constraint of "adequate" annual profits or fixed annual profits;

ii) the selection of a policy which maximises the total amount of gold produced, also within constraints specifying "adequate" annual profits or fixed annual profits;

iii) the selection of a policy which maximises the life or the profits of a mine, subject to constraints specifying that the mine will avoid paying tax.

The above objectives reflect in a confused and imprecise way the true objective of maximising the profits of the shareholders. Confusion arises from improper identification of objectives and from

the confusion of objectives with constraints. For example, besides seeking maximum profits, management may also have other objectives such as maintaining a stable (constant) policy. This, in fact, is not an objective in the sense that it can be maximised, but rather a constraint on the policy which maximises profits.

It is current practice to assess the overall economics of a mining venture or mining policy on the present value of future net profits. This practice is reasonable, as it is necessary to take discounting assumptions into account, because present money is at a premium compared with future money.

The above practice is only correct if there are no decisions of capital expenditure involved.

In his paper on "Analysis of Mine Operating and Capital Expenditure" Ewing states that: "The mining engineer, when deciding upon the nature of permanent installations to be selected as preliminary to valuing or initiating a new venture, will wish to select the installations that will make the present value of the estimated stream of profits a maximum for the whole process of winning the whole available metal present in the ore deposits to be exploited."[17] This objective is false. The argument for the falsity of the above claim is as follows:

i) Ewing has shown that the Present Value of sums received (Profits) of a mine can be expressed as a function of the capital spent on establishing the mine. This function is

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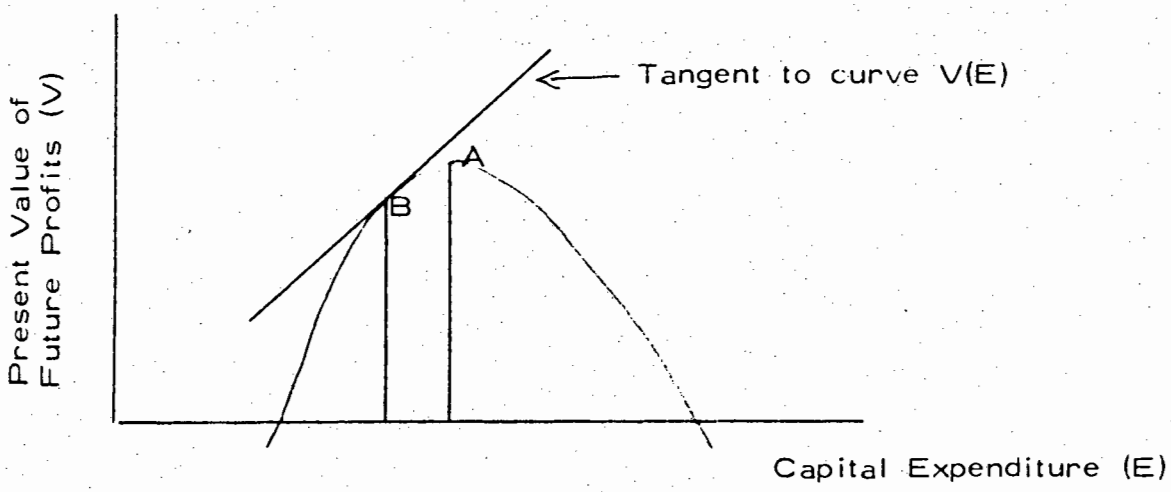
17. Ewing, S., "Analysis of Mine Operating and Capital Expenditure", C. I. M. M. Special Valume No. 10, 1970.

roughly parabolic in shape (Fig. 6.5)



Present Value as a function of Capital Expenditure, V(E)

Fig. 6.5

ii) Maximum present value, V, occurs at a point A in Fig. 6.5. If, at this point, we invest an additional amount, the present value of the mine will not be increased.

At point A, the marginal increase in the present value, V, is zero for an increase in capital expenditure, E, i.e. $\frac{dV}{dE} = 0$. At this point, the marginal productivity of capital is zero and it is inconsistent with general principles of investment to operate in this state. Effectively, it means that an investment of ΔE produces an increase of $\Delta V = 0$ in the value of the enterprise.

iii) The optimum policy will occur where ΔE, the additional investment, produces an increase in the value of the enterprise equal to ΔV and $\Delta V \geqslant \Delta E$.

This will be at some point, B, in Fig. 6.5 such that $\frac{dV}{dE} \geqslant 1$, (i.e. the slope of the tangent to the curve $V(E) \geqslant 1.0$).

We assume that the precise point B can be determined from considering the relationship between the present value, V, of the mine, and the average value, M, of the shares of the mining company. In general, $M < V$ because of risk factors. If $V = .9M$, then we could say that there is a probability of .9 that the mine will produce profits such that the value of these profits is M.

If the additional investment does not alter the risk factors, then an additional investment of $\triangle E$ should produce an increase of $\triangle V$ in the present value of the mine, such that $.9 \triangle V = \triangle E$

or $\frac{dV}{dE} = 1.11$

hence the optimum investment policy will occur where

$$\frac{dV}{dE} = 1.11$$

To arrive at the optimum policy we have to establish the present value curve as a function of capital expenditure and then, in order to determine the optimum capital expenditure decision, find a point B on this curve such that $\frac{dV}{dE} = \frac{V}{M}$.

In practice, to determine the curve V(E) we would maximise V(E), the Present Value, with the capital expenditure not constrained and then maximise V(E), subject to restrictions on E until the tangent at point B had the required value.

In the above discussion we have not distinguished various sources of capital such as -

- equity capital
- short term (overdrafts, etc.)
- medium and long term loans

Rights issues

New issues

Preference shares

Retained profits, etc.

The real (after tax) cost of some of those sources of finance is often substantially less than the cost of Equity finance (which would be normally used in establishing a mine). This reduction in a company's cost of capital decreases the marginal productivity requirements of capital expenditure in establishing the optimum policy.

6.6.4 Influence of Government on optimum Policies

There is a conflict of interests insofar as shareholders are interested in maximum profits, and the contention that it is to South Africa's advantage to produce maximum gold over the life of the mines.

In criticism of the influence of state planning on the gold mines, it has been pointed out that, although governmental assistance policies to marginal gold mines may be of benefit to the country, they are of no benefit to the shareholders of mining companies. Assistance to gold mines (loans, etc.) can actually cause losses to shareholders both in actual returns and potential mine break up value.

The problem is complicated by the fact that shareholders have both an interest in earning maximum profits and in the welfare of the national economy.

CHAPTER 7

CONCLUSIONS

Until South Africa manages to free herself of her historic and erstwhile dependence on gold, fluctuations in the price of gold will continue to have a marked effect on the state of the South African economy. At present the drop in the gold price towards the $300 mark has prolonged the day when economic recovery will be attained.

In addition to this, the gold mining industry was further burdened by an increase in the surcharge on tax payable, to 15%, following the 1982/83 Budget Speech. However, the fall in the Rand against the U.S. dollar has served to cushion the impact of the fall in the gold price on the gold mines.

Given the above information it is not difficult to see why a correct policy, with regard to the extraction of this resource, is of great importance to South Africa.

7.1 Gold and Optimal Extraction Patterns

Although gold has been analysed according to the traditional wasting assets theory, it has been shown that it has properties which differ to most other resources, which are also classified as "wasting assets". Although gold is a "wasting asset" in the sense that it is a non-renewable resource which has the character of a fixed stock which is non-replenishable in its existing form, it is also a resource which is not destroyed in consumption - once it has been mined, unlike oil, it is an "everlasting asset". Furthermore, gold is a financial asset. Gold differs, say, from energy sources because, as the price of gold increases, there is no incentive to develop substitutes for gold as a hedge commodity/investment. Generally,

as the price of a wasting asset increases, there exists every incentive to develop substitutes. Gold usage in industry follows the latter hypothesis. Despite its attractive properties, at a price there exist substitutes.

Every act of consumption of stock resources means that there is less remaining for future use. The potential depletion of these resources gives rise to the need to consider whether market forces are leading to a too rapid exploitation of these resources for the good of future generations and whether there is a need for government intervention to make greater provision for the future. The conservation of resources does not (and should not) imply lack of use, merely wise and careful use, so that the utility derived from a resource may be maximised over time.

As with all wasting assets, the key to a sound conception of the conservation of minerals lies in the recognition of their representing part of the national capital. A concern for the optimal depletion of exhaustible resources becomes a concern for the optimal rate of investment and capital formation in the economy at large. From an economic point of view, it makes no difference whether we save resources for tomorrow by not using them today, or instead use them today in a process that does not yield direct satisfaction, but creates capital goods which yield their services tomorrow. The principle that determines the rate of investment - the rate of return on capital, must thus be used to govern the extraction of mineral resources.

The objective function to solve the problem of the optimum rate of

depletion is to maximise the net present value of the stock. In partial equilibrium market theory, there will be stock equilibrium in an asset market when all assets of a given risk class yield the same rate of return, partly as current dividend and partly as capital gain. Resource deposits yield no current dividend as long as they remain "in situ", so the rate of return is purely in terms of capital appreciation. The present value of a resource deposit is the net present value of future sales from it, after deduction of extraction costs. So, in equilibrium, net price or scarcity rent must be increasing at the market rate of interest.

If net price rises at less than the rate of interest, the return on investment in conservation of a resource is less than the return on other investment, so the rate of extraction will be increased and the resource will be exhausted more quickly. If net price rises faster than the rate of interest, owners of mines delay production while they enjoy supernormal capital gains.

Differing expectations affect the extraction rate of resources, such as gold. If the interest rate, which the mine owner uses, diverges from the market rate of interest, (i.e. if it is greater), mine owners will extract the ore more quickly. This may occur because the mine owner discounts the future at a higher rate than the market. If the market rate of interest is greater than the "social rate of discount", intervention in the market to slow down the rate of extraction would be justified. However, this is unlikely to be the case, as the social rate of discount would be determined by politicians who are generally quite old, so in fact they might discount the future at a higher rate of interest than the market. Within the

time horizon, the market works impeccably and optimal extraction patterns will result if resources are extracted at a rate equal to the market rate of interest. (The only question is whether information is good or bad.) Although this does not provide for generations beyond the time horizon, there is no reason to believe that the government's time horizon is longer than that of the market. Furthermore, there is no evidence that the government has access to "better" information than individual or collective market participants.

The possibility also exists that, far from being exploited too quickly, mineral resources may have been exploited too slowly because, inter alia, of the monopoly power exerted by resource owners.

While individual mine owners may be criticised for not taking a long enough view of the future, there is no reason to suggest that the political process can be relied upon to be more future orientated than the average corporation. This criticism is, moreover, irrelevant, given the capital nature of minerals - unless mine owners consume their profits and do not reinvest in exploration or in the stock of repoducible capital.

Given the fundamental nature of mineral resources, and the likelihood of the discovery of new deposits and of technological innovation, the principle of intergenerational equity demands only that society channels its investments in such a manner that its aggregate income is made as great as the funds available for investment can make it. Since all capital is exhaustible and must be replaced, investment in the conservation of non-repoducible capital should not be seen as more desirable than in produced means of production, knowledge, technology and economic institutions. In general, I believe that the

interests of future generations would be better served if we left them capital equipment rather than minerals in the ground.

7.2 Gold and Government Intervention

In South Africa the government has undertaken to ensure that the life of the gold mines is extended as far as possible and that secondary industry is developed to take the place of gold mines in providing employment on the decline of the gold mines.

The lease and taxation formulae, introduced by the Mining Taxation Act No. 6 of 1910 sought to rectify the divergence between the private and social interests by ensuring that the lowest economically possible ores were mined and thus the length of the lives of the mines extended, with the funds available for the development of other industries.

The disadvantage of these regulations are, that once the government regulates with such a formula, it will pay the mine owner from the narrow point of view of his own interest to deliberately make a loss on additional low grade ores because the resultant reduction would so lower the government's share, that on balance his own share would be increased. Thus the capital value of the mine is diminished.

Frankel has shown that excess profits have not been made in the South African gold mining industry. In 1963, the average rate of return on investment in gold mining was 4,3% as opposed to 7% in United Kingdom equities. The objectives of the system which were intended to obtain the inherent rental value of the mineral deposits

for the state, seem to have been based on confusion as to the economic nature of "rent" and failed to appreciate fully the difference between economic returns which are pure Ricardian rents and those which are quasi-rents. The system does not take sufficient account of the effects on the supply of capital for new exploration activities. The net result is that less capital goes into gold mining and more into other activities and the national income is diminished in the outcome.

So the aim of high taxation is to obtain for the state, rents from gold mining, so as to prevent the consumption of these, and also to prevent the payout of high dividends to foreigners. A tax on profits discriminates against capital intensive and risky ventures. Furthermore, if the return on other investment in South Africa is sufficiently attractive, any funds which flow from the country in the form of dividends will return.

A tax on profits would serve the purpose of increasing investment, only if the governmen ear-marked this revenue for investment. While a case exists for taxing the surplus product of a wasting asset at a higher level than industries with indefinite lives, provided that the revenue is channelled into the development of industry, the different rates of tax on gold mines and on other extractive industries cannot be justified. Furthermore, taxes paid by extractive industries in excess of the rates of company tax should be placed in a separate fund earmarked for investment purposes and not poured into the general revenue fund, as in the case in South Africa. If anything, a tax on dividends would be superior.

With respect to diversification, the government has not in fact

channelled the funds into capital investment (witness the flow in the 1930s from mining to agriculture).

Furthermore, it is not clear why profit maximising firms should not diversify their own portfolios. Large mining finance houses can purchase skills in other fields if they do not already have them. However, at this stage it may not be optimal to force diversification - it may be preferred to have greater investment in exploration for gold deposits. What the government is essentially doing is restricting choice.

Finally, the recognition of wasting assets as part of our total capital stock results in the fact that no case exists for the conscious conservation of mineral resources, particularly gold, for future generations. However, this does not imply that wasteful extraction should be condoned. As long as the stock of reproducible capital is not run down and is augmented by the present generation, future satisfaction will be served. While the market is imperfect there is no reason to expect that government regulation will lead to a more efficient utilisation of resources or provide a higher rate of investment than would market forces.

LEASE PAYMENTS AND TAXATION

Lease Assessment

The profit assessment for the purpose of estimating lease payments is the working profit less the capital expenditure redemption (or amortisation) allowance. No lease payment is charged until cumulative profits exceed cumulative capital expenditure and, thereafter, capital expenditure is treated as an expense as and when incurred.

There is also an additional interest allowance calculated on any unredeemed balance of capital expenditure. For leases granted before October 1967 this is calculated at 5% simple interest, for leases granted after this date at 6% compound interest.

The lease payments of certain old mines are also subject to special features. There is an Offset Clause (OC) which gives relief in the event of increased income tax, while in some cases a minimum payment is fixed regardless of formula assessment.

The lease payment is calculated before the tax payment, as it is allowed as a charge against profits for the purpose of tax calculations. Each mine has its own lease formula, a typical example being

$Y = 15 - \frac{90}{X}$. where X is the ratio of profit (less redemption allowance) to revenue expressed as a percentage, and Y represents the percentage of profits (less redemption allowance and capital allowance) payable to the State.

To illustrate. Assume a mine which has a revenue of R30 million,

has incurred costs of R15 million and spent R1 million on capital account through the year, such that the capital allowance is calculated at R25 000. The lease formula is:

$$Y = 15 - \frac{90}{X}.$$

From this information the profit for X in the lease formula is equal to R30 million, less R15 million and less R1 million, or R14 million. Substituting in the formula, this becomes

$$Y = 15 - \frac{90}{\frac{\text{R14 million}}{\text{R30 million}}} \times 100$$

$$= 13.072\%$$

The assessable profit for lease purposes is R30 million, less R15 million, less R1 million, less R25 000 — or R13 975 000. Therefore the full lease payment will amount to 13.072% of the above figure, or R1 826 812.

Income Tax

As previously indicated, the lease payment is treated as an expense in arriving at liability for taxation. In addition, as in the case of the lease, no taxation is payable until cumulative profits exceed cumulative capital expenditure, and capital expenditure thereafter is treated as an expense, as and when incurred.

The special capital allowances for tax purposes fall away in the year in which liability for taxation is first incurred. Present capital allowances for tax purposes are 8% per annum for the Cooke Section of Randfontein, and 10% per annum for Unisel, Deelkraal, Elandsrand and Ergo.

The taxation formula for pre 1967 mines is:

$$Y = 60 - \frac{360}{X}$$

where, in this case, X is the ratio of profit less lease payment and less redemption allowance (including as much of the redemption allowance as is attributable to the capital allowance in the years preceding that in which taxation is first incurred) to revenue expressed as a percentage. Y is the percentage of profits (less redemption allowance, lease payment and, where applicable, capital allowance) payable as income tax.

Taking the same theoretical mine as above, the profit less redemption allowance less lease payment is equal to R12 173 188, therefore

$$Y = 60 - \frac{360}{\frac{R12\ 173\ 188}{R30\ 000\ 000} \times 100}$$

$$= 51.128\%$$

Tax payable is then equal to 51.128% of R12 173 188 or R6 223 908.

In addition to the tax payable under the formula, as calculated above, there is also a 5% surcharge. Thus, actual tax paid would amount to R6 535 103.

The total tax and lease payments would thus amount to R8 361 915 equivalent to 59.7% of profits. These figures refer to profits resulting from mining precious metals and uranium. Additional non-mining income is taxed at the existing company rate.

MINE TAXATION* AND LEASE FORMULAS FOR INDIVIDUAL S.A. MINES+

Blyvooruitzicht (1942) Lease: $Y = 16.3 - \frac{254.5}{X}$ minimum 5%

Bracken (1962) Lease: $Y = 15 - \frac{90}{X}$

Buffelsfontein (1957) Lease: $Y = 16 - \frac{96}{X}$

Deelkraal (1979) New mine tax formula: $Y = 60 - \frac{480}{X}$

Lease: $Y = 15 - \frac{120}{X}$

Doornfontein (1953) Lease: $Y = 15 - \frac{120}{X}$

Driefontein Cons. (1952)

E. Drie Section Tax: $Y = 60 - \frac{480}{X}$

Lease: $Y = 15 - \frac{120}{X}$

W. Drie Section Tax: $Y = 60 - \frac{360}{X}$

Lease: $Y = 21 - \frac{210}{X}$

Durban Roodepoort Deep (1898) Lease: Mainly non lease (state-assisted)

Ergo (1981) New mine tax formula: $Y = 60 - \frac{480}{X}$

Lease: No Lease

East Rand Proprietary (1908) Lease: "Ra = 1.4X - 8.4" on 5 286 claim

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* where no tax formula is given, it is taken as read that the tax formula for pre-1967 mines applies, i.e. $60 - \frac{360}{X}$. The date when milling operations began is given in brackets.

\+ correct as of 28 Feb. 1982.

Elandsrand (1983) New mine tax formula: $Y = 60 - \frac{480}{X}$

Lease: $Y = 15 - \frac{115}{X}$

Free State Geduld (1956) Lease: $Y = 27.6 - \frac{165.6}{X}$

Grootvlei Prop. Mines (1938) Lease: $Y = 27 - \frac{660}{X}$

Harmony (1954) Lease: $Y = 12.5 - \frac{75}{X}$

Hartebeesfontein (1955) Lease: $Y = 17 - \frac{102}{X}$

Kinross (1967) Lease: $Y = 12.5 - \frac{75}{X}$

Kloof (1968) Lease: $Y = 15 - \frac{90}{X}$

Leslie (1962) Lease: $Y = 15 - \frac{90}{X}$

Libanon (1949) Lease: $Y = 15 - \frac{225}{X}$

Loraine (1955) Lease: $Y = 15 - \frac{90}{X}$

Marievale Consolidated (1939) Lease: $Y = 20.3 - \frac{406}{X}$

President Brand (1954) Lease: $Y = 12.5 - \frac{75}{X}$

President Steyn (1954)

Lease: $Y = 12.5 - \frac{75}{X}$ (original mine): $Y = 10 - \frac{80}{X}$

(Video - profits taxes on new formula $Y = 60 - \frac{480}{X}$)

Randfontein (1889 (original property), 1974 (Cooke section))

Lease: $Y = 12.5 - \frac{100}{X}$ Tax: $Y = 60 - \frac{480}{X}$

St. Helena (1951 Lease: $Y = 11 - \frac{110}{X}$

Stilfontein (1976 Lease: $Y = 23 - \frac{138}{X}$

Tax: $Y = 60 - \frac{480}{X}$

Unisel (1979) New mine tax formula: $Y = 60 - \frac{480}{X}$

Lease: $Y = 10 - \frac{80}{X}$

Vaal Reefs (1956 (Vaal Reefs) and 1941 (Western Reefs))

Lease: $Y = 12.5 - \frac{75}{X}$

Venterspost (1939) Lease: Non-Lease (state assisted)

West Rand Consolidated (1908) Lease: Non-lease (state assisted)

Western Areas (1961 (W. Areas) and 1968 (Elsburg))

Lease: $Y = 12.5 - \frac{75}{X}$

Western Deep Levels (1962) Lease: $Y = 15 - \frac{90}{X}$

Western Holdings (1951)

Lease: (W.H./W.) $Y = 26.82 - \frac{160.92}{X}$

(F.S.S.(E.D) $Y = 15 - \frac{120}{X}$

Winkelhaak (1958) Lease: $Y = 15 - \frac{90}{X}$

Witwatersrand Nigel (1939) Lease: Non-lease (state assisted)

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