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University of Cape Town

AN EVALUATION OF THE GOLD SHARE MARKET ON THE JSE

by

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A thesis prepared under the supervision
of Dr. G.D.I. Barr, in partial
fulfilment of the requirements for the
degree of Master of Science
in Operations Research

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CHAPTER 1

INTRODUCTION AND SUMMARY

Gold has traditionally been a highly prized metal, stored for value and used in the manufacture of ornaments and jewellery; its use dates as far back as the Ancient Egyptians. Since August 1971, however, when the dollar/gold convertibility was officially terminated, the price of gold bullion has become very volatile, but has also increased so rapidly that the attractive profits that were attainable in the gold bullion and gold share markets attracted many speculators. The volatile gold price over this period, however, has also been the cause of many lost fortunes. The following quotation extracted from the Supplement to the Financial Mail (May 30 1980) emphasizes this point with some cynicism.

"Gold: A yellow metal greatly prized for its convenience in the various kinds of robbery known as trade. The word was formerly spelled 'God' - the 'l' was inserted to distinguish it from another .... deity. Gold is the heaviest of all the metals except platinum, and a considerable amount of it will sink a man so much more quickly and deeply than platinum that the latter is made into lifebelts and used as a lifting power for balloons. British gold, an imaginary metal greatly used in the manufacture

of American traitors to the patriotic axiom that two and two are five."

Investors interested in the gold market need not, however, hold a physical stake in gold to enter gold related markets, but can speculate in investments such as gold shares and futures markets as well. It is indeed surprising that so little research in these markets has been published to date, especially in the South African context, since not only has the gold share sector on the Johannesburg Stock Exchange attracted vast sums of money from foreign and local investors alike, but the entire South African economy relies on the performance of these markets to some extent. It may be that the remarkable lack of published empirical research in this field could be attributed to researchers in this field being more concerned with being rich than being famous.

In this thesis a detailed analysis of the South African gold share market is carried out with the emphasis on the valuation of gold shares.

In Chapter 2 the well known concept of market efficiency is tested for the gold share market on the JSE using three different statistical tests. The tests were conducted over both bull and bear phases of the gold share market separately as well as over the periods partitioned according to the operation of the securities rand, the blocked rand and the financial rand - both the case of the local and foreign investor are considered. The study revealed that none of the above mentioned partitionings had any significant difference in the degree of efficiency, however, in general the gold share market was found to be more inefficient than might be assumed from previous studies. Although inefficiency was found, the magnitude of the non-random behaviour exhibited by the relevant "inefficient" gold shares was thought to be too small to discard the concept of an efficient gold share market.

Chapter 3 includes a theoretical discussion on the market model as well as the Markowitz approach to portfolio selection, incorporating empirical studies on the JSE. A study on beta coefficients show that betas do not differ significantly over bull and bear markets on the JSE while a study based on portfolio selection between the various sectors shows the relative importance of gold shares for portfolio selection over past periods. A further study on portfolio selection based solely on gold shares shows very different ranges of portfolio returns and standard deviations attainable over the past 5 years. The study also views Kruger Rands for portfolio selection, surprisingly indicating that Kruger Rands do not exhibit desirable portfolio selection qualities.

Traditional share evaluation models are discussed in Chapter 4. Further two share evaluation models are proposed for gold shares, the second one being a more sophisticated version of the first.

The components of gold mine profitability are discussed in detail in Chapter 5 and specific attention is given to factors influencing the gold price. Regression techniques are applied to estimate costs, capital expenditure and production of gold mines. It was found that good estimates of costs were obtained using the regression technique. The sophisticated policy of gold mine tax and lease payments is also discussed here.

In Chapter 6 the two models proposed in Chapter 4 are researched using estimates of the components obtained in Chapter 5. The models were viewed in terms of the "implied gold price" reflected by a gold share at given yields. It was found that the first model was misspecified but that the second more sophisticated model performed well over the period under study. Further the second model was used to determine weekly yields over the last four years. The slight decrease in the trend of these yields indicate that investors tend to view gold shares as being a less risky investment than in the past. Frequent short term fluctuations in yield from the general trend were found to persist in the gold shares researched. A trading rule was thus formulated, where "buy" and "sell" signals were based on these short term fluctuations from the general trend. It was found that five of the six mines researched here showed substantially superior profits using this trading rule over a naive "buy and hold" policy for the past three years. It is felt, however, that further research in connection with the formulation of the trading rule is required, specifically with reference to the magnitude of the filters and the length of the moving averages used, as well as using different periods to test the model.

Estimates of earnings per share as well as share prices under various gold price, inflation and expected yield scenarios are given in Chapter 7 using the second model.

Finally, directions of future research leading on from the work researched in this thesis is viewed. The major thought here is that the second model should be used interactively so that problems of obtaining out-of-period estimates can be avoided.

All computer-based work was performed on the University of Cape Town's UNIVAC 1100 computer. BMDP P1R and P2R packages were used for all the regression analysis in this thesis and all other programs used for empirical computations in this thesis were written in the FORTRAN language.

CHAPTER 2

MARKET EFFICIENCY AND EMPIRICAL RESULTS ON THE JOHANNESBURG STOCK EXCHANGE

2.1 Introduction

The concept of market efficiency has received a lot of favourable attention in recent literature.

Stern (1977) defines market efficiency in the following way:

> *"One can call a capital market efficient if (1) security prices always 'fully reflect' available information determining a company's intrinsic, or fair, market value, and (2) no investors in the market have a monopoly of price sensitive information."*

The implication of market efficiency for technical analysts is pointed out by Stern (1977) who continues

> *"The two conditions together imply that investors who employ trading rules to select investments based on available information cannot outperform a simple buy-and-hold policy."*

Brealey and Myers (1981, p.256) express their view of valuing securities under the concept of efficient capital markets by the following statement:

> *"If capital markets are efficient, then purchase or sale of any security at the prevailing market price is a zero net present value transaction."*

Clearly then, price changes in an efficient market will be random. Brealey and Myers explain why this is so by saying

> *"If prices always reflect all relevant information, then they will only change when new information arrives. But new information cannot by definition be predicted ahead of time (otherwise it would not be new information). Therefore price changes cannot be predicted ahead of time. To put it another way, if stock prices already reflect all that is predictable, then stock price changes must reflect only the unpredictable."*

According to Brealey and Myers (1981) the concept of efficient markets was a chance discovery by Kendall, who in 1953 met with the Royal Statistical Society to discuss one of Kendall's papers (c.f. Kendall (1953)) concerning the behaviour of stock and commodity prices. Brealey and Myers (1981, p.257) continue:

> *"Kendall's purpose had been to separate out regular price cycles, but to his surprise he could not find any such cycles. Each series appeared to be 'a "wandering" one, almost as if once a week the Demon*

of Chance drew a random number .... and added it to the current price to determine the next week's price.' In other words, prices seemed to follow a random walk."

Kendall, in fact, was making a startling suggestion at the time, i.e. that price changes are independent. In fact 53 years earlier this idea was proposed by Louis Bachelier (c.f. Cootner (1964)) in a doctoral thesis that was almost forgotten. During the 1930's Working (1934), a food economist, also detected the random behaviour of commodity prices.

More recently numerous researchers have applied various statistical efficiency tests resulting in support for the random walk concept. The more important studies include Osborne (1959), Cootner (1962), Granger and Morgenstern (1963), Mandelbrot (1963), Young (1971) and Schwartz and Whitcomb (1977). Fama (1965) conducted perhaps the most important of these studies containing the most detail on the topic.

As evidence supporting the random walk concept accumulated, the focus of attention shifted to the kind of market process which would produce such a result. This led to the theory of efficient markets in which prices adjust rapidly to new information.

Roberts (1967) defined three forms of market efficiency.

(i) Weak form: In this case current prices fully reflect the information contained in the record of past prices. That is, the investor cannot enhance his ability to select stocks by knowing the history of successive prices and the results of analyzing them in all possible ways.

(ii) Semi-strong form: In this form current prices fully reflect published information. Thus any efforts to acquire and analyze this public information cannot be expected to produce superior results.

(iii) Strong form: Here, even privileged information cannot be used to obtain superior investment results. That is, prices reflect not just public information but all information that can be acquired by fundamental analysis of the company and economy.

The validity of the random walk model which will be discussed below shows that the market is at least efficient in the weak form.

2.2 The Random Walk Model

The random walk model has been widely discussed in the literature. For a more detailed discussion, the full implications of the model are given by Fama (1965).

The model can be formulated as:

$$P_t = P_{t-1} + e_t$$

where P_t is the price at time t and e_t is the random error, assuming

(i) $E(e_t) = 0$ for all t

(ii) e_t and e_s are independent for all $s \neq t$.

Several forms of the random walk model have resulted in the literature due to a lack of statistical understanding by some researchers. The confusion arose in the interpretation of the error terms, where a lack of correlation, while a necessary condition for independence, is not generally a sufficient condition. The names given to the different series where $P_t = P_{t-1} + e_t$

are: (i) second order martingale - if e_t and e_s are uncorrelated for all $t \neq s$

(ii) strict random walk - if e_t and e_s are independent for all $t \neq s$

(iii) a Wiener process - if e_t and e_s are independent for all $t \neq s$ and the e_t are all identically normally distributed.

The second order martingale form is the most common form found in the literature, and for practical considerations is sufficient as far as the random walk model is concerned. This form is all that is required since as far as the investor is concerned a lack of correlation implies that one series cannot be predicted from the other by means of a linear relationship.

Affleck-Graves (1974) used the change of the logarithm of price to test the random walk model, i.e.

$$e_t = \log_e P_t - \log_e P_{t-1}$$

instead of the model $e_t = P_t - P_{t-1}$. This can be justified on two counts:

Firstly, the difference in the logarithms of price is the return with continuous compounding over the period considered (c.f. Affleck-Graves (1974, p.6.4)).

Secondly, Granger and Morgenstern (1970) have shown that if the percentage change in price e_t/P_{t-1} is small (this is usually the case) then the above two models are approximately the same.

2.3 Empirical Results on the Johannesburg Stock Exchange

In capital markets throughout the world, investment analysts study an individual company's business and try to uncover information that will shed new light on the value of the stock. Competition among investors is keen which thus rapidly impounds any new information in the price of securities thus yielding fairly priced securities.

However, most of the research concerning market efficiency has been conducted on the New York Stock Exchange, and it is thus necessary to check whether the stock prices on the Johannesburg Stock Exchange are subject to a sufficiently intense degree of competitive investment analysis to conclude that the South African market is efficient.

Affleck-Graves and Money (1975) conducted a study on 50 shares representing a cross-section of shares listed on the JSE. The study involved testing the correlation between the e_t and e_s for $t \neq s$ (called the autocorrelation). The results showed a presence of 7 out of 50 autocorrelations greater than two standard deviations from zero for lags of one or two weeks (i.e. 14 for lags of one and two weeks). Under the null hypothesis of zero autocorrelation, approximately 95 per cent of the values would be expected to be within two standard deviations from zero. Affleck-Graves and Money thus concluded that although a very slight dependence was indicated, the shares on the JSE did not display any marked non-zero autocorrelation.

It is worth noting that similar results were obtained by various researchers who have conducted similar studies on other Exchanges. Table 2.1 below extracted from the paper of Affleck-Graves and Money (1975) shows support for the above statement.

2.4 Empirical Study on Efficiency of Gold Shares on the JSE

Since the behaviour of gold shares is the major concern of this thesis a comprehensive study was conducted concentrating entirely on the gold share sector of the JSE.

This study attempts to determine if there is any difference in degree of efficiency on the Johannesburg Stock Exchange for foreign and local investors as well as researching

TABLE 2.1

Author	Exchange	Differencing Interval	Average Auto-correlation (Lag of 1 Period)	S.D.
Fama (1965)	New York	4 days	-0,038	0,058
Solnik (1973)	London	1 week	-0,055	0,060
Solnik	Paris	1 week	-0,049	0,060
Solnik	Frankfurt	1 week	0,056	0,060
Graves & Money	Johannes-burg	1 week	-0,018	0,061
Fama	New York	9 days	-0,057	0,086
Solnik	London	2 weeks	0,005	0,090
Graves & Money	Johannes-burg	2 weeks	0,000	0,087
Fama	New York	16 days	-0,009	0,116
Solnik	London	4 weeks	0,020	0,120
Graves & Money	Johannes-burg	3 weeks	0,037	0,107

differences in degree of efficiency over bull and bear market phases.

The aim of this study therefore is divided into three cases. Firstly, to determine whether there is any significant difference in the efficiency of gold share prices quoted on the JSE during the period over which the dual exchange rate was operative, viewed by local investors and foreign investors apart. Secondly, whether there was any difference in efficiency of the local market before and after the financial rand discount was introduced. Thirdly, whether there is any difference in efficiency of gold share prices over bull and bear market phases, again viewed by local and foreign investors seperately.

Efficiency Tests

Three statistical tests were used on the data:

1. The Runs Test

A run is defined to be a sequence of sign changes of the same sign (logarithm of price changes is used in this study). The runs test is constructed as follows (Wallis and Roberts (1956)):

Assuming that the sample proportions of the positive, negative and zero price changes are good estimates of the population proportions, then under the null hypothesis of independence, the total expected number of runs is

$$m = \frac{\left(T(T+1)-\sum_{i=1}^{3} t_i^2\right)}{T} \qquad (2.1)$$

where T is the total number of observations; t_i for $i = 1,2,$ or 3 is the total number of positive, negative and zero changes in the sample respectively. The variance of m is

$$\sigma_m^2 = \frac{\sum_{i=1}^{3} t_i^2\left(\sum_{i=1}^{3} t_i^2+T(T+1)\right)-2T\sum_{i=1}^{3} t_i^2-T^3}{T^2(T-1)} \qquad (2.2)$$

It can be shown that for large T, m is approximately normally distributed (Wallis and Roberts). The test statistic used was

$$K = (R+\tfrac{1}{2}-m)/\sigma_m$$

where R is the number of runs observed (headed: "ACTUAL" in the tabled results), the $\frac{1}{2}$ is a discontinuity adjustment and m is the expected number of runs (headed: "EXPECTED" in the tabled results. The test for independence was performed at a significance level of 0,10 in this study. The tabled result of the test is headed: "DEPENDENCE", where a "NO" indicates there is no dependence.

2. The Autocorrelations Test

The relationship between the value of a random variable at time t and its value s periods later can be measured by the autocorrelation, Q_s;
where

$$Q_s = \frac{E\{(U_t-\bar{U})(U_{t+s}-\bar{U})\}}{E(U_t-\bar{U})^2} \qquad (2.3)$$

$\bar{U}$ is the mean of the series $\{U_t\}$ of T price changes, $t = 1,2,\ldots,T$.

From the observed series, an estimate of Q_s, i.e. the empirical autocorrelation coefficient, can be computed using the formula (c.f. Malinvaud (1966)):

$$r_s = \frac{\sum_{t=1}^{T-s} U_t \cdot U_{t+s} - \left(\sum_{t=1}^{T-s} U_t \cdot \sum_{t=s+1}^{T} U_t\right)/(T-s)}{\sum_{t=1}^{T} U_t^2 - \left(\sum_{t=1}^{T} U_t\right)^2/T} \qquad (2.4)$$

The above statistic appears in the tabled results in columns headed: "1", "2",...,"7", for differencing intervals of one week for lags of 1,2,...,7.

The column headed "S.D." contains an estimate of the standard deviation of r_s, computed using the formula (c.f. Anderson (1942)):

$$var(r_s) = \frac{(n-1)}{(n-2)^2} \tag{2.5}$$

The above formula is based on the assumptions of normality and constant variance in the series. These assumptions may not necessarily hold, however, this does not constitute a serious disadvantage as the results are only intended as an indication of how the true autocorrelation might behave.

Under the null hypothesis of zero autocorrelation, approximately 95% of the values would be expected to fall within two standard deviations from zero.

3. The Q-Statistic Test

A test based on the empirical autocorrelation coefficients at various lags was used. The formula used for computing the test statistic is given by (c.f. Box and Pierce (1970)).

$$Q = n \sum_{k=1}^{h} r^2_{s_{(k)}} \tag{2.6}$$

where $r_{s_{(k)}}$ is the empirical autocorrelation coefficient computed using equation (2.4) where $k = 1,2,...,7$. For h

sufficiently large Box and Pierce showed that Q is distributed as χ^2_{h-1}.

The Q values will be shown in the column's headed "Q" in the tabled results. (These values are compared to $\chi^{2(0,10)}_{7-1}$ = 10,645 in this study and all values exceeding this limit imply the null hypothesis of zero autocorrelation for the specific security is rejected.)

The Sampled Data

The data which was used throughout the analysis consisted of the change in the logarithm of weekly prices of 37 gold shares quoted on the JSE.

The 37 gold shares do not represent a random sample of all the quoted gold shares but were chosen as only the data for these shares was at hand over the desired period.

The data covered the period 2 February 1973 to 31 December 1981. The names of the shares are listed in Appendix A.

Partitioning of the Data

Case 1: Difference in efficiency for local and foreign investors during the period over which the financial rand market was operative

Before the abolishment of the financial rand discount in February 1983, foreign investors had access to gold shares listed on the JSE at a discounted price via the financial rand discount (formally introduced in January 1979). Hence, two markets can be considered; a foreign and a local market where different prices of shares prevailed.

Thus the first case to be considered is whether there is any difference in the efficiency of gold share prices (adjusted by the financial rand discount) for foreign investors and the efficiency of prices as quoted on the JSE (i.e. for local investors).

Hence two data sets were constructed for testing the above case, one with the prices adjusted via the financial rand discount and the other without the adjustment. Both data sets covered the period from 2 January 1979, when the financial rand was first introduced, to 31 December 1981 (i.e. 155 observations).

TABLE 2.2

		No. of shares exhibiting significant non-random behaviour		
	No. of obs.	Runs test	Autocorrelation test	Q-statistic test
local investors	155	7	7	7
foreign investors	155	2	2	10

Table 2.2 displays a summary of the number of shares (out of 37) that exhibited significant non-random behaviour at the 10% level of significance using the three different statistical tests. Table 2.3 and Table 2.4 show the detailed statistics obtained using the runs test for local and foreign investors

respectively, while Tables 2.5 and 2.6 show the statistics obtained using the autocorrelation and Q-statistic test for local and foreign investors respectively.

To test if the number of significant shares are more than sampling theory suggests, a test* based on the binomial distribution was performed at the 5% level. This test indicates that with 37 shares being simultaneously tested at the 10% level, 7 or more would have to be rejected to constitute the existence of non-random behaviour. Inspection of Table 2.2 shows that the results of all three tests exhibit significant non-random behaviour at the 5% level, however, it should be noted that the critical value was only exceeded by a marginal amount, and at a 2½% level the result of all three tests would indicate that no significant non-random behaviour persists. For the foreign investors only the Q-statistic test resulted in significant non-random behaviour.

It is worth noting that the two shares Durban Deep and West Rand Consolidated (i.e. share numbers 5 and 31) exhibited significant non-random behaviour in almost all the tests as can be seen from Tables 2.3, 2.4, 2.5 and 2.6.

It could thus be concluded that significant non-random behaviour was detected in a small proportion of the shares,

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*This is a binomial process with $n = 37$ and $p = 0{,}1$ which can be approximated by the normal distribution with $\mu = np$ and $\sigma^2 = npq$. At a 5% significance level the test statistic becomes $np + 1{,}64\sqrt{npq}$ i.e. 6,693.

TABLE 2.3 Financial Rand Period : Local Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	97.00	91.45	.85186	NO
2	81.00	79.65	.62389	NO
3	74.00	83.81	.05438	NO
4	70.00	81.78	.02649	YES
5	76.00	87.09	.03408	YES
6	79.00	82.03	.33555	NO
7	79.00	88.96	.05143	NO
8	87.00	87.30	.51397	NO
9	89.00	83.01	.86311	NO
10	80.00	82.82	.34748	NO
11	84.00	85.05	.46274	NO
12	71.00	81.04	.05206	NO
13	87.00	83.81	.73787	NO
14	78.00	82.03	.27668	NO
15	86.00	86.19	.52092	NO
16	91.00	83.18	.92591	NO
17	81.00	91.16	.04662	YES
18	86.00	85.66	.55683	NO
19	84.00	87.74	.29006	NO
20	82.00	86.39	.25243	NO
21	78.00	83.84	.17496	NO
22	82.00	86.70	.23660	NO
23	73.00	87.96	.00630	YES
24	82.00	84.70	.34767	NO
25	91.00	86.65	.79964	NO
26	76.00	83.09	.12203	NO
27	74.00	83.18	.06563	NO
28	80.00	86.56	.15002	NO
29	80.00	91.39	.02986	YES
30	82.00	91.79	.05145	NO
31	75.00	87.01	.02515	YES
32	70.00	84.32	.00899	YES
33	86.00	85.73	.55317	NO
34	80.00	86.88	.13516	NO
35	72.00	79.74	.11287	NO
36	87.00	85.82	.61271	NO
37	86.00	91.25	.20304	NO
AVERAGES	80.97	85.59		

TABLE 2.4 Financial Rand Period : Foreign Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	87.00	77.99	.93803	NO
2	83.00	76.95	.85863	NO
3	74.00	76.64	.35721	NO
4	77.00	76.13	.58982	NO
5	79.00	78.44	.56838	NO
6	73.00	76.43	.31438	NO
7	79.00	77.36	.63621	NO
8	77.00	76.70	.55226	NO
9	89.00	77.79	.97117	YES
10	80.00	78.26	.64361	NO
11	85.00	76.70	.92609	NO
12	77.00	76.43	.57020	NO
13	83.00	77.53	.83419	NO
14	79.00	76.43	.69394	NO
15	77.00	76.70	.55226	NO
16	97.00	76.70	.99969	YES
17	76.00	78.05	.39908	NO
18	81.00	76.13	.81329	NO
19	71.00	77.53	.16320	NO
20	71.00	77.17	.17705	NO
21	74.00	75.08	.46130	NO
22	83.00	77.68	.82788	NO
23	74.00	75.81	.41400	NO
24	80.00	77.17	.70697	NO
25	79.00	77.36	.63621	NO
26	67.00	74.68	.11258	NO
27	74.00	75.45	.43658	NO
28	71.00	77.36	.16952	NO
29	70.00	76.96	.13999	NO
30	75.00	76.70	.42168	NO
31	70.00	77.53	.12629	NO
32	77.00	76.70	.55226	NO
33	81.00	77.53	.74069	NO
34	77.00	77.53	.49789	NO
35	71.00	77.17	.17705	NO
36	76.00	77.68	.42432	NO
37	83.00	76.95	.85863	NO
AVERAGES	77.76	76.96		

TABLE 2.5 Local Investors : Financial Rand Period

SHARE	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	-.05848	.06593	.09077	.09608	.00639	-.01627	-.00235	.08138	3.93467
2	-.11195	.02335	-.02929	.03122	.02744	-.03815	-.01833	.08138	2.68823
3	.10038	.05146	.02996	.03811	.04653	-.13085	-.12072	.08138	7.53600
4	.01227	-.02848	.04247	.01303	.19780	-.09139	-.06910	.08138	8.49894
5	.17700	.02597	.10490	-.04031	.14705	.01932	.03118	.08138	10.41117
6	-.08484	-.05877	.12229	-.13721	.04534	-.04813	.06200	.08138	8.10800
7	.18902	.20012	.18057	.02742	.16606	.03589	.07458	.08138	22.10801
8	.00745	.00349	.03866	-.00380	.00115	.01077	-.00430	.08138	.26366
9	-.20844	.00443	.00580	-.01308	.12568	-.05625	-.01745	.08138	9.69211
10	-.00845	-.05401	.04576	.06138	.17099	.09480	.01373	.08138	7.27840
11	.09208	-.04079	.05734	.01561	.20782	-.00706	-.01576	.08138	8.80289
12	.10827	-.07684	.07283	.00808	.08039	.02944	-.09007	.08138	5.91969
13	-.03556	.07348	.03836	-.02852	.16091	-.04478	-.05797	.08138	6.19168
14	-.07310	.18098	.01302	.03197	.11395	-.09121	-.07480	.08138	10.19316
15	-.03015	-.05858	.02189	.04365	.19690	-.15914	-.04285	.08138	11.18943
16	-.19409	.00979	.11820	-.08218	.14564	-.07092	.07620	.08138	13.94253
17	.03522	.02194	-.03586	.02570	.15378	-.11881	.03110	.08138	6.52966
18	.00195	-.01470	.02062	-.03415	.16674	.03116	-.05775	.08138	5.22354
19	.14190	.08439	.09232	.00947	.18689	-.00480	.06069	.08138	11.47346
20	.17355	-.01096	.08712	.09919	.05564	-.03489	-.03513	.08138	8.19530
21	.02573	-.05208	.00751	.06832	.14210	-.00638	.08484	.08138	5.47159
22	.02790	-.05529	.00442	.07065	.07723	-.11462	-.05080	.08138	4.70139
23	.16571	.09788	.04497	.09309	.11170	.03354	.05062	.08138	9.83952
24	-.03831	-.04798	.06078	-.00629	.08494	-.06138	.05591	.08138	3.32814
25	.08457	-.05109	-.07566	.00072	.14131	-.04531	-.04105	.08138	6.03564
26	-.01225	.09967	.01198	.12620	.06270	-.00261	.04641	.08138	4.96592
27	.08562	-.07001	.03243	.11643	.11721	-.17416	.06727	.08138	11.61656
28	.04004	-.00876	.05104	.01385	.15820	.06673	-.06089	.08138	5.80039
29	.10691	.09763	.01176	.07783	.20037	-.05292	-.03055	.08138	10.93956
30	.03190	.07115	.05016	-.00965	.05361	-.03722	.03966	.08138	2.23633
31	.21225	.08785	.02583	-.06590	.09415	-.07670	.06902	.08138	11.90251
32	.12794	-.08494	-.02338	.04098	.18417	-.06148	-.06503	.08138	10.43145
33	.03066	.03950	-.04398	.04964	.24470	-.01577	.03676	.08138	10.53005
34	.08794	-.06243	-.06451	.11262	.14155	-.10302	-.08161	.08138	10.13120
35	.04865	-.07022	-.03702	-.02174	.12486	-.11827	-.04522	.08138	6.27763
36	.02466	.03999	.05064	-.02225	.09874	-.03266	-.02587	.08138	6.27763
37	.03689	.08807	.02237	.06827	.17933	-.10907	-.03602	.08138	9.18353
AVERAGE	.03570	.01408	.03370	.02363	.12486	-.04331	-.00659		

TABLE 2.6 Foreign Investors : Financial Rand Period

	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK								
SHARE	1	2	3	4	5	6	7	S.D.	Q
1	-.10099	.11894	.00681	.11588	-.02980	-.00144	-.00407	.08138	5.96396
2	-.11798	.02822	.05958	-.05039	.05540	-.14764	.02343	.08138	7.11809
3	-.01372	.09529	.02824	-.03702	.00738	-.15470	-.07804	.08138	6.39306
4	-.01053	.02518	.06327	-.07349	.17464	-.21247	-.07045	.08138	13.97582
5	.12751	.05027	.11326	-.10134	.17027	-.05226	.05727	.08138	11.84087
6	-.07846	-.01654	.09670	-.10091	.00933	-.11163	.06112	.08138	6.50631
7	.12546	.17741	.16159	-.02963	.18217	-.01952	.02603	.08138	16.70112
8	-.05987	.03524	.03231	-.01640	-.03375	-.02786	.00641	.08138	1.24672
9	-.20512	.09588	.03928	-.06635	.11400	-.16187	-.00836	.08138	14.85816
10	-.04033	.00797	.02271	.01199	.15313	.00585	.05080	.08138	4.37559
11	.00115	-.04050	.03014	-.02636	.21682	-.11666	.00961	.08138	9.84941
12	-.00976	.02956	.04908	.02124	.04178	-.04731	-.07772	.08138	2.13361
13	-.09933	.10528	.04326	-.06693	.14718	-.10513	-.05364	.08138	9.68513
14	-.11446	.17842	.03587	-.00206	.06472	-.16865	-.08338	.08138	13.21462
15	-.08146	-.04992	.05015	.02096	.13143	-.19065	-.00509	.08138	10.12234
16	-.23758	.05089	.16173	-.10231	.13397	-.15254	.06664	.08138	21.76234
17	-.04456	.01847	.01365	.00362	.14049	-.16861	.05110	.08138	8.20904
18	-.07637	.04139	.01502	-.04347	.11508	-.04554	-.05496	.08138	4.31193
19	.10974	.07201	.08179	-.01529	.16819	-.06258	.08844	.08138	9.88319
20	.08810	.02820	.08231	.06055	.04021	-.09134	-.00476	.08138	4.46311
21	-.06647	.02680	-.03370	.01570	.09125	-.14328	.09890	.08138	6.95419
22	-.01742	-.00966	.01800	-.00701	.06917	-.13706	.01947	.08138	3.80685
23	.09968	.12635	.01570	.07720	.07298	-.00156	.04158	.08138	6.03119
24	-.16082	.03489	-.00789	-.00952	.05208	-.11708	.06520	.08138	7.37742
25	-.02133	-.04106	-.02939	-.01402	.10679	-.18651	-.01702	.08138	7.65076
26	-.06021	.06797	.02480	.06017	.07143	-.12975	.04002	.08138	5.54716
27	-.02955	.00756	.01894	.09543	.08353	-.23725	.02821	.08138	11.46658
28	.03139	.01040	.03879	.01174	.11973	-.02059	-.03147	.08138	2.84694
29	.03254	.15941	.00248	.10601	.16978	-.07241	-.00301	.08138	11.05561
30	.00259	.13410	.05442	-.03894	.04502	-.11853	.05780	.08138	6.45004
31	.11361	.16016	.03468	-.10202	.08877	-.09636	.05527	.08138	10.84009
32	.04473	-.04211	-.02491	.00823	.15690	-.15226	-.01091	.08138	8.06684
33	-.04980	.10137	-.04261	.00156	.20222	-.09472	.05188	.08138	10.33790
34	-.08048	.03137	-.07782	.01970	.18656	-.17351	-.06936	.08138	12.87850
35	-.07612	.03226	-.06293	-.02200	.10728	-.17509	-.05987	.08138	8.78223
36	.00331	.08505	.02836	-.04633	.12172	-.10855	-.05669	.08138	6.16113
37	-.01830	.12247	.05714	.07259	.03980	-.15287	-.05669	.08138	8.01315
AVERAGE	-.02949	.05565	.03245	-.00527	.10237	-.11216	.00415		

but that no obvious difference in the degree of efficiency was found for local and foreign investors apart.

Case 2: Difference in efficiency for local investors before financial rand market

The second case that was considered was whether there was any difference in the efficiency of gold shares for local investors before the introduction of the financial rand market and after.

For a review of the management of the dual exchange rate system from 1976 to 1978, see Gidlow (1979). On the basis of this review, the following partitions were considered:

2/2/73 - 6/2/76	blocked rand market (157 observations)
6/2/76 - 19/12/78	securities rand market (151 observations)
2/1/79 - 31/12/81	financial rand market (155 observations)
2/2/73 - 29/12/78	blocked rand and securities rand
2/2/73 - 31/12/81	entire period.

Note as the only consideration here is the effect the above five partitions had on the local market, the above five partitions contained unadjusted data quoted on the JSE.

Table 2.7 displays a summary of the number of shares (out of 37) that exhibited significant non-random behaviour for local investors only at the 10% level of significance using the three statistical tests. Tables 2.8 to 2.16 show the detailed results of this section.

TABLE 2.7

Period	No. of obs.	No. of shares exhibiting significant non-random behaviour		
		Runs test	Autocorrelation test	Q-statistic test
Blocked rand	157	7	4	7
Securities rand	151	2	8	7
Financial rand	155	7	7	7
Blocked rand & Securities rand	308	6	9	13
Entire period	463	6	12	16

The test statistic based on the binomial distribution yielded critical values of 6,693 and 7,277 at the 5% and 2½% significance levels respectively. Table 2.7 thus shows that 11 and 5 out of the 15 cases considered exceeded the critical limits at the 5% and 2½% significance levels respectively. Further, there was no discernable evidence indicating that any of the first three periods shown in Table 2.7 exhibited any different levels of efficiency.

It should be noted, however, that in the last 2 partitionings (i.e. blocked rand and securities rand and the entire period) both tests based on the autocorrelations had a higher number of rejected cases than all the other periods.

The reason for this is that the estimated standard deviation of r_s as discussed previously is a function of the sample size, hence the larger the sample size the smaller the standard deviation (see equation (2.5) and the associated assumptions). However the autocorrelations are of similar magnitude and since the critical value of the test statistic is based on the standard deviation, the larger samples tend to have more securities being rejected.

TABLE 2.8

	Average Autocorrelations of the 37 Shares						
Period	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6	Lag 7
1.Blocked rand	.04753	.06067	.03566	-.04642	.03812	-.02531	-.00441
2.Securities rand	.06824	.02140	-.04557	-.08576	-.00818	-.00818	.00428
3.Financial rand	.03570	.01408	.03370	.02363	.12486	-.04331	-.00659
4.Blocked rand & securities rand	.05900	.04065	-.00178	-.06454	.00292	-.01974	-.00181
5.Entire period	.05323	.03312	.01232	-.03497	.04064	-.02194	-.00247

The averages shown in Table 2.8, while of interest, are not completely meaningful since it can be argued that each share should be viewed separately as they are individual entities. Secondly no attempt was made to compute the average standard deviation, since the 37 series of price changes are obviously not independent. Nevertheless the results displayed in Table 2.8 are consistent with the earlier findings, i.e. that there is slightly more non-random behaviour than sampling theory suggests. This is evident by noticing that all the average autocorrelations for the various periods are positive for both lag 1 and lag 2, also they are all negative for the 6th lag. Since efficiency implies that there should be no

TABLE 2.9

BLOCKED RAND LOCAL INVESTORS

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	85.00	92.24	.12499	NO
2	89.00	91.08	.39232	NO
3	94.00	91.69	.72054	NO
4	92.00	89.29	.70597	NO
5	84.00	86.73	.35436	NO
6	86.00	94.94	.07351	NO
7	83.00	86.86	.28730	NO
8	82.00	93.42	.03028	YES
9	82.00	82.30	.51307	NO
10	97.00	91.55	.84468	NO
11	83.00	89.23	.16641	NO
12	86.00	91.55	.19494	NO
13	86.00	83.80	.67262	NO
14	86.00	93.03	.13233	NO
15	74.00	86.81	.01981	YES
16	88.00	87.52	.56527	NO
17	79.00	92.03	.01594	YES
18	80.00	86.66	.14401	NO
19	78.00	87.61	.06304	NO
20	91.00	90.10	.59400	NO
21	89.00	87.39	.64041	NO
22	79.00	83.94	.23113	NO
23	87.00	86.02	.59728	NO
24	77.00	90.10	.01646	YES
25	87.00	91.32	.25467	NO
26	93.00	90.12	.71635	NO
27	92.00	89.23	.70982	NO
28	70.00	84.77	.00878	YES
29	80.00	90.81	.03647	YES
30	95.00	87.68	.90534	NO
31	79.00	86.73	.11309	NO
32	82.00	88.54	.15472	NO
33	84.00	80.49	.74091	NO
34	78.00	88.39	.04776	YES
35	86.00	89.34	.31561	NO
36	80.00	89.97	.05413	NO
37	91.00	93.54	.36346	NO
AVERAGES	84.70	88.82		

TABLE 2.10

SECURITIES RAND LOCAL INVESTORS

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	86.00	87.82	.40942	NO
2	87.00	87.49	.50069	NO
3	90.00	89.05	.59975	NO
4	89.00	90.42	.43615	NO
5	82.00	87.04	.21618	NO
6	82.00	89.21	.12107	NO
7	91.00	91.25	.51734	NO
8	103.00	96.14	.90244	NO
9	81.00	86.18	.20961	NO
10	76.00	83.62	.10798	NO
11	84.00	84.31	.51315	NO
12	83.00	89.87	.13279	NO
13	88.00	85.50	.69668	NO
14	87.00	83.70	.74186	NO
15	87.00	86.28	.58297	NO
16	89.00	84.58	.80074	NO
17	83.00	91.86	.07133	NO
18	78.00	83.78	.18363	NO
19	83.00	88.62	.18444	NO
20	85.00	86.15	.32156	NO
21	87.00	85.48	.63598	NO
22	74.00	82.67	.07838	NO
23	95.00	91.97	.73370	NO
24	79.00	83.70	.23634	NO
25	88.00	86.51	.63558	NO
26	77.00	88.55	.02742	YES
27	79.00	80.60	.42578	NO
28	84.00	85.24	.44934	NO
29	101.00	93.53	.91964	NO
30	84.00	89.95	.17066	NO
31	89.00	86.67	.68868	NO
32	83.00	87.77	.22953	NO
33	85.00	84.22	.58738	NO
34	78.00	81.94	.27663	NO
35	97.00	86.18	.97468	YES
36	81.00	85.34	.25401	NO
37	95.00	89.56	.85140	NO
AVERAGES	85.68	87.16		

TABLE 2.11 Blocked and Securities Rand Period : Local Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	170.00	178.37	.17012	NO
2	175.00	178.32	.36632	NO
3	182.00	179.32	.62738	NO
4	180.00	178.45	.59814	NO
5	165.00	173.05	.18278	NO
6	166.00	182.68	.02431	YES
7	173.00	177.60	.30967	NO
8	184.00	188.72	.30222	NO
9	162.00	167.88	.26146	NO
10	172.00	174.41	.40844	NO
11	166.00	172.99	.21641	NO
12	167.00	180.51	.05679	NO
13	173.00	168.77	.71297	NO
14	174.00	175.96	.42993	NO
15	162.00	172.95	.10497	NO
16	178.00	171.42	.80116	NO
17	163.00	183.14	.00824	YES
18	158.00	169.65	.09207	NO
19	162.00	176.88	.04112	YES
20	175.00	177.60	.39949	NO
21	175.00	172.27	.65166	NO
22	152.00	165.99	.05382	NO
23	181.00	178.37	.64776	NO
24	157.00	173.05	.03115	YES
25	174.00	178.41	.31790	NO
26	171.00	177.71	.22634	NO
27	170.00	169.10	.56628	NO
28	154.00	169.75	.03476	YES
29	180.00	184.32	.31934	NO
30	178.00	176.14	.61229	NO
31	167.00	172.64	.26842	NO
32	164.00	175.42	.09411	NO
33	168.00	164.28	.69026	NO
34	155.00	171.19	.03022	YES
35	183.00	174.58	.85835	NO
36	161.00	174.64	.05702	NO
37	186.00	183.36	.64895	NO
AVERAGES	169.81	175.42		

TABLE 2.12 Blocked and Securities Rand Period : Foreign Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	265.00	268.38	.38779	NO
2	255.00	257.97	.40383	NO
3	256.00	263.31	.25013	NO
4	249.00	260.22	.14524	NO
5	240.00	259.02	.03447	YES
6	244.00	264.62	.02343	YES
7	251.00	265.53	.08278	NO
8	270.00	275.40	.31143	NO
9	250.00	249.52	.53784	NO
10	251.00	257.69	.27220	NO
11	249.00	256.51	.24522	NO
12	237.00	261.40	.00902	YES
13	259.00	251.67	.77765	NO
14	250.00	257.03	.26077	NO
15	246.00	257.14	.14831	NO
16	268.00	254.62	.91259	NO
17	243.00	273.36	.00148	YES
18	243.00	253.94	.15411	NO
19	244.00	262.51	.03811	YES
20	256.00	262.71	.26980	NO
21	251.00	255.26	.35479	NO
22	233.00	251.21	.04163	YES
23	253.00	265.53	.11722	NO
24	237.00	258.52	.01927	YES
25	263.00	264.23	.47129	NO
26	245.00	261.54	.05640	NO
27	243.00	251.23	.22372	NO
28	233.00	255.06	.01770	YES
29	260.00	274.93	.07484	NO
30	259.00	267.58	.21170	NO
31	242.00	258.94	.05316	NO
32	234.00	259.78	.00647	YES
33	253.00	250.11	.62850	NO
34	233.00	256.16	.01314	YES
35	253.00	253.84	.48670	NO
36	246.00	259.22	.10606	NO
37	271.00	272.97	.44158	NO
AVERAGES	249.59	260.23		

TABLE 2.13 Blocked Rand Period : Local Investors

SHARE	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	.04553	-.00163	.00944	.05516	.03462	-.15479	.01635	.08058	4.80920
2	-.04720	.08402	.02436	-.09213	.03951	-.10117	.05193	.08058	5.15931
3	-.04270	.10082	-.04163	-.00672	.00083	.06767	-.01863	.08058	2.93490
4	-.04932	.01743	.10207	-.14417	.14824	-.15911	-.04890	.08058	13.12891
5	.20038	.08410	.14858	-.01429	.03614	.04791	.05401	.08058	11.93558
6	.11280	-.01149	.21378	-.13296	-.10321	-.05449	-.08476	.08058	15.23542
7	.17651	.24364	.07712	.04260	.05944	.06899	.01903	.08058	16.78884
8	.01514	.02317	.08869	.09920	-.02883	-.05184	.05401	.08058	3.91076
9	.05563	.11947	-.06650	-.04934	.02079	-.09899	-.11748	.08058	7.57616
10	-.10772	.16412	-.00958	-.05218	.10324	-.01053	.05681	.08058	8.69019
11	-.05168	-.01806	.07773	-.12927	.17372	-.09192	.02614	.08058	10.21475
12	.10338	.10275	.03956	.03428	.00110	.01555	.02235	.08058	3.88212
13	-.01107	.15674	.06266	.01733	.15488	.05783	-.02859	.08058	8.95976
14	.01146	-.10406	.01624	-.02912	.00987	-.04915	.01055	.08058	2.30714
15	.11366	.03986	.11232	-.06889	.06807	-.06263	-.12402	.08058	8.76150
16	-.06127	-.02167	.01848	-.01517	.06937	-.11565	.00197	.08058	3.60896
17	.12321	.07967	.04478	-.02715	.17544	-.00525	-.03603	.08058	8.85091
18	.06483	-.03309	-.01638	-.09699	-.00322	-.03579	.06095	.08058	3.14788
19	.15046	.00224	.00667	-.02287	.06193	.02026	.09575	.08058	5.74992
20	.04276	.12877	.01740	-.05933	.07139	-.07069	.04441	.08058	5.38465
21	-.04350	.06352	-.05802	-.02233	.02173	-.00731	-.03400	.08058	1.80139
22	.01979	.12301	.05082	-.03403	.07556	-.03388	.06832	.08058	4.83381
23	.03557	.19865	.02303	-.01810	-.07270	.01343	-.03369	.08058	7.56528
24	.16093	.11219	.05062	-.05553	-.00638	-.16348	-.04933	.08058	11.51313
25	.10606	.06162	-.01746	-.09830	.05585	-.08943	-.06160	.08058	6.26820
26	-.00604	.08670	.05983	-.07500	.00176	.02381	.04448	.08058	3.03113
27	.00841	.02724	.13692	-.13190	-.11902	.02636	-.06060	.08058	8.71215
28	.24310	.17665	.01593	-.00030	.00874	.04058	.08388	.08058	15.70385
29	.04241	.06934	-.00334	.07914	-.03921	-.00962	.06469	.08058	2.93533
30	-.05736	.02991	.12642	-.09796	.09211	.11889	-.14703	.08058	11.61811
31	.16358	.01228	.10354	.07390	-.04277	-.03610	-.03101	.08058	7.40814
32	-.05069	-.04181	.03957	-.13596	.10015	-.04516	-.02024	.08058	5.84920
33	.06968	.16008	.06926	-.09911	.03505	.01327	-.01455	.08058	7.83514
34	.02428	.02558	-.07809	-.13338	.05748	.06887	-.10143	.08058	6.82418
35	.10767	-.06694	-.10754	-.11607	-.00042	.09237	.03286	.08058	7.96374
36	-.00070	.03477	-.00203	-.06176	.05964	-.09735	.01687	.08058	2.88069
37	.07091	.01308	-.01368	-.09882	.08961	-.06797	.03123	.08058	4.51795
AVERAGE	.04753	.06067	.03566	-.04642	.03812	-.02531	-.00441		

TABLE 2.14 Securities Rand Period : Local Investors

EMPIRICAL SERIAL CORRELATION
LAGS IN PERIODS OF 1 WEEK

SHARE	1	2	3	4	5	6	7	S.D.	Q
1	.01230	-.01862	.05965	-.01247	-.03204	-.00696	-.03759	.08220	1.01168
2	-.17519	.05746	-.18173	.01565	-.13062	.08910	.05032	.08220	14.31449
3	.12245	-.01330	-.13032	-.17902	-.04977	-.02868	.07123	.08220	10.95849
4	-.02294	.06120	-.03850	-.09134	.00506	-.02845	.01742	.08220	2.30065
5	.20344	.03356	-.06140	-.08966	.00084	-.05803	-.03068	.08220	8.85352
6	.16940	.01646	-.04916	-.07193	-.01229	-.00408	-.02367	.08220	5.63007
7	-.06592	.02499	.15690	.02048	-.06635	-.05769	-.08497	.08220	6.78859
8	.03600	.03877	.01540	-.16022	-.05040	.01953	-.00949	.08220	4.78952
9	.13487	.00306	-.07909	-.20204	-.06102	.03006	.10680	.08220	12.27732
10	.12970	.03578	.06888	-.14336	-.09693	-.03324	-.01175	.08220	8.15943
11	-.00124	.07255	-.02956	-.17823	-.04445	-.06434	.03624	.08220	6.84513
12	.22876	.02986	-.09199	-.07447	-.00149	.01769	-.03268	.08220	10.36081
13	-.09194	.04824	-.02260	.02533	-.07207	.08216	-.11320	.08220	5.54066
14	.03831	.10467	-.12853	-.16284	-.07869	-.02213	.14813	.08220	12.69663
15	.04588	-.07109	.03841	-.18045	-.01919	-.01519	.09649	.08220	7.71662
16	.05877	-.03263	-.12257	-.08557	-.12034	-.01428	.13903	.08220	9.19267
17	.06164	.09524	-.08356	-.07334	.04401	.07808	.04242	.08220	5.29841
18	.27741	.02851	-.18474	-.16229	-.05926	.13782	.02492	.08220	24.36525
19	.15082	.00676	-.01450	-.02506	-.04127	-.00413	-.04454	.08220	4.12746
20	.08605	-.07256	-.13452	.00090	.04658	.03066	.00032	.08220	5.11516
21	-.02894	-.04244	-.09249	-.16093	-.02482	-.08764	.04654	.08220	7.18078
22	.14164	.13469	-.04352	-.09365	.05601	-.15223	.02511	.08220	11.44731
23	.16021	-.01340	-.05095	-.04440	-.04769	.05595	.12920	.08220	7.92912
24	.27721	.00313	-.09623	-.14739	-.05731	-.01024	.00439	.08220	16.79853
25	-.07385	-.00041	-.03222	-.04100	.00861	.02846	.00486	.08220	1.37129
26	.08393	.02717	-.03462	.06858	-.14625	-.09314	-.14656	.08220	9.84945
27	.05571	.05517	-.04584	-.07800	-.08486	.05431	-.05499	.08220	4.15367
28	.19132	.11753	.01558	.04534	.04472	-.04486	-.07319	.08220	9.37473
29	-.10642	-.01052	-.06168	.01538	.04221	-.02161	-.08095	.08220	3.66592
30	.04066	-.12675	.05359	-.12373	-.02101	.03284	-.04722	.08220	5.98946
31	.16510	-.01179	-.06152	-.03395	.07996	.00493	.00180	.08220	5.85201
32	.12936	.04602	-.06960	-.17015	-.21135	-.14619	-.00672	.08220	17.92867
33	.15085	.04078	-.03499	-.13593	-.09193	.00883	.00374	.08220	7.95203
34	.08251	-.07131	-.08568	-.17881	-.05292	.01985	-.01477	.08220	8.24771
35	-.00598	.06225	.10972	-.15603	-.01324	-.00116	-.03160	.08220	6.26208
36	-.05338	.11482	-.08534	-.05495	-.10366	-.03224	-.02710	.08220	5.86691
37	-.08394	.01796	-.05663	-.05351	.00888	-.06639	.08105	.08220	3.69649
AVERAGE	.06824	.02140	-.04557	-.08576	-.03931	-.00818	.00428		

TABLE 2.15 Blocked and Securities Rand Period : Local Investors

SHARE	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	.03431	-.00192	.03736	.01734	.00433	-.07384	-.00622	.05726	2.58328
2	-.10507	.06824	-.08326	-.04588	-.04216	-.01053	.05254	.05726	9.04961
3	.05338	.04007	-.08511	-.10348	-.02316	.01388	.03269	.05726	7.45519
4	-.03695	.03438	.04536	-.12396	.08998	-.10479	-.02629	.05726	12.24004
5	.20207	.05546	.03850	-.05344	.02350	-.01242	.01136	.05726	15.11783
6	.14582	.00422	.07153	-.10124	-.05341	-.02725	-.05185	.05726	13.22300
7	.07066	.14762	.11234	.02805	.01058	.00314	-.01896	.05726	12.52777
8	.02415	.02641	.06210	.00763	-.03711	-.02596	.02960	.05726	2.50174
9	.09057	.06435	-.07349	-.11648	-.00932	-.04912	-.02266	.05726	10.57220
10	.02611	.09226	.03126	-.10685	-.00311	-.02078	.01941	.05726	6.90099
11	-.02065	.03229	.01729	-.15528	.05172	-.07349	.02971	.05726	10.73024
12	.16900	.06189	-.02501	-.02228	-.00060	.00954	-.00516	.05726	10.35903
13	-.04741	.10497	.02527	.02106	.05452	.06615	-.06646	.05726	8.04280
14	.02182	-.01229	-.04341	-.08744	-.01947	-.04608	.06254	.05726	5.10416
15	.08045	-.01221	.07439	-.12146	.02436	-.04705	-.02130	.05726	9.29178
16	-.01148	-.02628	-.03693	-.04983	-.00219	-.08119	.05632	.05726	4.44714
17	.09528	.09001	-.01006	-.04343	.11742	.03270	-.00473	.05726	10.48623
18	.15909	-.00650	-.09393	-.12687	-.02270	.03069	.03250	.05726	16.25720
19	.14924	.00246	-.00568	-.02544	.01166	.00683	.02747	.05726	7.36007
20	.07244	.01508	-.06853	-.02887	.05529	-.02724	.01424	.05726	4.62197
21	-.03367	.01272	-.07218	-.08695	.00052	-.04448	.00330	.05726	4.94528
22	.05530	.12490	.02303	-.05059	.07031	-.06643	.05269	.05726	10.43521
23	.09679	.09716	-.01292	-.02841	-.05892	.03220	.04725	.05726	8.16922
24	.20177	.07198	-.00853	-.09199	-.02706	-.10269	-.03393	.05726	20.59222
25	.01813	.03190	-.01716	-.06694	.03869	-.02641	-.02753	.05726	2.79465
26	.02873	.06548	.02366	-.01985	-.05576	-.02014	-.03452	.05726	3.31826
27	.02832	.04030	.06767	-.10776	-.10577	.03895	-.06367	.05726	10.89595
28	.21522	.14418	.01906	.02344	.03340	-.01035	-.00238	.05726	21.32802
29	-.02223	.03478	-.03610	.06191	-.01316	-.01280	.00407	.05726	2.21539
30	-.01363	-.03753	.09502	-.11152	.04093	.07926	-.10613	.05726	13.02221
31	.16502	.00180	.03443	.02820	.00748	-.01932	-.01646	.05726	9.21442
32	.04187	.00137	-.01096	-.14918	-.05468	-.09353	-.02133	.05726	11.18764
33	.12257	.09817	.01457	-.12428	-.02967	.00146	-.01146	.05726	12.73082
34	.06036	-.03120	-.07693	-.15996	-.00474	.03868	-.05426	.05726	12.50027
35	.06627	-.01978	-.02841	-.13362	-.00250	.05224	.01095	.05726	8.10058
36	-.02367	.07219	-.03830	-.05490	-.01357	-.07490	-.00468	.05726	4.94916
37	.00291	.01503	-.03165	-.07725	.05225	-.06509	.04649	.05726	5.03013
AVERAGE	.05900	.04065	-.00178	-.06454	.00292	-.01974	-.00181		

TABLE 2.16 Entire Period : Local Investors

SHARE	1	2	3	4	5	6	7	S.D.	Q
				EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK					
1	.01500	.02202	.05675	.04450	.00995	-.05642	-.00301	.04673	4.24171
2	-.10475	.05190	-.05530	-.01234	-.01531	-.01574	.02549	.04673	8.30177
3	.06993	.04485	-.04172	-.05030	-.00155	-.03481	-.02040	.04673	5.90176
4	-.01741	.01269	.04561	-.07478	.12792	-.09438	-.03862	.04673	16.08865
5	.19688	.04753	.05793	-.04748	.05573	.00152	.01939	.04673	23.10212
6	.06943	-.01394	.09398	-.10915	-.01224	-.02770	-.00784	.04673	12.32717
7	.10300	.16247	.13237	.02891	.05335	.01402	.00704	.04673	26.94750
8	.01976	.02239	.05890	.00828	-.03195	-.01671	.02410	.04673	2.90948
9	-.01106	.04516	-.04403	-.08030	.03432	-.04685	-.02017	.04673	6.60579
10	.01529	.04545	.04150	-.04981	.05653	.02422	.01556	.04673	4.85287
11	.01475	.00973	.03082	-.09768	.10381	-.04798	.01843	.04673	11.16612
12	.15566	.03034	-.00313	-.00931	.02209	.02032	-.01799	.04673	12.20302
13	-.04253	.09586	.03377	.00911	.08777	.03594	-.06298	.04673	11.60958
14	.00105	.03329	-.02788	-.05823	.01073	-.05221	.02879	.04673	4.12435
15	.05007	-.02421	.06936	-.07528	.07260	-.07283	-.02824	.04673	11.49935
16	-.07137	-.01137	.01945	-.05520	.05175	-.07350	.06472	.04673	9.64271
17	.08237	.07464	-.01596	-.01813	.13098	.00455	.00053	.04673	13.88298
18	.11431	-.00769	-.05601	-.09793	.03571	.03401	.00703	.04673	13.06203
19	.14922	.02642	.02693	-.01113	.06286	.00699	.03528	.04673	13.39610
20	.09955	.00942	-.02772	.00658	.05750	-.02720	.00198	.04673	6.85073
21	-.01227	-.00543	-.04358	-.03519	.04369	-.02856	.03030	.04673	3.20856
22	.05061	.08126	.02363	-.01495	.07286	-.07593	.02715	.04673	10.02997
23	.11620	.09930	.00641	.00477	-.01342	.04115	.04778	.04673	12.71566
24	.13433	.03908	.01360	-.06197	.00696	-.08428	-.00883	.04673	14.21140
25	.04147	.00980	-.03286	-.03818	.07360	-.03223	-.02869	.04673	5.36189
26	.02168	.07490	.01722	.01917	-.02193	-.01227	-.01468	.04673	3.49965
27	.04535	.01343	.06110	-.04431	-.04582	-.01100	-.03403	.04673	5.21433
28	.17083	.10414	.03240	.02688	.06616	.01401	-.01494	.04673	21.48078
29	.00146	.04785	-.02389	.06528	.02855	-.02078	-.00222	.04673	3.86135
30	-.00086	-.00560	.08573	-.08027	.04613	.05189	-.06457	.04673	10.51736
31	.17547	.02069	.03202	.00767	.02790	-.03346	.00060	.04673	15.76623
32	.06637	-.02146	-.01427	-.09106	.01644	-.08146	-.02721	.04673	9.68395
33	.09374	.07922	-.00483	-.06699	.06029	-.00011	.00604	.04673	10.71659
34	.07002	-.03997	-.07060	-.07419	.04419	-.00027	-.05920	.04673	10.34776
35	.06122	-.03715	-.02970	-.09193	.04303	-.00495	-.00748	.04673	7.55713
36	.01410	.05604	.02561	-.02672	.06511	-.04019	-.01602	.04673	4.98823
37	.01082	.03221	-.01783	-.04212	.07752	-.06845	.02566	.04673	6.73052
AVERAGE	.05323	.03312	.01232	-.03497	.04064	-.02194	-.00247		

discernable systematic behaviour of the autocorrelations, Table 2.8 shows that a certain amount of systematic behaviour is evident implying that there is slightly more non-random behaviour than would be expected if the market were totally efficient.

Case 3: Differences in efficiency during bull and bear phases for local and foreign investors

A further test was conducted to determine whether differing levels of efficiency prevailed during bull and bear markets for both foreign and local investors apart. To test if such a difference exists 4 data sets were constructed according to the following partitions:

2/1/79 - 3/10/80 bull market (90 observations)
3/10/80 - 31/12/81 bear market (64 observations)

Conveniently the data over the period of the financial rand market contained a distinct major bull and bear market (the division being the peak of the gold price in October 1980).

Note that 2 data sets were considered for the bull market partitioning, the first data set contained unadjusted data (local market) and the second data set contained the data adjusted by the financial rand discount (foreign market). Similarly for the bear market.

Table 2.17 displays the number of shares (out of 37) that exhibited significant non-random behaviour for both local and foreign investors for both phases of the market. Tables 2.18 to 2.25 show the detailed test results for both foreign and local investors during the bull and bear market phases.

TABLE 2.17

			No. of shares exhibiting significant non-random behaviour		
Period		No. of obs.	Runs test	Autocorrelation test	Q-statistic test
Bull	local	90	4	2	4
	foreign	90	3	2	6
Bear	local	64	4	0	3
	foreign	64	6	3	6

Inspection of Table 2.17 yields no emphasis of efficiency for either local or foreign investors in both phases of the market.

2.5 Conclusion

Firstly, it was found that the degree of efficiency of the JSE was the same for both foreign and local investors during the period of the financial rand market.

Secondly, there was no evidence found that supported the hypothesis that there was any difference in the efficiency of the JSE before the financial rand market was introduced.

Thirdly, the degree of efficiency of the JSE was not found to be different over bull or bear phases for local or foreign investors.

TABLE 2.18 Bull Market : Local Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	58.00	54.04	.84980	NO
2	44.00	41.00	.79842	NO
3	42.00	43.51	.40057	NO
4	41.00	44.80	.21324	NO
5	44.00	46.53	.30940	NO
6	45.00	47.60	.31827	NO
7	46.00	50.18	.19343	NO
8	47.00	47.04	.54261	NO
9	55.00	47.60	.96227	YES
10	49.00	44.18	.89634	NO
11	55.00	49.64	.90796	NO
12	44.00	45.98	.36077	NO
13	48.00	47.64	.58068	NO
14	45.00	47.64	.30488	NO
15	51.00	47.64	.82689	NO
16	54.00	47.04	.96004	YES
17	46.00	49.24	.25452	NO
18	54.00	48.20	.93551	NO
19	52.00	49.73	.74470	NO
20	52.00	49.33	.76535	NO
21	50.00	49.73	.57391	NO
22	49.00	50.84	.38051	NO
23	49.00	49.73	.47739	NO
24	48.00	45.91	.74008	NO
25	53.00	49.73	.82004	NO
26	44.00	44.53	.49657	NO
27	42.00	47.11	.13305	NO
28	48.00	48.13	.53436	NO
29	53.00	52.98	.54945	NO
30	47.00	53.80	.06762	NO
31	50.00	50.60	.49092	NO
32	39.00	47.04	.03819	YES
33	47.00	45.91	.65358	NO
34	50.00	49.60	.58857	NO
35	45.00	42.93	.72774	NO
36	50.00	48.71	.66485	NO
37	47.00	52.04	.13474	NO
AVERAGES	48.19	48.05		

TABLE 2.19 Bear Market : Foreign Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	55.00	45.36	.98784	YES
2	48.00	42.24	.92626	NO
3	41.00	40.31	.61371	NO
4	40.00	41.00	.45247	NO
5	37.00	44.53	.05517	NO
6	48.00	43.31	.87917	NO
7	44.00	42.80	.65112	NO
8	46.00	44.20	.69434	NO
9	44.00	44.20	.52642	NO
10	50.00	44.20	.91804	NO
11	50.00	44.58	.90269	NO
12	42.00	42.24	.52359	NO
13	49.00	45.73	.79704	NO
14	46.00	43.31	.76411	NO
15	50.00	44.58	.90269	NO
16	47.00	43.51	.82339	NO
17	54.00	42.24	.99773	YES
18	43.00	44.20	.43854	NO
19	50.00	42.80	.96071	YES
20	50.00	43.78	.93321	NO
21	46.00	42.24	.83779	NO
22	48.00	45.64	.72917	NO
23	42.00	44.20	.35360	NO
24	38.00	39.58	.39472	NO
25	48.00	44.58	.80484	NO
26	42.00	41.64	.57968	NO
27	42.00	43.31	.42739	NO
28	44.00	44.20	.52642	NO
29	40.00	44.53	.17993	NO
30	40.00	41.00	.45247	NO
31	46.00	45.44	.58964	NO
32	38.00	43.78	.11944	NO
33	48.00	44.91	.78230	NO
34	46.00	44.20	.69434	NO
35	44.00	43.78	.56402	NO
36	44.00	43.78	.56402	NO
37	46.00	45.20	.61052	NO
AVERAGES	45.30	43.55		

TABLE 2.20 Bear Market : Local Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	38.00	36.40	.71792	NO
2	38.00	35.92	.75629	NO
3	32.00	36.40	.14265	NO
4	30.00	35.16	.10769	NO
5	32.00	36.30	.14049	NO
6	33.00	33.48	.50245	NO
7	34.00	37.00	.24423	NO
8	41.00	38.97	.75583	NO
9	34.00	35.29	.41759	NO
10	31.00	35.16	.15611	NO
11	28.00	35.25	.03669	YES
12	27.00	33.35	.06476	NO
13	38.00	35.25	.80525	NO
14	32.00	32.11	.53985	NO
15	36.00	35.48	.61017	NO
16	37.00	35.92	.66466	NO
17	34.00	37.63	.18552	NO
18	32.00	34.49	.29399	NO
19	31.00	33.25	.30926	NO
20	31.00	36.87	.07349	NO
21	28.00	33.44	.10071	NO
22	32.00	36.11	.16700	NO
23	24.00	35.48	.00135	YES
24	34.00	37.57	.20174	NO
25	38.00	35.16	.81288	NO
26	33.00	36.05	.24730	NO
27	31.00	35.25	.15983	NO
28	32.00	36.11	.15875	NO
29	28.00	35.76	.02098	YES
30	36.00	37.63	.37902	NO
31	26.00	34.78	.01027	YES
32	32.00	35.92	.17855	NO
33	38.00	36.11	.74579	NO
34	31.00	33.44	.29961	NO
35	28.00	34.02	.07183	NO
36	38.00	34.14	.88478	NO
37	38.00	37.44	.61344	NO
AVERAGES	32.86	35.52		

TABLE 2.21 Bull Market : Foreign Investors

SECURITY	ACTUAL	EXPECTED	PROBABILITY	DEPENDENCE
1	34.00	32.68	.68496	NO
2	30.00	31.86	.36240	NO
3	37.00	32.43	.90170	NO
4	32.00	32.30	.52023	NO
5	31.00	32.43	.40655	NO
6	41.00	32.43	.98955	YES
7	30.00	32.49	.30637	NO
8	31.00	32.49	.40049	NO
9	40.00	32.49	.97906	YES
10	28.00	32.49	.15520	NO
11	28.00	32.49	.15520	NO
12	25.00	32.30	.04102	YES
13	37.00	32.30	.90809	NO
14	40.00	32.43	.98007	YES
15	29.00	32.49	.22354	NO
16	39.00	32.49	.96252	YES
17	37.00	31.86	.92838	NO
18	31.00	32.49	.40049	NO
19	33.00	32.11	.63957	NO
20	28.00	32.49	.15520	NO
21	32.00	32.43	.50726	NO
22	34.00	32.49	.69505	NO
23	30.00	32.30	.32254	NO
24	37.00	32.49	.89840	NO
25	33.00	32.43	.60750	NO
26	31.00	32.49	.40049	NO
27	36.00	32.49	.84576	NO
28	27.00	32.43	.10475	NO
29	31.00	32.49	.40049	NO
30	34.00	33.35	.61725	NO
31	31.00	31.54	.49585	NO
32	34.00	32.49	.69505	NO
33	31.00	32.43	.40655	NO
34	30.00	32.30	.32254	NO
35	35.00	32.43	.78291	NO
36	42.00	32.11	.99624	YES
37	34.00	32.30	.71297	NO
AVERAGES	33.05	32.39		

TABLE 2.22 Bull Market : Local Investors

SHARE	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	-.19192	-.00612	.07885	-.03294	-.09568	.11818	-.05073	.10720	6.28818
2	-.13427	.06371	-.02313	-.00639	-.06225	-.03066	-.03436	.10720	2.57921
3	.04984	.02138	.03931	-.00324	-.00802	-.15054	-.19573	.10720	5.89802
4	-.07818	.02876	-.00920	-.17110	.20520	-.06322	-.07637	.10720	7.94122
5	.12113	-.10659	-.04600	-.11247	-.00485	-.07736	.10450	.10720	5.19559
6	-.10900	-.10192	.17392	-.23443	-.09313	.02005	.04801	.10720	10.69720
7	.12909	.13344	.15931	-.06554	.04896	.03102	.01115	.10720	6.08630
8	-.06874	-.07803	.06654	-.12560	-.06862	.00498	-.10665	.10720	4.24119
9	-.25547	.02832	.06216	-.17005	.20717	-.00892	-.03065	.10720	12.85049
10	-.14348	-.14408	.15248	-.06015	.05294	-.02200	.02728	.10720	6.50180
11	-.10301	-.09115	.07036	-.15961	.19265	-.01896	.00063	.10720	7.81348
12	.01474	-.11950	.01140	-.07410	-.01852	.02867	-.19221	.10720	5.24079
13	-.08825	-.04446	-.01389	-.06631	.10572	-.07403	-.08442	.10720	3.43237
14	.00387	.10661	-.15431	.04774	-.04298	-.13917	-.17057	.10720	7.90031
15	-.12158	.01073	-.01761	-.02667	.25706	-.21655	-.04400	.10720	11.77410
16	-.31063	.00557	.08581	-.21934	.21840	-.07872	.05081	.10720	18.76240
17	-.04845	-.01169	-.06510	-.12889	.15595	-.16594	.04670	.10720	6.96358
18	-.10365	-.03791	-.07368	-.12782	.06686	.00100	-.05898	.10720	3.77063
19	.07583	.00211	.03600	-.06710	.02924	-.05853	-.02158	.10720	1.46709
20	.11001	-.04952	.03857	.03568	-.06984	-.10274	-.18662	.10720	6.08156
21	-.12422	-.05082	.01489	-.13315	.13865	.00146	.00922	.10720	4.97471
22	-.04984	-.09704	.03339	.01869	.01765	-.08581	-.02723	.10720	1.96037
23	.05167	.03135	.02514	-.00552	-.05697	-.08880	-.03046	.10720	1.47367
24	-.05525	-.01128	-.01122	-.03979	.10856	-.02016	.03371	.10720	1.63952
25	.06277	-.03696	-.16946	.03768	.09311	-.03817	-.05793	.10720	4.40320
26	-.14994	-.12149	.11065	-.06608	.03040	-.00495	-.02613	.10720	4.99351
27	.09470	-.03713	-.08097	.00239	.19587	-.08073	-.00085	.10720	5.56109
28	.00828	-.10607	.03626	-.06844	-.04515	.01118	-.04979	.10720	1.97634
29	-.00652	-.00818	-.01540	-.05865	.10644	-.08724	-.15581	.10720	4.23041
30	-.07597	-.06557	-.00920	-.08475	-.02155	-.00816	.03213	.10720	1.70107
31	-.04008	.08160	.05750	-.12829	.11388	-.20888	.03026	.10720	7.69910
32	.11454	-.18646	-.05647	-.15108	.13226	.06265	-.10224	.10720	9.51927
33	-.06467	.02872	.01748	-.03555	.12406	-.15642	.02622	.10720	4.24084
34	-.06037	-.08484	-.10214	-.06240	.07585	-.16082	-.02145	.10720	5.15220
35	.00126	-.06299	-.05417	-.13481	.15962	-.09433	-.04020	.10720	5.49628
36	-.03460	.01946	.00641	-.13272	.25934	.02254	-.04436	.10720	8.00698
37	.00766	.04744	-.02302	.00040	.13657	-.23695	-.17459	.10720	9.73036
AVERAGE	-.04250	-.02839	.00950	-.07596	.07148	-.05884	-.04225		

TABLE 2.23 Bull Market : Foreign Investors

SHARE	1	2	3	4	5	6	7	S.D.	Q
	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK								
1	-.07054	-.03035	.07837	-.10204	.07474	-.00560	-.02970	.10720	2.60545
2	-.23002	.23285	-.09672	.06323	-.15845	-.01254	-.18428	.10720	16.17322
3	.02459	.11122	.05743	-.02287	.04231	-.15618	-.23902	.10720	9.00984
4	-.08313	.19599	-.08932	-.12033	-.02784	-.07207	-.20175	.10720	10.30066
5	.10278	.06465	-.07022	-.01977	-.07605	-.02283	-.00159	.10720	2.37342
6	-.11751	.01722	.16956	-.22316	-.09236	.01012	-.02163	.10720	9.15830
7	.09627	.23206	.11175	-.01428	.00651	.01400	-.02711	.10720	6.91062
8	-.12481	.04012	.05227	-.10542	-.10423	-.04887	-.11494	.10720	5.17450
9	-.23225	.14347	.05272	-.11682	.02171	.01985	-.17092	.10720	10.89257
10	-.12987	.01771	.14053	-.00793	-.05654	-.01006	-.02957	.10720	3.70480
11	-.12887	.07418	-.07590	-.03179	.01064	-.01083	-.10328	.10720	3.58016
12	.03241	-.01035	.07059	-.09897	.04339	-.08107	-.19093	.10720	5.47616
13	-.09050	.12062	.00894	-.04536	.05371	-.13651	-.15493	.10720	6.33606
14	-.00323	.18413	-.12086	-.03805	-.09147	-.18744	-.22225	.10720	12.85771
15	-.21237	.17755	-.04444	-.04222	.18029	-.15208	-.11503	.10720	13.43240
16	-.17939	.05486	.02452	-.08189	-.00146	-.00271	-.02959	.10720	3.90447
17	-.18021	.17627	-.06610	-.00075	.11765	-.19030	-.03795	.10720	10.74749
18	.02417	.00999	-.06890	-.10304	-.03761	-.07804	-.05942	.10720	2.43754
19	.06180	.12897	.00935	-.00784	.00573	-.00127	-.02603	.10720	1.91821
20	.03518	.02891	.00142	.01853	-.07777	-.11590	-.17466	.10720	4.71669
21	-.03747	.03110	.01872	-.13090	-.09810	-.02732	-.15592	.10720	4.90849
22	-.08653	.13009	-.10498	.05051	-.07925	-.03862	-.05964	.10720	4.43803
23	.10478	.02138	.10465	.05219	-.06940	-.12448	-.06711	.10720	4.49347
24	.03291	-.03866	-.03541	-.10769	.07062	.00012	-.04427	.10720	2.01384
25	-.09956	.12931	-.11982	.01412	.00629	-.10129	-.22861	.10720	9.33747
26	-.18787	.15230	-.09076	.01203	-.17310	-.07076	-.12853	.10720	10.65248
27	-.00963	.15410	-.08070	.02316	.05485	-.11601	-.18368	.10720	7.29851
28	-.00440	.07849	.06317	-.03250	-.08344	-.04182	-.10165	.10720	2.72434
29	.02492	.07692	.04430	-.07873	.09130	-.08714	-.19985	.10720	6.35099
30	.00213	.03589	.05944	.02427	-.14586	-.00417	-.07230	.10720	2.87416
31	.06033	.14504	.01155	.00297	-.01825	-.16676	.06586	.10720	5.15687
32	.08240	-.02663	-.11023	-.09658	.04469	.06958	-.14407	.10720	5.09149
33	-.01345	.09447	.05435	-.00364	-.01570	-.11850	-.07061	.10720	2.82123
34	-.03935	-.04635	-.13593	-.07466	-.02164	-.08779	-.04619	.10720	3.42505
35	.02342	-.02326	.05798	-.15597	.07574	-.18462	-.07864	.10720	6.73046
36	.03323	.02477	.06602	-.00236	-.02973	.00273	-.08790	.10720	1.32300
37	-.08947	.18304	-.03419	-.07703	.07104	-.27025	-.16660	.10720	13.90040
AVERAGE	-.04349	.08357	-.00235	-.04545	-.01316	-.07047	-.10552		

TABLE 2.24 Bear Market : Local Investors

SHARE	LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	-.00442	.08816	.04585	.17344	.10225	-.17193	-.03613	.12908	5.12149
2	-.17359	-.09330	-.10140	.01199	.10986	-.07671	-.05562	.12908	4.42958
3	.07697	.02265	-.05894	.06282	.08746	-.17927	-.08575	.12908	3.84295
4	.07610	-.16701	.05452	.19649	.14689	-.17248	-.09805	.12908	8.58093
5	.14840	.05524	.17023	-.06009	.22178	.05619	-.09691	.12908	7.52227
6	-.11580	-.05927	.01789	-.05710	.19311	-.17943	.05117	.12908	5.83439
7	.08160	.11873	.05561	-.00970	.20965	-.11594	-.02760	.12908	5.17226
8	.02541	.03159	-.04952	.10227	.03385	-.02402	.06849	.12908	1.32109
9	-.16926	-.03363	-.10841	.12300	-.01552	-.11327	-.00271	.12908	4.39360
10	.00879	-.09760	-.19225	.09073	.21389	.14786	-.09617	.12908	8.29450
11	.18606	-.09589	-.04591	.08241	.15611	-.06990	-.09475	.12908	5.72955
12	.13915	-.11580	.07445	.02937	.13909	-.01165	-.03848	.12908	3.78885
13	-.09436	.09634	-.00436	-.05497	.11478	-.10100	-.10756	.12908	3.53877
14	-.24287	.18343	.09769	-.08611	.19718	-.16002	-.01080	.12908	10.97463
15	-.00041	-.20789	.03130	.10820	.12369	-.12432	-.06604	.12908	5.73431
16	-.07468	-.04057	.15548	.08823	-.05194	-.14166	.10167	.12908	4.55366
17	.05249	-.07148	-.02870	.14131	.08828	-.08735	-.11686	.12908	3.63738
18	.03514	-.03022	.07453	.00392	.24708	.01293	-.07958	.12908	4.74178
19	.08766	.03536	.03700	-.03077	.26780	-.04600	.05924	.12908	5.58140
20	.18288	-.04821	.06563	.06223	.09598	-.00702	.08576	.12908	3.81568
21	.08534	-.14400	-.08205	.17792	.06949	-.05862	.11059	.12908	5.47498
22	.08558	-.02956	-.03157	.06621	.12257	-.11721	-.04447	.12908	2.29195
23	.18922	.04839	-.08400	.07899	.24068	.06903	.04252	.12908	7.30449
24	-.07367	-.13336	.11729	.02308	.08232	-.17083	.03888	.12908	4.72327
25	-.00362	-.12898	-.03528	-.09246	.21041	-.10972	-.08847	.12908	5.70655
26	.01584	.20014	-.15106	.20628	-.00204	-.09208	.01479	.12908	7.20577
27	.00898	-.18739	.12146	.20271	-.03734	-.37137	.11501	.12908	15.34534
28	-.02712	-.02830	-.00950	.01226	.26653	.04316	-.12832	.12908	5.74195
29	.11706	.13579	-.02978	.16205	.28613	-.09813	.02938	.12908	9.55405
30	.11216	.18788	.05630	.04181	.10495	-.13642	-.00241	.12908	5.19307
31	.34184	.01978	-.06691	-.10137	-.01109	-.07014	-.01442	.12908	8.64651
32	.03603	-.10094	-.07591	.17392	.17912	-.25457	-.02845	.12908	9.14757
33	.01335	-.08129	-.23956	.03878	.29546	.06121	-.02993	.12908	9.92971
34	.15596	-.15507	-.13228	.23809	.14515	-.11855	-.18736	.12908	12.14493
35	.04206	-.17842	-.03965	.13551	.02914	-.20723	-.06233	.12908	6.37658
36	-.23914	.05134	-.14168	.20938	.01488	-.10004	-.03892	.12908	8.53536
37	-.02877	.04965	-.03462	.00873	.15117	-.07332	.05084	.12908	2.22892
AVERAGE	.02855	-.02443	-.01535	.06918	.13051	-.09108	-.02351		

TABLE 2.25 Bear Market : Foreign Investors

SHARE	EMPIRICAL SERIAL CORRELATION LAGS IN PERIODS OF 1 WEEK 1	2	3	4	5	6	7	S.D.	Q
1	-.10471	.18994	-.09982	.18687	.09888	-.06899	-.05496	.12908	6.89727
2	-.23669	.01917	-.11013	-.06094	.17867	-.18050	.12269	.12908	9.56250
3	-.16291	.18685	-.17689	.01085	.08958	-.19724	-.00654	.12908	8.81385
4	.02697	-.06730	.01505	.02037	.20290	-.17850	.00496	.12908	4.97395
5	.05482	.10999	.07912	-.12389	.16678	.01091	-.04639	.12908	4.20829
6	-.20020	.02712	-.08894	-.12636	.16487	-.18285	.09581	.12908	8.47265
7	-.04627	.21079	-.03779	-.03117	.14609	-.14522	-.02492	.12908	5.79760
8	-.07123	.03393	-.13647	.02517	.01723	.02054	.08338	.12908	2.08871
9	-.34751	.16933	-.25109	.07953	.00752	-.08252	.00129	.12908	14.21728
10	-.06023	-.01686	-.25951	.06429	.14836	.14105	-.12531	.12908	8.37894
11	.08007	-.02681	-.18126	.05485	.13948	-.03728	.00423	.12908	4.02300
12	.02127	-.05165	.03063	-.02651	.11040	-.00568	.00182	.12908	1.07005
13	-.22971	.27110	-.17660	-.05906	.06428	-.13367	-.09248	.12908	12.06396
14	-.36508	.25441	-.09077	-.12291	.23061	-.17674	.08606	.12908	19.73059
15	-.14398	-.11087	-.01606	-.01397	.17828	-.14812	-.00990	.12908	5.49974
16	-.24549	-.00430	.05333	.07899	-.01545	-.17832	.27262	.12908	11.07058
17	-.07944	.05771	-.15516	.05422	.02949	-.07848	-.03830	.12908	2.84464
18	-.09705	-.00188	-.02163	-.06072	.25035	-.00795	-.01605	.12908	4.82396
19	-.03253	.06024	.01113	-.07297	.25291	-.01243	.02928	.12908	4.73208
20	.04547	.00500	.02121	-.00779	.07946	-.01924	.10011	.12908	1.21641
21	-.06543	-.00411	-.24334	.10465	.03615	-.04701	.15106	.12908	6.35043
22	.01804	.09948	-.14580	.06054	.08079	-.04888	-.00307	.12908	2.77640
23	.12720	.06502	-.14226	.03591	.19835	.02075	.00697	.12908	5.15056
24	-.21160	-.01808	-.06946	-.00001	.09883	-.13278	.03216	.12908	4.93660
25	-.01502	.00250	-.13799	-.19916	.13106	-.17733	.02547	.12908	6.81710
26	.00131	.20070	-.19407	.06400	.02974	-.09390	.06858	.12908	6.07593
27	-.22233	.02753	-.08418	.12168	-.03707	-.21695	.12133	.12908	8.52027
28	-.08408	.01922	-.07035	-.03082	.26454	-.02798	-.09185	.12908	5.82985
29	.06958	.17476	-.10891	.07810	.19644	-.12059	-.00348	.12908	6.70855
30	-.00982	.24341	.00875	-.03732	.03991	-.11496	-.05897	.12908	4.98314
31	.12140	.06012	-.23199	-.06114	.02620	.01334	-.00800	.12908	4.84077
32	.00046	-.07721	-.12864	.08428	.21994	-.22858	-.03285	.12908	8.27260
33	-.11590	.03409	-.33608	-.00126	.20090	.06305	.00182	.12908	10.82881
34	.07502	-.04047	-.21110	.10940	.16925	-.04807	-.05171	.12908	6.13786
35	-.14347	-.06186	-.15058	.03562	.00749	-.16077	-.04804	.12908	4.82367
36	-.39187	.24889	-.23395	.13138	-.03425	-.05637	.00686	.12908	18.38991
37	-.17355	.12484	-.09927	-.10316	.09338	-.07014	.11191	.12908	5.81891
AVERAGE	-.08688	.06526	-.11273	.00707	.11521	-.08401	.01664		

Finally in all cases, slightly more non-random behaviour was found than sampling theory suggests. This was particularly evident in Table 2.8 where noticeable systematic behaviour was displayed by the average autocorrelations.

As a conclusion to this chapter it should be noted that more shares were found to exhibit significant non-random behaviour than was expected, however, in all cases the magnitude of the non-random behaviour, measured by the autocorrelations, was found to be too small to be exploited by investors. It is thus felt that sufficient rational and competitive investors trade in securities on the gold sector of the Johannesburg Stock Exchange to such an extent that price changes cannot be predicted from past price changes alone.

CHAPTER 3

BETA COEFFICIENTS, PORTFOLIO SELECTION AND EMPIRICAL STUDIES ON THE JSE

3.1 Risk

"October is one of the peculiarly dangerous months to speculate in stocks. The others are July, January, September, April, November, May, March, June, December, August and February."

The above quotation by Mark Twain typifies the attitude that "seasoned" investors have towards the risks associated with investing in securities. Even investors using some intuitive non-mathematical approach to investment in the stock market at some stage consider the possible risks and the return associated with their venture. Jensen (1969) says:

"In a world dominated by risk averse investors, a risky portfolio must be expected to yield higher returns than a less risky portfolio, or it would not be held."

In general a rational investor would aim to satisfy two objectives:

(i) the highest possible return on his investment

(ii) the degree of uncertainty on the return as low as possible.

In this chapter a mathematical approach will be used in considering the above two objectives. The concept of risk and uncertainty and the quantification thereof have been discussed extensively in the literature.

In an attempt to define the concepts of risk and uncertainty Williamson (1970) argues that the individual who is faced with a risk problem does not know the final outcome, however he does know the exact probability that any given outcome will occur. That is, the individual can determine the probability distribution associated with that problem. Williamson mentions the problem of betting on the throw of a die to be an example involving risk. Williamson continues:

> "*The individual faced with a problem in uncertainty, however, has no objective knowledge about the probability distribution associated with the outcome. The investor buying a share of stock is faced with a problem of uncertainty.*"

Levy and Sarnat (1972) argue that the borderline between uncertainty and risk is rather elusive as it is always possible to convert uncertainties into risks by introducing subjective probabilities. The two terms risk and uncertainty will thus be used interchangeably in this thesis.

The risk associated with a security or a portfolio can be thought of as a measure of the uncertainty of the expected return. Numerous quantitative methods of measuring risk have been used, namely the variance, the semi-variance, the mean absolute deviation and the coefficient of variation. The variance appears, from the literature, to be one of the more popular measures of risk.

Markowitz (1959) considering the concept of risk proposed a linear relationship between each individual security and the market. This has been extended and developed by numerous researchers into the so called "market model". This model will be discussed below.

3.1.1 The Market Model

The model can be briefly summarized as follows:

Symbolically the relationship between the return on the ith security and the return on the market from period t-1 to period t can be written as

$$r_{it} = \alpha_i + \beta_i r_{mt} + e_{it} \qquad (3.1)$$

where r_{it} is the return on the ith security in the t-th period;

α_i and β_i are the parameters unique to security i;

r_{mt} is the disturbance or error term for security t;

e_{it} is the disturbance or error term for security i and is assumed to have zero expectation and to be independent of all e_{ts}, $s \neq t$.

The α and β parameters can be estimated using standard regression analysis procedures. The return on the market is generally computed using some overall market index.

The Beta Coefficient

The β parameter has been used extensively as a measure of risk of the specific security in relation to the market. It can be shown that

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2} \tag{3.2}$$

where β_i is the beta coefficient for share i;

σ_{im} is the covariance between the returns on share i and the market return;

σ_m^2 is the variance of returns on the market index.

The value of β_i indicates the volatility of security i's rate of return by comparison with the market.

If a security's β is greater than one, then when the market rises, the return on the security will rise more rapidly than the return on the market. On the other hand, if the market falls, the return on the security will fall more rapidly than the return on the market. However if a security's β is less than one, then in a rising market the security will rise more slowly than the market, and in a falling market will fall less than the market. Securities having β's greater than one therefore are regarded as being more volatile and hence more risky than the market, while securities having β's less than one are regarded as being less risky than the market.

Unique (unsystematic) and Market (systematic) Risk

Inspection of equation (3.1) shows that the variance of a security's returns stems from two sources:

(i) the variance of the return on the market index, r_m;

(ii) the variance of the random error term, e_i.

These two elements of risk are commonly known as market or systematic risk and unique or unsystematic risk respectively.

Mathematical expressions for the above 2 components of risk can be found by considering

$$\begin{aligned} var(r_i) &= var(\alpha_i + \beta_i r_m + e_i) \\ &= var(\alpha_i) + var(\beta_i r_m) + var(e_i) \end{aligned}$$

since α_i is a constant, $var(\alpha_i) = 0$

therefore $var(r_i) = var(\beta_i r_m) + var(e_i)$

$$= \beta_i^2 \; var(r_m) + var(e_i) \; .$$

Using a more compact notation the above equation can be written as

$$\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma_{e_i}^2 \qquad (3.3)$$

where

σ_i^2 is the variance of returns on share i

σ_m^2 is the variance of returns on the market index

$\sigma_{e_i}^2$ is the residual variance.

Verbally, equation (3.3) can be written as:

Total risk = Market risk + Unique risk

Brealey and Myers (1981) interpret the above two components of total risk as:

> *"Unique risk stems from the fact that many of the perils that surround an individual company are peculiar to that company and perhaps its immediate competitors."*

They continue:

> *"Market risk stems from the fact that there are other economy wide perils which threaten all businesses. That is why stocks have a tendency to 'move together'. And that is why investors are exposed to 'market uncertainties' no matter how many stocks they hold."*

Clearly unique risk is the risk embodied in individual companies, for example, local strikes, bad management and setbacks affecting production, while market risk is the risk in a share which is associated with general economic conditions affecting the market as a whole.

Mathematical expressions for the market and unique risk of a portfolio can be found by considering

$$\sigma_p^2 = \mathrm{var}(\textstyle\sum_{i=1}^n X_i r_i)$$

$$= \mathrm{var}(\textstyle\sum_{i=1}^n X_i(\alpha_i+\beta_i r_m+e_i))$$

$$= \mathrm{var}(\textstyle\sum_{i=1}^n X_i\alpha_i+\sum_{i=1}^n X_i\beta_i r_m+\sum_{i=1}^n X_i e_i)$$

since $\sum_{i=1}^n X_i\alpha_i$ is a constant it has a variance equal to zero.

therefore

$$\sigma_p^2 = \text{var}(r_m\textstyle\sum_{i=1}^n X_i\beta_i + \sum_{i=1}^n X_ie_i)$$

$$= (\textstyle\sum_{i=1}^n X_i\beta_i)^2\sigma_m^2 + \sum_{i=1}^n X_i^2\sigma_{e_i}^2 \qquad (3.4)$$

that is: Total portfolio risk = Market risk of the portfolio + Unique risk of the portfolio

where σ_p^2 is the variance of returns of the portfolio;
n is the number of shares in the portfolio;
X_i is the proportion of total capital invested in share i;

and the other terms have been previously defined.

It is argued that in the context of measuring portfolio risk, the market risk of a well diversified portfolio is the only risk that needs to be considered. This can be justified by considering equation (3.4), for ease of explanation assume that an equal proportion of funds is invested in each share, that is, the proportion X_i equals $\frac{1}{n}$ for each of the n securities. Now as n becomes large the value of X_i will become smaller and the value of X_i^2 will become even smaller. Since the values of $\sigma_{e_i}^2$ will not generally vary a great deal the expression for unique risk in equation (3.4) becomes negligible. Hence the market risk becomes dominant.

Brealey and Myers (1981) substantiate this argument by saying:

"If we want to know the contribution of an individual security to the risk of a well diversified portfolio,

it is no good thinking about how risky that security is if held in isolation - we need to measure its market risk and that boils down to measuring how sensitive it is to market movements. The sensitivity of an investments return to market movements is usually called its beta."

They also state:

"Most stocks are substantially more variable than the market portfolio and only a handful are less variable. This raises an important question: 'The market portfolio is made up of individual stocks, so why doesn't its variability reflect the average variability of its components?' The answer is that diversification reduces variability."

The above quotations typify results found in the literature where empirical studies have shown evidence that diversification can provide a substantial reduction in variability. Further studies have shown, however, that most of the benefit in risk reduction can be achieved by relatively few securities and that the improvement in risk reduction is slight when the number of securities is increased by more than 10. Clearly for an investor holding only one security, unique risk is extremely important, however, for a reasonably well diversified portfolio, only market risk matters. Therefore the predominant source of uncertainty for a diversified investor is that the market will rise or plummet.

The implication of this in terms of portfolio analysis is that a shares unique risk is of little concern since only the market risk element of each share affects the overall risk of the portfolio. Inspection of equation (3.4) shows that the beta values are instrumental in the computation of market risk as the variance of returns on the market is constant over any given period.

3.1.2 Empirical Studies on Beta Coefficients

The use of beta coefficients have received much favourable attention in recent literature, thus considerable effort has been expended on obtaining empirical estimates of these statistics. The ordinary least squares technique is typically utilized, where the regression coefficient of a simple linear regression is used to estimate beta.

Perhaps the most important results which have appeared in the literature which have relevance here are:

(i) the linearity assumption seems to be fairly well satisfied (Fama, Fisher, Hensen and Roll (1969))

(ii) the beta coefficients were found to be relatively unstable over time, in the short term (Fabozzi and Francis (1978), Kon and Frank (1978) and Levy (1971) have researched this aspect).

(iii) the beta coefficients were found to be stable over bull and bear market conditions (Fabozzi and Francis (1977) on the NYSE).

The third result requires substantiation for the Johannesburg Stock Exchange thus a study will be presented below examining this aspect. A further motive for the study stems from a proposition by Lindahl-Stevens (1980) that different results might be obtained if the risk-free rate was used as the dividing line between bull and bear markets.

Stability Tests for Beta's over Bull and Bear Markets in the JSE

Fabozzi and Francis (1977) employed standard statistical tests on 700 New York Stock Exchange (NYSE) shares and concluded that neither the alpha nor the beta statistics in the single-index market model (SIMM) appear to be significantly affected by the alternating forces of bull and bear markets.

The motivation for Fabozzi and Francis' work stems from the fact that they believed Levy (1974) and Black's (1972) suggestion that separate alpha's and beta's be calculated for bull and bear markets was erroneous. On the strength of these two studies large national brokers and investment advisors sell separate alpha's and beta's for bull and bear markets.

Since factors influencing prices of shares on the Johannesburg Stock Exchange (JSE) differ somewhat from those of the NYSE it was decided that a similar analysis should be attempted on the JSE.

The Test

The standard model used to compute alpha's and beta's is the SIMM (Single Index Market Model).

i.e. $r_{it} = \alpha_i + \beta_i r_{mt} + e_{it}$

where r_{it} is the return on the ith security in the t-th period;

r_{mt} is the return on the market index in the t-th period;

α_i and β_i are the regression parameters; and

e_{it} is the unsystematic residual return.

Fabozzi and Francis proposed a modified version of the SIMM which could be used to test alpha and beta shifts over bull and bear markets. This modified model was used in this study and can be written as:

$$r_{it} = A_{1i} + A_{2i}d_t + B_{1i}r_{mt} + B_{2i}d_t r_{mt} + u_t$$

where,

d_t is a binary variable that assumed the value of 1 in bull markets and zero in bear markets; A_{2i} and B_{2i} measure the differential effects of bull market conditions on the alpha and beta coefficients of the ith stock; u_{it} is the unsystematic residual return.

The rationale of the model is that if the A_{2i} and B_{2i} differ significantly from zero then the alpha and beta of the ith security differs over bull and bear markets.

Definitions of Bull and Bear Markets

Since there is no definitive criterion for the existence of bull and bear markets, four different definitions of bull and bear markets were tested using the modified SIMM model.

The first three definitions are similar to those used by Fabozzi and Francis. The fourth definition was proposed by Lindahl-Stevens (1980).

Case 1. (ZERO) Bull and bear markets were delineated according to non-negative and negative values for r_{mt} respectively. Thus every week with $r_{mt} \geqslant 0$ was treated as a "bull" week, and every week in which $r_{mt} < 0$ was considered a "bear" week.

Case 2. (SD) Bull and bear markets were partitioned according to substantial up or down movements of weekly market returns. The criterion being that the absolute value of the returns on the market had to be larger than one half of a standard deviation of the market's returns (σ_m) measured over the sampled period. Thus every week in which $r_{mt} > 0{,}5\ \sigma_m$ was considered a "bull" week, and every week in which $r_{mt} < -0{,}5\ \sigma_m$ was considered a "bear" week.

Case 3. (VIS) Long term bull and bear markets were delineated in accordance with dates published in previous research work by Affleck-Graves (1977). Visual inspection of a plot of r_{mt} versus time justifies the above delineation (see Figure B.1, Appendix B). All weeks within these long term bull markets were treated as "bull" weeks regardless of whether r_{mt} was positive or negative. Bear markets were similarly treated.

Case 4. (RISK-F) Lindahl-Stevens (1980) claimed that the dividing line between bull and bear markets should be the so called risk-free rate. She argued that the dividing line in terms of security performance should not be zero return on the market but rather the certain return one could have obtained in the period, i.e. the risk free rate (r_{ft}). Thus any week in which $r_{mt} < r_{ft}$ should be treated as a "bear" week and all weeks in which $r_{mt} > r_{ft}$ should be treated as "bull" weeks. Lindahl-Stevens further suggested that Fabozzi and Francis might have found that changes in alpha's and beta's were significant in "bull" and "bear" markets using this definition. However she presented no empirical evidence to support this assertion.

Sampled Data

Weekly returns for 48 industrial stocks on the JSE from 22/3/68 to 20/6/76 were computed resulting in 412 observations for each security. The corresponding returns on the RDM 100 Industrial Index were also computed.

Using the first definition of "bull" and "bear" markets (ZERO) the data was divided into two mutually exclusive and exhaustive sets. The total number of observations on each security therefore remained at 412.

Using the second definition (SD); 245 observations on the RDM 100 index were found to lie outside $\pm\ 0{,}5\sigma_m$. Hence 167 observations were deleted for each security and the remaining 245 were divided into those for which r_{mt} was greater than $0,5\sigma_m$ and those for which r_{mt} was less than $-0,5\sigma_m$.

The third definition (VIS) partitioned the data according to the following dates:

22/3/68	to	30/5/69	first bull market
30/5/69	to	5/11/71	first bear market
5/11/71	to	6/7/73	second bull market
5/7/73	to	1/11/74	second bear market

The above partitioning included 346 weekly observations on each security.

Using the fourth definition (RISK-F) monthly returns were used instead of weekly returns. The reason for this was that the risk-free rate used was the rate on long term (redemption date in excess of 20 years) Government securities, which was only available on a monthly basis. Hence 94 observations on each security were analysed.

To justify the use of the SIMM the R^2 value was tested for significance for the 48 stocks using all 412 observations.

Using the standard F test, 6,25% of the securities were found to exhibit no significant relationship between the 2 variables of the SIMM at the 5% significance level (see Appendix B).

On the basis of this result it was assumed that the sample was suitable for further testing.

Statistical Tests used to Measure Alpha and Beta Shifts

(i) Separate tests on the coefficients.

The t-test was used to determine if either the alpha or the beta had significant shifts (i.e. whether A_2 or B_2 were individually significantly different from zero). These results are presented in full in Appendix B and are summarised in Table 3.1 below.

TABLE 1

SUMMARY STATISTICS FOR SEPARATE t-TESTS ON ALPHAS AND BETAS

Bull and Bear defn. (observations)	Coefficient tested	5% No.	5% %	1% No.	1% %
CASE 1 ZERO (412 obs)	$A_2 \neq 0$	3	6,25%	0	0
	$B_2 \neq 0$	3	6,25%	3	6,25%
CASE 2 SD (245 obs)	$A_2 \neq 0$	5	10,41%	3	6,25%
	$B_2 \neq 0$	4	8,33%	1	2,08%
CASE 3 VIS (346 obs)	$A_2 \neq 0$	7	14,58%	0	0
	$B_2 \neq 0$	3	6,25%	2	4,17%
CASE 4 RISK-F (94 obs)	$A_2 \neq 0$	3	6,25%	0	0
	$B_2 \neq 0$	4	8,33%	0	0

Table 3.1 shows the percentage of securities having significant shifts in their alpha and beta coefficients. Visual inspection of this table shows a very small percentage of significant alpha and beta shifts.

To test if the proportion of A_{2i}'s and B_{2i}'s siginificantly different from zero are more than sampling theory suggests, a test based on the binomial distribution can be performed. This test indicates that with 48 shares being simultaneously tested more than 10,17% would have to be rejected to constitute strong proof that over all securities either the alpha or the beta coefficients shift in different markets.

Comparing the percentages shown in Table 3.1 with this value, it can be seen that the proportion of A_{2i}'s significantly different from zero exceeds this value in only Cases 2 and 3 and even in these cases only by a marginal amount. Moreover the number of B_{2i}'s significantly different from zero was less than 10,17% in all four cases examined.

These results tend to indicate that the alpha and beta coefficients are not affected by the nature of the market - i.e. bull or bear. This is further substantiated by inspection of Appendix B displaying the $\bar{R}^2$ values of the modified SIMM. This shows that many of the rejected cases in the different definitions of bull and bear markets are associated with very low $\bar{R}^2$ with many being less than 0.10. This is shown in Table 3.2 below.

(ii) Joint tests on the coefficients

It is of considerable interest to examine whether the modified model results in a better explanation of r_{it} than the SIMM.

TABLE 3.2

	Significant difference		No significant difference	
	No.	Avg. $\bar{R}^2$	No.	Avg. $\bar{R}^2$
CASE 1 : $A_2 \neq 0$	3	0,1461	45	0,1524
$B_2 \neq 0$	3	0,1148	45	0,1546
CASE 2 : $A_2 = 0$	5	0,1806	43	0,2071
$B_2 = 0$	4	0,1759	44	0,2069
CASE 3 : $A_2 = 0$	7	0,1058	41	0,1516
$B_2 = 0$	3	0,0725	45	0,1498
CASE 4 : $A_2 \neq 0$	3	0,2354	45	0,3246
$B_2 \neq 0$	4	0,3519	44	0,3240

Accordingly, an F test was performed to determine if there was any significant increase in explanation by advancing from the SIMM to the modified SIMM. The test statistics used was computed using the formula

$$F = \frac{R^2_{1 \cdot r+s} - R^2_{1 . s}}{1 - R_{1 \cdot r+s}} \times \frac{N-(r+s)}{r}$$

which is distributed as F with r and N-(r+s) degrees of freedom

where N is the number of observations on each security;

s is the number of variables in the original model; and

r is the number of variables added

This test was performed for each of the various definitions of bull and bear markets. These results are presented in Appendix B. These results are summarised in Table 3.3 below.

TABLE 3.3

SUMMARY STATISTICS FOR ADVANCING FROM SIMM TO MODIFIED SIMM

Bull and Bear def. observations	5%			1%		
	Critical Value	No. shares exceeded	%	Critical Value	No. shares exceeded	%
CASE 1 ZERO (412 obs)	3,00	8	16,67%	4,61	1	2,08%
CASE 2 SD (245 obs)	3,00	7	14,58%	4,61	2	4,17%
CASE 3 VIS (346 obs)	3,00	7	15,58%	4,61	2	4,17%
CASE 4 RISK-F (94 obs)	3,10	3	6,25%	4,85	0	0

Table 3. displays the percentage of securities that had a significan increase in explanation by advancing from the SIMM to the modified SIMM.

Examination of the table reveals that a relatively small percentage of the securities in each of the four cases exhibited significantly better fits when using the modified SIMM. But, for 3 of the 4 cases (Cases 1, 2 and 3) the percentage significant was greater than the 10,17% upper limit suggested by the binomial distribution. Thus, it appears that Table 3.2 does provide some evidence of differences in bull and bear markets for some securities. However, the extent of such differences is likely to be extremely small and it is unlikely that the additional explanation afforded by the modified model is worth the additional computational work involved.

This is furter supported by studying the multiple correlation coefficiets of the modified model for each of the significant secrities (c.f. Appendix B). These results are summarised in Tale 3.4 below.

TABLE 3.4

	Signiicant Difference		No Significant Difference	
	No.	Avg. $\bar{R}^2$	No.	Avg. $\bar{R}^2$
CASE 1	8	0,1079	40	0,1560
CASE 2	7	0,1533	41	0,2130
CASE 3	7	0,1121	41	0,1506
CASE 4	3	0,2789	45	0,3217

Thus the highnumber of significant values found in Cases 1, 2 and 3 appear to be caused not by the modified model being better than the SIMM, but rather because of the inadequacy of both modes.

It is also interesting to note that Case 4 resulted in fewer significant securities than the other three cases, and that the percentage of securities was less than the binomial distributions upper limit of 10,17%. This indicates exactly the opposite effect to that proposed by Lindahl-Stevens (1980). Thus the results presented in Table 3.3 indicate that if the definition of bull and bear markets are adjusted to that proposed by Lindahl-Stevens, then there is even less evidence that different alpha and beta coefficients exist in bull and bear markets.

It can thus be concluded that the results found on the JSE are consistent with those of Fabozzi and Francis on the NYSE, i.e. that the SIMM is not affected by the alternating forces of bull and bear markets.

Using the four different definitions of bull and bear markets it was found that the alpha and beta coefficients were not (either separately or jointly) influenced by the bull and bear market conditions. The small percentage of securities that did appear to have significant shifts in their alpha and/or beta coefficients could be attributed to the occurrence of random fluctuations or poorly fitting SIMM's rather than a genuine economic change.

It was also found that use of the definition of bull and bear markets proposed by Lindahl-Stevens (i.e. that the risk free rate should be used as the dividing mark between bull and bear markets) yielded results which were similar to those obtained using the other three definitions. This contradicts Lindahl-Stevens' suggestion that significant changes in alpha and beta coefficients might be found using this definition. In fact, if anything the opposite of her assertion is true.

3.1.3 Risk and Gold Shares

The two components of risk, i.e. unique risk and market risk are very distinct for gold mines.

Unique risk can be referred to as mining risk here and can be associated with events causing unexpected changes in production. Floods, fires, explosions, seismic activity, labour unrest and unexpected grades of ore being mined are examples of such events.

Market risk, however, is related to the performance of the gold price. Clearly a mines earnings will fluctuate according to the fluctuations of the gold price, hence earnings of mines having costs per ounce similar to the gold price will change drastically when the gold price changes. These mines will generally have high costs and are referred to as marginal mines. Marginal mines generally have high market risk, that is, have beta's greater than 1.

Selected betas for gold mining shares quoted on the JSE are shown in Table 3.5.

TABLE 3.5 Gold Mining Share Betas on the JSE

SHARE	BETA 1	BETA 2
Blyvooruitzicht	1.10	1.25
Deelkraal	0.59	1.05
Doornfontein	1.24	1.34
Elandsrand	1.55	1.11
E.R.P.M.	1.32	1.15
Kloof	1.03	1.07
President Steyn	1.19	1.24
Randfontein	0.64	0.89
Venterspost	2.06	1.58
Western Deep Levels	1.24	1.43

Source: McKie Bros, Van Velden, Channing & R.S. Mennie Inc., Cape Town.

With reference to the betas shown in Table 3.5 it should be noted that:

Beta 1 : Gold mining shares regressed against the JSE All Mining Index - up to July 1981

Beta 2 : Gold mining shares regressed against the JSE All Mining Index - calculated recently.

3.2 Portfolio Theory

It has been pointed out in the previous section that a great reduction in risk can be achieved by holding a well diversified portfolio. This section therefore, will contain a brief discussion on the development of portfolio theory whereafter an empirical study on the relative importance of the various sectors for portfolio selection on the JSE will be discussed.

The portfolio approach proposed by Markowitz (1959) which will be discussed here uses the standard deviation of a portfolio as a measure of risk. The return on a portfolio is taken to be weighted sum of the returns on each of the individual securities.

3.2.1 The Markowitz Model

Since an investor's choice among portfolios should be based solely on the basis of the expected return and the uncertainty associated with that return, the following assumptions are relevant.

(i) If two portfolios have the same risk, the one with larger expected return is preferred.

(ii) If two portfolios have the same expected return, the one with less risk is preferred.

(iii) If one portfolio has less risk and a larger expected return than another it is preferred.

Hence the definition of efficient and inefficient portfolios arises:

'Efficient portfolio' - A portfolio is said to be 'efficient' if it is impossible to find a portfolio which has a greater expected return without incurring greater risk, also, it is impossible to obtain smaller risk without decreasing expected return.

'Inefficient portfolio' - A portfolio is said to be 'inefficient' if it is possible to obtain higher expected return with no greater uncertainty of return, or to obtain a lower uncertainty of return without a reduction in expected return.

Obviously investors will always prefer efficient portfolios, however, the higher the expected return of an efficient portfolio the higher will be the associated level of risk. In order to accommodate every investor's preference, the entire set of efficient portfolios has to be generated.

The first stage therefore involves generating the efficient set of portfolios. The following notation will be used in this regard:

E_i = Expected return on the ith security

σ_i = Standard deviation of return on the ith security

E_p = Expected return on the portfolio

σ_p = Standard deviation of return on the portfolio

σ_{ij} = Covariance between security i and security j

ρ_{ij} = Correlation coefficient for the returns on securities i and j

X_i = Proportion of funds invested in security i

N = Total number of shares considered

also

$$E_p = \sum_{i=1}^{N} X_i E_i = X'E \tag{3.1}$$

and
$$\sigma_p^2 = \sum_{i=1}^{N}\sum_{j=1}^{N} X_i X_j \sigma_{ij} \tag{3.2}$$

$$= \sum_{i=1}^{N}\sum_{j=1}^{N} X_i X_j \sigma_i \sigma_j \rho_{ij}$$

$$= X'\ddagger X$$

where $X' = (X_1, X_2, \ldots, X_N)$

$E' = (E_1, E_2, \ldots, E_N)$

and
$$\ddagger = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{21} & \sigma_2^2 & \cdots & \sigma_{2N} \\ \vdots & \vdots & & \vdots \\ \sigma_{N1} & \sigma_{N2} & \cdots & \sigma_N^2 \end{pmatrix}$$

If the expected return and standard deviation of all possible portfolios consisting of combinations of the securities under consideration were computed, the diagram of E_p plotted against σ_p would have a 'broken-egg-shaped' form shown in Figure 3.1 below.

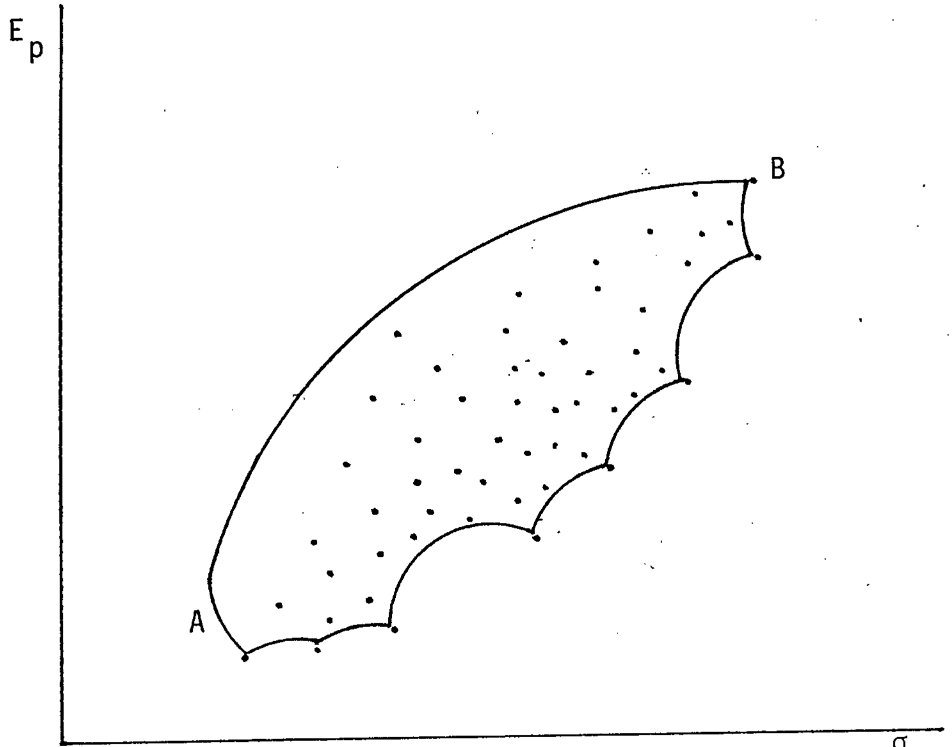


FIGURE 3.1

Each dot typifies the expected return and standard deviation of an individual security. Any point within the 'broken-egg-shaped' area is attainable by some combination of the individual securities. The upper curve AB consists of all the efficient portfolios and is called the efficient border.

Clearly portfolios located on the efficient E_p, σ_p border are also located on the efficient E_p, σ_p^2 border and vice versa. The efficient border of the E_p, σ_p^2 region is usually found and then converted to the efficient E_p, σ_p border as this simplifies computations.

Sharpe (1970) considered the following objective function to find the set of efficient portfolios

minimize $-\lambda E_p + \sigma_p^2$ for all possible $\lambda > 0$

where $\sigma_p^2 = X'\Sigma X$

subject to the constraints:

(i) $\sum_{i=1}^{N} X_i = 1$

that is, the entire portfolio must be invested.

(ii) $X_i > 0$ for all $i = 1,2,\ldots,N$

that is, no security may be held in negative quantities thus no short sales are permitted.

Note that a portfolio is represented by a vector

$$X' = (X_1, X_2, \ldots, X_N)$$

where X_i is the proportion of funds invested in the ith security. The value of the objective function thus changes for varying values of X_i.

Solution of the above model can be attained by using the following steps (c.f. Affleck-Graves (1974)).

(i) assign a particular numeric value between 0 and ∞ to λ;

(ii) solve for the X_i's;

(iii) change the value of λ and repeat.

It should be noted that the objective function $-\lambda E_p + \sigma_p^2$ is linear in (σ_p^2, E_p) space with slope λ. The minimum value of the objective function will thus be attained at the point where the line $-\lambda E_p + \sigma_p^2$ is a tangent to the efficient border.

Generally portfolio analysis problems would involve more constraints of the form:

$$L_i \leqslant X_i \leqslant U_i \qquad \text{for all} \quad i = 1,2,\ldots,N$$

where L_i is the lower bound and U_i is the upper bound on the proportion of funds to be invested in security i.

A typical example might be a restriction that not more than 20% of all available funds should be invested in any one security. Hence the following constraint would be included:

$$0 \leqslant X_i \leqslant 0{,}2 \qquad \text{for} \quad i = 1,2,\ldots,N.$$

Various other linear constraints could be included, such as restrictions of certain proportions being invested in certain sectors of the market.

Solution of the above problem requires a quadratic programming technique, since V_p contains terms in X_i^2.

3.2.2 Borrowing and Lending

Besides investing in the security market investors also have the option of either borrowing or lending capital at some risk-free rate of interest; for example in a building society. Some allowance for this must be made in the selection of efficient portfolios.

To understand the concept of borrowing and lending in the context of portfolio theory it will be initially necessary to assume that investors can lend and borrow at the same risk-free rate of interest. Also assume that borrowing may be considered as the issuance of some riskless security (where the lender will be repaid at some future date) and lending may be considered as investment in a riskless security.

Let security 1 be the above-mentioned riskless security. Then

$X_1 > 0$ implies the investor lends,

$X_1 < 0$ implies the investor borrows

and $X_1 = 0$ implies the investor neither borrows or lends.

Since equal borrowing and lending rates are assumed

$$E_1 = r_f$$

where r_f is the risk-free rate of interest, and

$$\sigma_1 = 0$$

This implies that all the $\sigma_{1i} = 0$ for $i = 1,2,\ldots,N$ since $\sigma_{1i} = \sigma_1\sigma_i\rho_{1,i}$

If a portfolio is chosen to contain only two securities; the riskless security, say security k, all possible combinations of the proportions of funds in this portfolio will generate a straight line connecting the two points in the σ_p, E_p plane. This is evident since:

$$E_p = X_1E_1 + X_kE_k$$

and

$$\sigma_p^2 = X_1^2\sigma_1^2 + X_k^2\sigma_k^2 + 2X_1X_k\sigma_1\sigma_k\rho_{1,k}$$

$$= 0 + X_k^2\sigma_k^2 + 0$$

hence $\sigma_p = X_k\sigma_k$.

If all possible securities were now considered, lending and borrowing would extend the range of investment possibilities. Figure 3.2 shows that if investors can borrow or lend to the market at the same rate, r_f, then all investors would invest their funds at risk in portfolio S (the intersection of ASB and r_fSD).

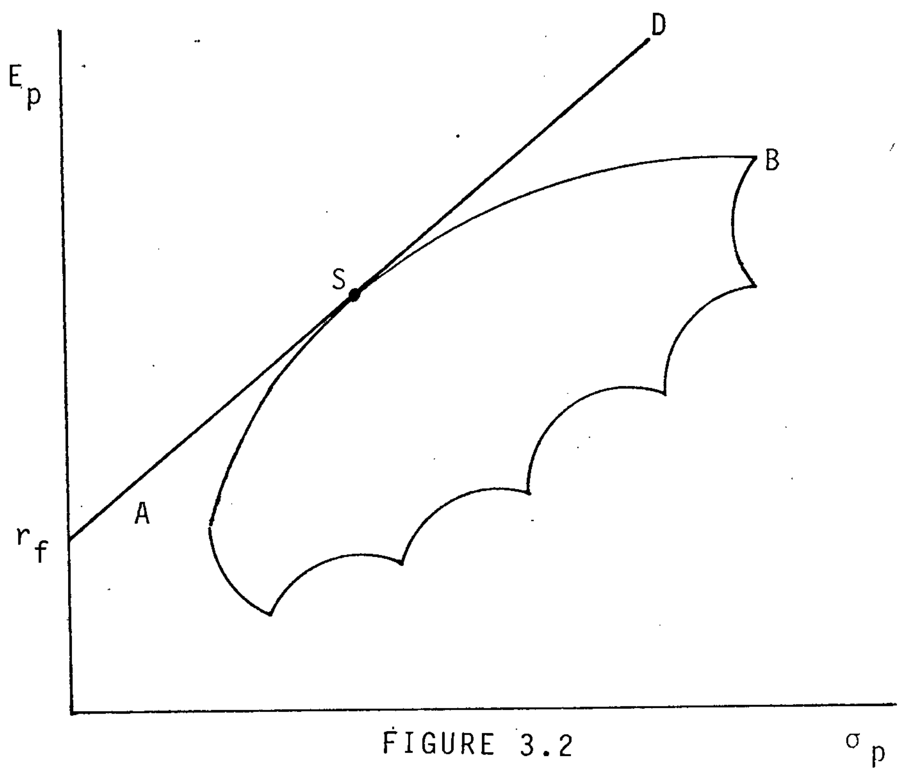


FIGURE 3.2

If an investor is willing to lend a portion of his funds to the market he would invest the remainder of his funds in portfolio S and his preference would be located along the r_fS segment. An investor who borrows and invests the total in S would have his preference located on the SD segment depending on the proportion of funds borrowed.

Portfolio S, called the optimal combination of risky securities is thus extremely important and under the above assumptions the optimal investment choice for all investors should be to choose portfolio S. Thus the individual investor need only consider how much he should borrow or lend in accordance with where his preference would be located along r_fSH. This concept is known as the Separation Theorem.

It is argued that under market equilibrium S would consist of all securities in the market and the proportion of each security must equal its proportionate value in the market as a whole. Hence portfolio S is often called the 'market portfolio'.

In the real world, however, all investors do not invest in the 'market portfolio'. The reason for this is that the assumptions imposed on the above model are too strict for this theory to be applied in practice. Brealey (1969) substantiates this statement by arguing that investors should only choose the same portfolio if they are faced with the same set of opportunities and agreed on the same expected return for each security. Brealey argues further:

"In practice, of course, such agreement is rare. Even if they do share identical views of each stock's prospects, differences in the cost to which they are liable could result in differences in their expectations of return. For example, high-yielding stocks offer very low returns to investors with a high tax rate."

It is also felt that brokerage costs are extensive for large portfolios such as the 'market portfolio'. It is a well known fact that diversification reduces risk, however, researchers (c.f. Wagner and Lau (1971)) have shown that the improvement in risk reduction by diversifying portfolios by more than 10 securities is small.

Lastly it is unlikely that investors are able to borrow from the market at a rate equal to the lending rate. The case of unequal borrowing and lending rates will be discussed below.

If the lending rate (E_L) is less than the borrowing rate (E_B) the efficient border becomes LRST as shown in Figure 3.3 below.

Depending on the risk and return an investor prefers he can choose any point along the LRST curve, where the following alternatives can be considered:

(i) Between L and R the investor will split his funds between R and the riskless investment

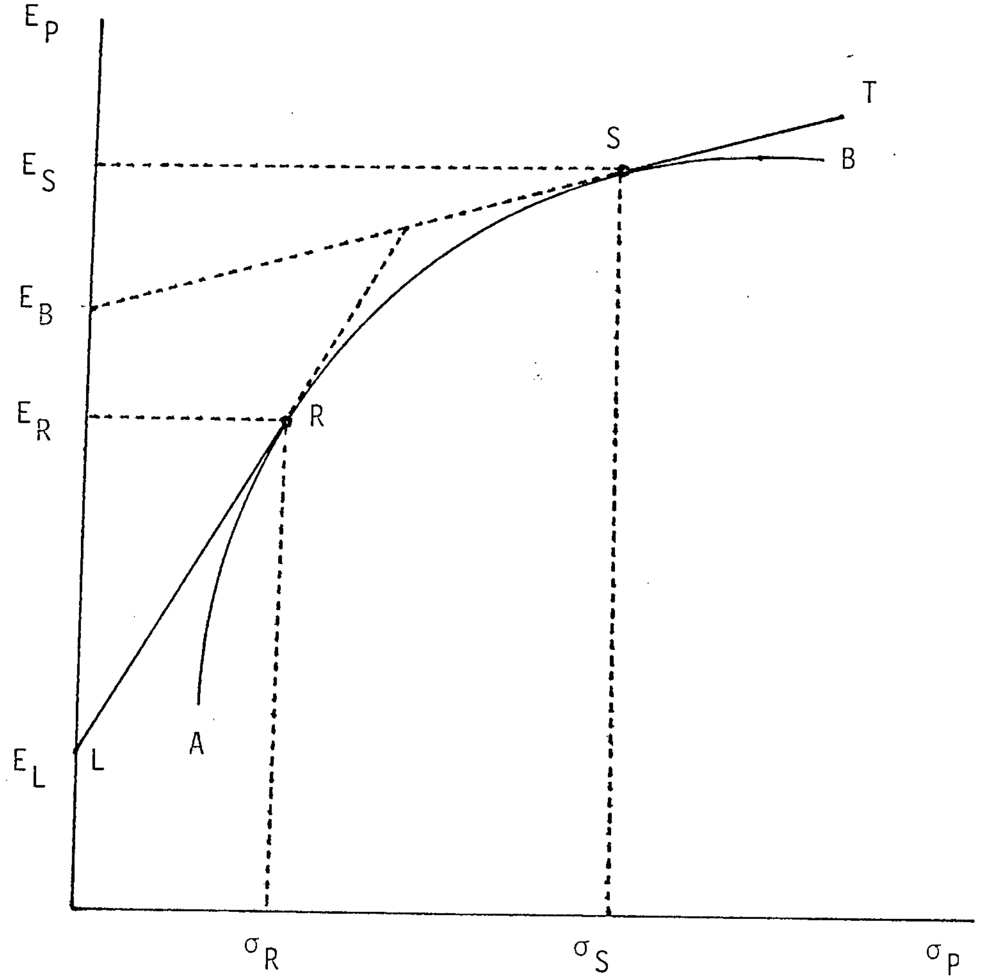


FIGURE 3.3

(ii) Between R and S he will invest all his funds in risky securities but the portfolio chosen will depend on his risk profile.

(iii) Above S he will invest all his funds in S and will borrow excess funds which he also invests in S.

3.2.3 Empirical Studies

Generally portfolio selection based entirely on gold shares will not yield a substantial reduction in overall risk.

The reason for this is simple; the correlations between the gold shares are generally positive and relatively large.

To substantiate the above argument the following example of a portfolio consisting of only two securities is considered: It can be shown that

$$E_p = X_1E_1 + X_2E_2 \qquad (3.3)$$

and

$$\sigma_p^2 = X_1^2\sigma_1^2 + X_2^2\sigma_2^2 + 2X_1X_2\sigma_{12}$$
$$= X_1^2\sigma_1^2 + X_2^2\sigma_2^2 + 2X_1(1-X_1)\sigma_1\sigma_2\rho_{12} \qquad (3.4)$$

since $\sigma_{12} = \sigma_1\sigma_2\rho_{12}$

and $X_2 = (1-X_1)$ for a 2-security portfolio

where the same notation as defined previously is used above.

Inspection of equation (3.4) above shows that σ_p^2 will be a maximum for $\rho_{12} = 1$ and a minimum for $\rho_{12} = -1$ indicating perfect positive and negative correlation respectively between the two securities. Clearly then the inclusion of securities that are negatively correlated with each other will greatly reduce the variance and hence the risk associated with holding that portfolio. Generally gold shares are not negatively correlated with each other and mostly exhibit strong positive correlation through the gold price. It should be noted that even securities exhibiting zero correlation with each other would be better for risk reduction purposes than strong positive correlation.

An indication of the relative importance of gold shares for portfolio selection is of prime importance. Carter, Affleck-Graves and Money (1982) conducted a study based on the relative importance of the various sectors on the JSE for portfolio selection. This study will be discussed below, with special reference to gold shares. It should be noted, however, that in considering only sectors on the JSE, the results of the study is only meaningful to local investors since foreign investors have larger investment selection opportunities outside South Africa.

An Empirical Study on the JSE by Carter, Affleck-Graves and Money (1982)

The above-mentioned study consisted of the selection of efficient portfolios from the JSE. The JSE, however, was regarded as a 34 'security' market, where each 'security' consisted in fact of a portfolio of like securities aggregated into a sector index.

The structure of the sectoral and the composite indices used in their study with the percentage contribution that each index made to its immediately superior composite index at the end of June 1980 is shown in Figure 3.4.

The data used in the study was divided into three equal periods, namely:

(a) February 1965 to January 1970

(b) February 1970 to January 1975

(c) February 1975 to January 1980

JSE ACTUARIES INDICES *

		% to Immediate Index						
1.	Gold - Rand	7,5%						
2.	Gold - Evander	4,7%	All					
3.	Gold - Klerksdorp	20,1%	Gold	67,4%				
4.	Gold - OFS	24,5%			All			
5.	Gold - W Wits	43,2%			Mining	48,4%		
6.	Coal			6,5%				
7.	Diamonds			16,5%				
8.	Platinum	51,5%	Metals and					
9.	Copper, Tin, Others	48,5%	Minerals	9,6%				
10.	Mining Holding			27,1%	Mining			
11.	Mining Houses			72,9%	Financials	20,0%		
12.	Inv. Trusts	13,1%						
13.	Insurance	13,0%						
14.	Property	11,3%	Financial	16,0%				
15.	Banks	62,6%					All	
16.	Ind. Holding	19,5%					Shares	
17.	Beverages	7,4%					100%	
18.	Building	5,3%						
19.	Chemicals	22,1%						
20.	Clothing	2,1%			Industrial			
21.	Electrical	2,8%			&	31,6%		
22.	Engineering	6,0%			Financial			
23.	Fishing	0,5%						
24.	Food	5,3%						
25.	Furniture	2,8%	Industrial	84,0%				
26.	Motors	1,6%						
27.	Paper, Packaging	5,7%						
28.	Pharmaceutical	0,7%						
29.	Printing	0,4%						
30.	Steel	3,0%						
31.	Stores	6,2%						
32.	Sugar	4,0%						
33.	Tobacco	3,0%						
34.	Transport	1,6%						

* The indices have been expressed excluding Property Trusts which only entered in 1976.

FIGURE 3.4

Monthly returns for all the indices were calculated using the formula

$$R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}}$$

where R_{it} is the return for index i in month t

P_{it} is the value of the index i at the end of month t

P_{it-1} is the price of index i at the end of month t

The method for establishing the efficient borders (frontiers) was similar to the algorithm proposed by Sharpe (1970) and was adapted by Affleck-Graves (1974).

The graph of the efficient borders obtained for each of the three periods was extracted from the report of Carter, Affleck-Graves and Money and is shown in Figure 3.5.

With reference to Figure 3.5 the following salient points are worth noting:

(i) The range of risk/return options for selection of efficient portfolios was much more restricted in Period 3.

(ii) In general, a given level of risk (e.g. $\sigma_p = 7$) produced dramatically different returns in the three periods.

(iii) At given risk ranges the slope of the efficient frontiers sometimes are very different. It can also be noted that the slope at different risk levels is of crucial importance to the investor in deciding whether additional risk is worth bearing.

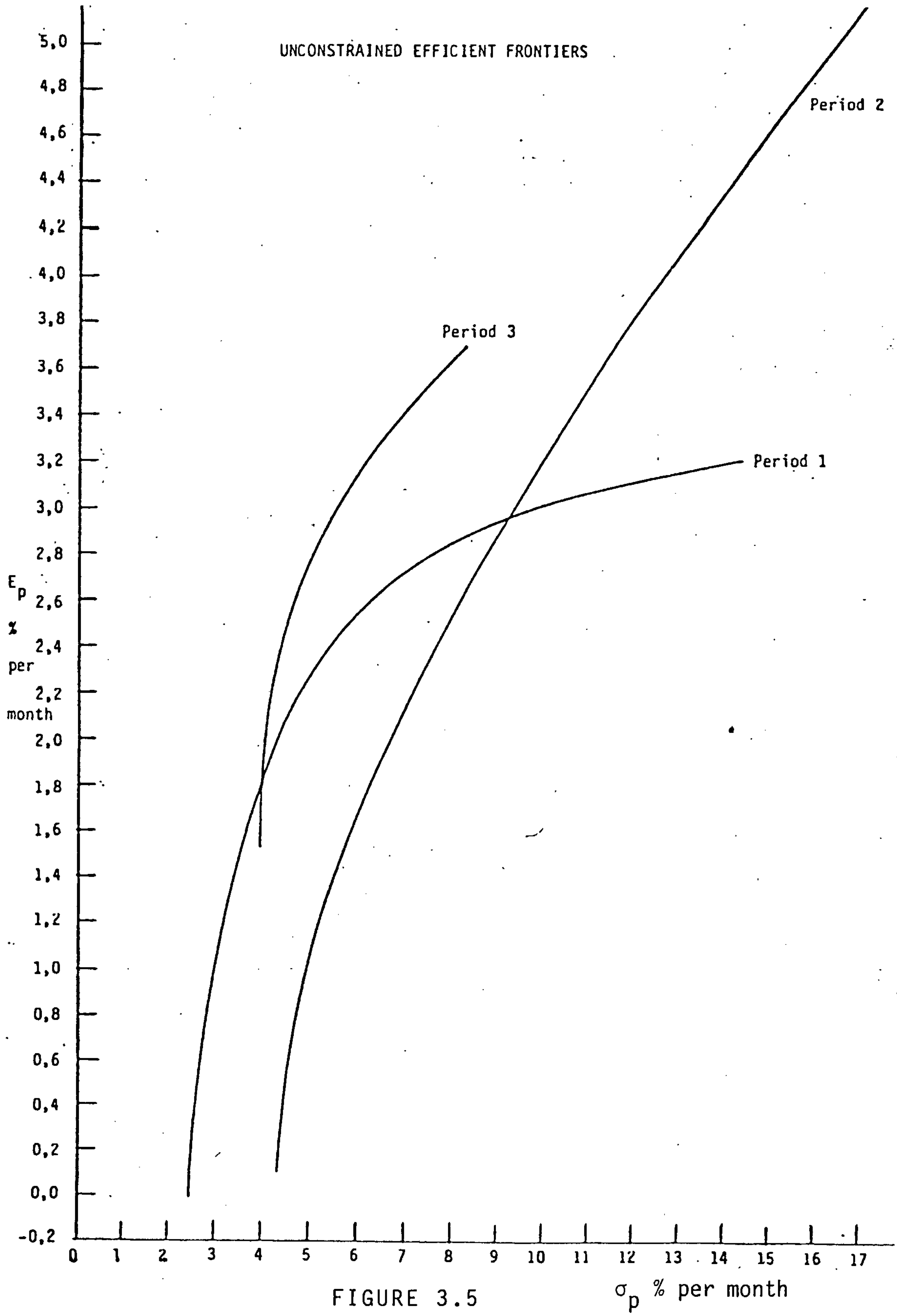

UNCONSTRAINED EFFICIENT FRONTIERS
Period 1
Period 2
Period 3
E_p % per month
5,0
4,8
4,6
4,4
4,2
4,0
3,8
3,6
3,4
3,2
3,0
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
-0,2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
σ_p % per month

FIGURE 3.5

The Relationships of Sector Indices to the Efficient Frontiers

It has been proposed that the market portfolio should be located on the efficient frontier assuming market equilibrium. A discussion on why this is not generally true has been considered in Section 3.2.2 and will thus not be repeated here. It is however of interest to determine where the market portfolio is located with reference to the efficient frontier.

Carter, Affleck-Graves and Money (1982) researched this aspect in their study and also included portfolios consisting of three other major indices on the JSE. The four portfolios consisted of the following indices, namely:

(a) All Share Index (M)

(b) All Mining Index (A)

(c) Mining Financial Index (F)

(d) Industrial and Financial Index (I)

The location of the risk/return points for the above mentioned indices with reference to the efficient frontiers for each of the periods 1, 2 and 3 were extracted from the authors' report and are shown in Figures 3.6, 3.7 and 3.8 respectively.

Comparison of the above mentioned graphs show the following interesting characteristics:

(i) The All Mining Index (A) dominates the Mining Financial Index (F) in all three periods, that is, it is closer in proximity to the efficient frontier. This was found

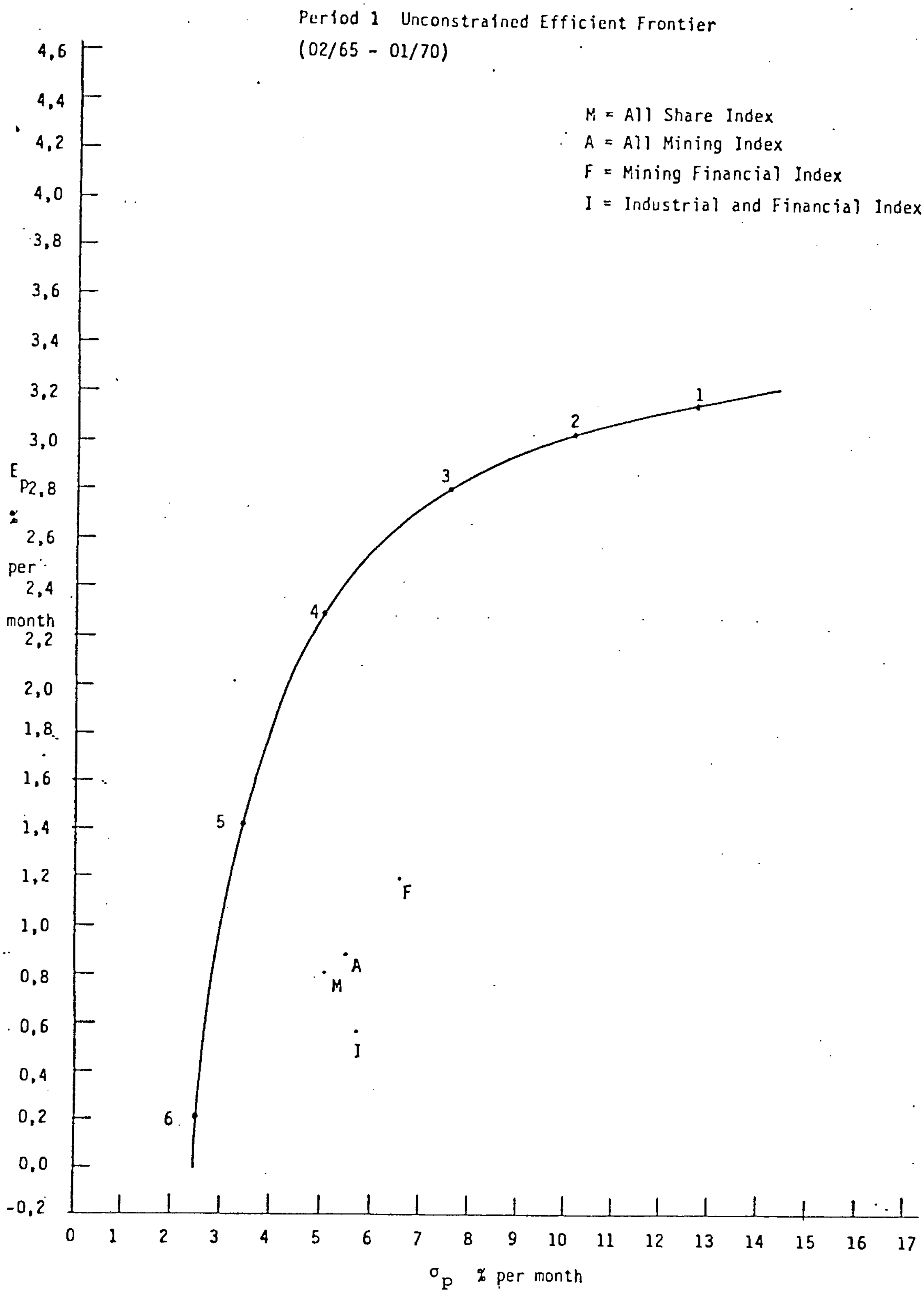

Period 1 Unconstrained Efficient Frontier
(02/65 - 01/70)
M = All Share Index
A = All Mining Index
F = Mining Financial Index
I = Industrial and Financial Index
4,6
4,4
4,2
4,0
3,8
3,6
3,4
3,2
3,0
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
-0,2
E P % per month
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
σ P % per month
1
2
3
4
5
6
M
A
F
I

FIGURE 3.6

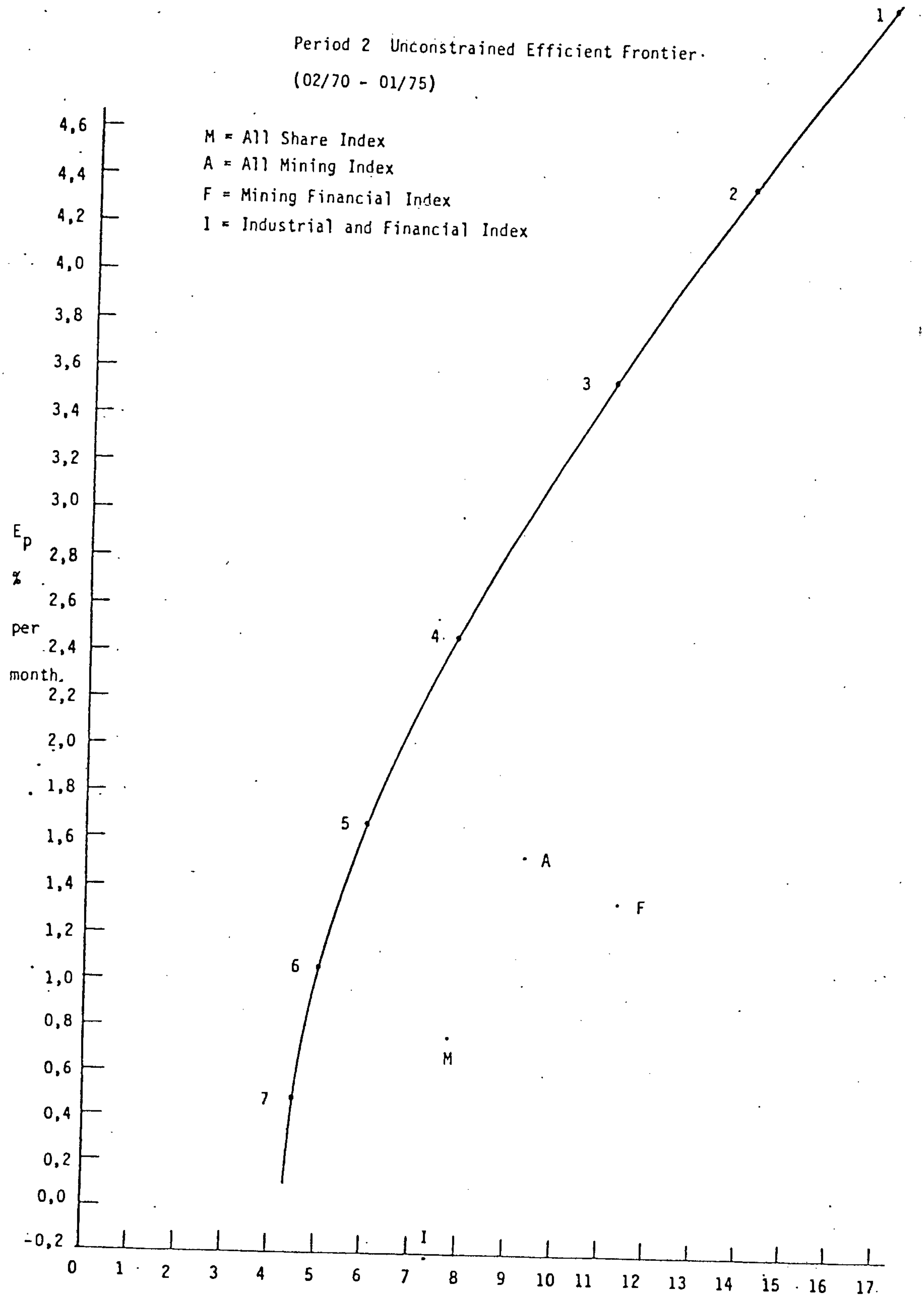

Period 2 Unconstrained Efficient Frontier
(02/70 - 01/75)
M = All Share Index
A = All Mining Index
F = Mining Financial Index
I = Industrial and Financial Index
E_p % per month
4,6
4,4
4,2
4,0
3,8
3,6
3,4
3,2
3,0
2,8
2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
-0,2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
1
2
3
4
5
6
7
A
F
M
I

FIGURE 3.7

Period 3 Unconstrained Efficient Frontier

(02/75 - 01/80)

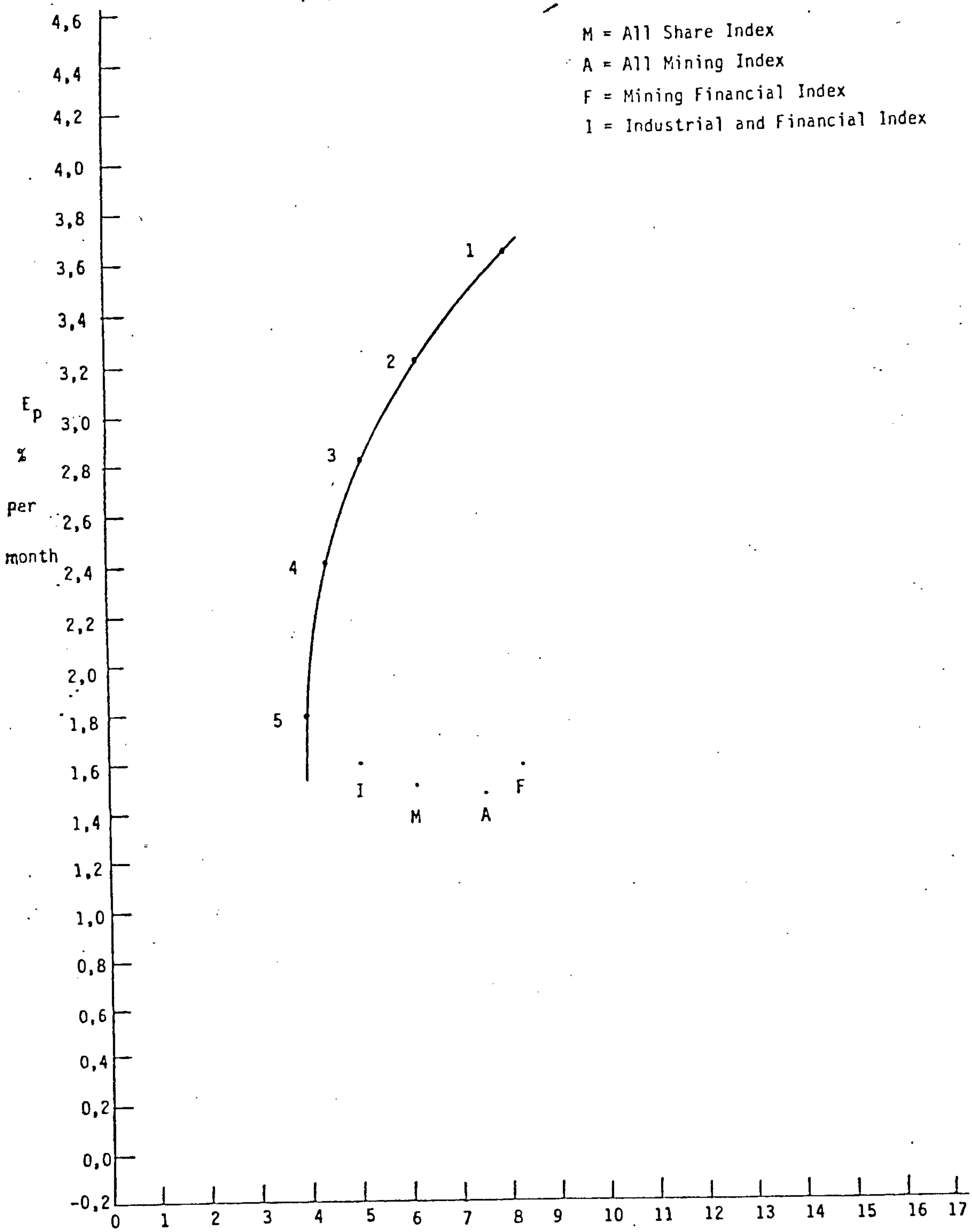


FIGURE 3.8

to be an interesting characteristic as securities in the Mining Financial Index derive their income from portfolio holdings of securities in the All Mining Index.

(ii) None of the indices are located on the efficient frontier.

It would thus appear that the efficient portfolios of the three periods under consideration will be made up of sectors from the All Mining and the Industrial and Financial market segments with little or no contribution being made from the Mining Financial market segment.

Carter, Affleck-Graves and Money further determined the composition of some of the efficient portfolios in the three periods. These findings will be considered below with the object of assessing the relative importance of gold shares in efficient portfolios.

Composition of Efficient Portfolios

Figures 3.6, 3.7 and 3.8 include numbered portfolios located on the efficient frontiers, the composition of these efficient portfolios are given in Tables 3.6, 3.7 and 3.8 (extracted from Carter, Affleck-Graves and Money (1982)) and refer to Figures 3.6, 3.7 and 3.8 respectively. The portfolios marked with an asterisk carry the same risk as the All Share portfolio.

σ_M = 5,020 % per month

R_M = 0,804 % per month

TABLE 3.6

Period 1

Portfolio No.	1.	2.	3.	4.*	5.	6.
σ_p (% per month)	13,000	10,000	7,500	5,020	3,400	2,500
E_p (% per month)	3,193	3,028	2,784	2,312	1,331	0,184
1. Gold - Rand						0,0081
2. Gold - Evander						0,0612
3. Gold - Klerksdorp					0,0427	0,1002
4. Gold - OFS						0,0690
5. Gold - W Wits						
6. Coal					0,0584	0,2010
7. Diamonds				0,1468	0,0811	
8. Platinum	0,0311	0,3560	0,5519	0,3065	0,1503	0,0678
9. Copper, Tin, Others			0,0887	0,2531	0,1615	0,0361
10. Mining Holding						
11. Mining Houses						
12. Inv. Trusts						
13. Insurance	0,9689	0,6440	0,3124	0,0197		
14. Property						
15. Banks						
16. Ind. Holding						
17. Beverages						
18. Building						
19. Chemicals						
20. Clothing						
21. Electrical						
22 Engineering						0,0100
23. Fishing						0,0681
24. Food						
25. Furniture						
26. Motors						
27. Paper, Packaging					0,0331	0,0490
28. Pharmaceutical						
29. Printing					0,3111	0,2491
30. Steel						0,0047
31. Stores						
32. Sugar					0,0395	0,0712
33. Tobacco				0,1576	0,0932	
34. Transport			0,0470	0,1163	0,0291	0,0045
TOTAL	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000

* Portfolio with same risk as the market

Period 2

σ_M = 7,861 % per month
R_M = 0,749 % per month

TABLE 3.7

Portfolio No.	1.	2.	3.	4.*	5.	6.	7.
σ_p (% per month)	17,000	14,000	11,000	7,861	6,000	5,000	4,500
E_p (% per month)	5,190	4,406	3,500	2,392	1,606	1,064	0,6372
1. Gold - Rand	0,8601	0,5268	0,2520	0,0497			
2. Gold - Evander	0,1215	0,1129	0,1005	0,0658	0,0178		
3. Gold - Klerksdorp							
4. Gold OFS							0,0363
5. Gold - W Wits	0,0185	0,3603	0,5320	0,5329	0,4614	0,3398	0,1914
6. Coal				0,0601	0,1305	0,1839	0,2187
7. Diamonds							
8. Platinum							
9. Copper, Tin, Others							
10. Mining Holding							
11. Mining Houses							
12. Inv Trusts							
13. Insurance							
14. Property							
15. Banks							
16. Ind. Holding							
17. Beverages				0,0585	0,0554	0,0536	
18. Building							
19. Chemicals							0,0686
20. Clothing							
21. Electrical				0,0070	0,2091	0,3596	0,4156
22. Engineering							
23. Fishing			0,0520	0,0867	0,0484	0,0157	
24. Food			0,0635	0,1393	0,0702	0,0061	
25. Furniture							
26. Motors							
27. Paper Packaging							
28. Pharmaceutical							
29. Printing							0,0261
30. Steel					0,0072	0,0414	0,0433
31. Stores							
32. Sugar							
33. Tobacco							
34. Transport							
TOTAL	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000

- * Portfolio with same risk as the market

σ_M = 6,292 % per month
R_M = 1,482 % per month

TABLE 3.8

Period 3

Portfolio No.	1.	2.*	3.	4.	5.
σ_p (% per month)	8,000	6,292	5,000	4,400	4,000
E_p (% per month)	3,644	3,235	2,765	2,379	1,802
1. Gold - Rand					
2. Gold - Evander			0,0044		
3. Gold - Klerksdorp					
4. Gold - OFS					
5. Gold - W Wits					
6. Coal	0,9648	0,7228	0,4523	0,2905	0,1442
7. Diamonds					
8. Platinum					
9. Copper, Tin, Others					0,0020
10. Mining Holding					
11. Mining Houses					
12. Inv. Trusts				0,0376	
13. Insurance					
14. Property					
15. Banks					
16. Ind. Holding					
17. Beverages					
18. Building					
19. Chemicals			0,0944	0,1031	0,0406
20. Clothing	0,0346	0,2726	0,3892	0,3283	0,1608
21. Electrical				0,0867	0,1286
22. Engineering					0,2338
23. Fishing					0,0479
24. Food					
25. Furniture					
26. Motors					
27. Paper, Packaging					
28. Pharmaceutical					
29. Printing					0,0558
30. Steel	0,0006	0,0046			
31. Stores					
32. Sugar			0,0134	0,0712	0,0759
33. Tobacco			0,0138		
34. Transport			0,0325	0,0826	0,1104
TOTAL	1,0000	1,0000	1,0000	1,0000	1,0000

* Portfolio with same risk as the market

On examining the tables the following points emerge:

(i) Examination of the portfolios with high risk show that limited diversification occurs. The reason for this occurrance is that only a limited number of sectors in each period had a sufficiently high return to compensate for the high risk. Diversification was also found to increase as the risk of the efficient portfolios decreased. This is consistent with the belief that diversification reduces risk. The portfolio with the least risk in each of the Periods 1, 2 and 3 contained 14, 7 and 10 sectors respectively.

(ii) The gold share sectors seem to occur in portfolios grouped in particular risk areas, for example, in Period 1 the gold sectors occur in the lower risk portfolios whereas in Period 2 they occur in the higher risk portfolios. In Period 3 only one gold sector occurred in only one of the efficient portfolios. This is obviously due to the level and relative volatility of the gold price during these three periods.

(iii) In Period 2, Gold-West Wits appears in every efficient portfolio considered, that is, all seven portfolios representing the specified risk levels. This is attributable to the fact that it not only displays a high return but also exhibits very little covariance with other currently efficient sectors in this period.

(iv) The sectors Mining Holdings, Mining Houses, Property, Banks, Industrial Holding, Building, Furniture, Motors, Pharmaceutical and Stores did not appear in any of the efficient portfolios considered in any period.

In conclusion it should be noted that none of the sectors including the gold share sector was found to be consistently dominant in all three periods. Clearly during the first period, that is, from February 1965 to January 1970 the gold market was reasonably dull due to the fairly stable gold price, hence the gold share sector was found to contribute to efficient portfolios of low risk and return only. During the second period the gold sector dominated all of the medium and high risk portfolios, however, during the third period the gold sector was hardly evidenced in efficient portfolios. It should be noted however that gold shares were still in great demand by foreign investors during the third period, hence it is assumed that gold shares did in fact exhibit strong portfolio selection qualities for foreign investors during this period.

An Empirical Portfolio Selection Study Based Solely on Gold Shares Quoted on the JSE

A portfolio selection study based solely on gold shares was conducted using the algorithm adapted by Affleck-Graves (1974). The aim of the study was firstly to compare the range and domain of the efficient frontiers generated by the algorithm over the annual periods, 1978, 1979, 1980, 1981, 1982 and 1983; secondly, to determine the composition of the optimal portfolios as defined by the Separation Theorem and lastly, to investigate the role of the Kruger Rand in portfolio selection based only on the gold share and Kruger Rand market.

1. Comparison of the Efficient Frontiers for Years 1978 to 1983

The efficient frontiers for each of the individual years were determined and are shown in Figure 3.9 below. It should be noted that the portfolio returns and standard deviations are expressed in units of average weekly percentages. The actual composition of a selected range of efficient portfolios for each of the years 1978 to 1983 are shown in Tables 3.9 to 3.14 respectively. The most notable features which emerge from Figure 3.9 are:

(a) The large differences in the range of returns of the efficient portfolios that existed in the individual years. In 1981 the average weekly returns of the efficient portfolios only had a range of about 0,6% whereas in 1979 the average weekly returns of the efficient portfolios had a range of about 7,3%. This is clearly due to the respective bear and bull market phases during these periods.

(b) The large differences in the magnitude of average weekly returns during the various periods. Average weekly returns of 10,13% were shown to be attainable during 1979 whereas the highest average weekly return attainable in the gold share market during 1981 was only 0,23%.

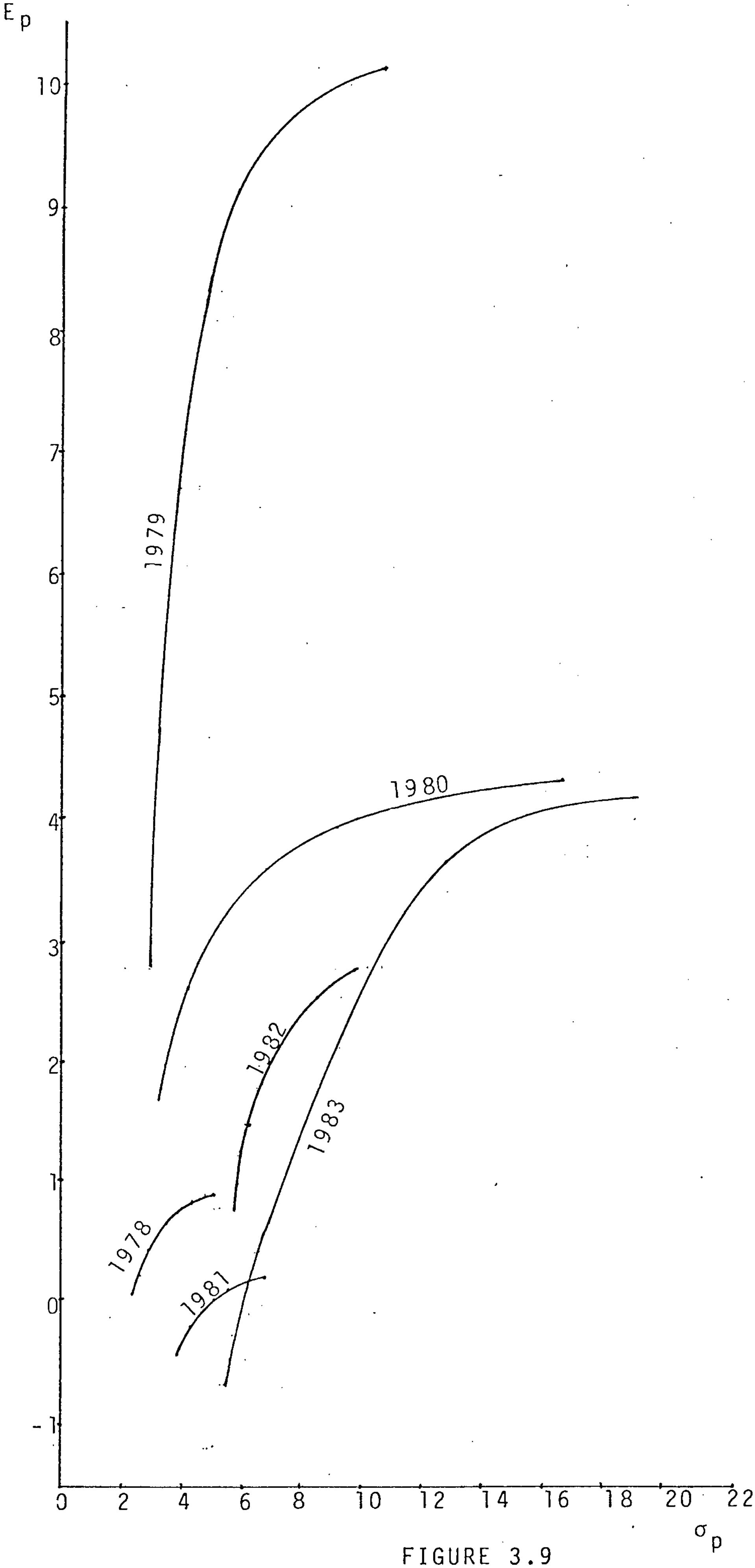

Ep
10
9
8
7
6
5
4
3
2
1
0
-1
0
2
4
6
8
10
12
14
16
18
20
22
σp
1979
1980
1982
1983
1978
1981

FIGURE 3.9

TABLE 3.9: Composition of Efficient Portfolios for 1978

E_p / σ_p	0,92 / 5,11	0,91 / 4,92	0,90 / 4,70	0,86 / 4,25	0,77 / 3,74	0,48 / 2,85	0,28 / 2,45	0,22 / 2,38	0,10 / 2,30
SHARE									
1 Dbn Dp									
2 E T Cons									
3 E R P M									
4 Ergo						20	37	42	50
5 Grootvl									
6 Marvale						3	4	5	7
7 Randfnt									10
8 Simmers					4	10	11	11	10
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie			4						
16 Winkels							7	9	7
17 Af Lease									3
18 Buffels									
19 Harties			6	18	25	13	2		
20 Sovaal									
21 Stilfnt				10	20	13	8	7	
22 Vaal Rfs						1			
23 Zandpan					5	2			
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel						10	10	10	7
31 Welkom					3	3			
32 W Holds									
33 Blyvoor						8	11	11	6
34 Deelkrl									
35 Doorns									
36 Dries									
37 Elands	100	92	80	61	35	14	5	2	
38 Elsburg									
39 Kloof									
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga		8	10	10	8	6	3	2	
45 Rd Lease									
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.10 : Composition of Efficient Portfolios for 1979

E_p	10,13	9,19	8,31	8,01	6,72	5,55	4,78	3,54	2,81
σ_p	10,62	5,78	4,74	4,51	3,85	3,40	3,18	2,90	2,84
SHARE									
1 Dbn Dp					3	5	6	6	2
2 E T Cons									
3 E R P M		60	45	40	28	17	11	1	
4 Ergo							3	8	11
5 Grootvl			18	21	15	10	5		
6 Marvale									
7 Randfnt									6
8 Simmers	100	40	31	28	24	20	18	15	12
9 Sallies			6	9	7	6	6	4	1
10 Village				3					
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels									
17 Af Lease					1	3	4	6	7
18 Buffels									
19 Harties									
20 Sovaal									
21 Stilfnt					22	30	31	32	28
22 Vaal Rfs									
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel						3	3		
31 Welkom							1	3	3
32 W Holds									
33 Blyvoor									
34 Deelkrl									
35 Doorns									
36 Dries									
37 Elands							4	14	18
38 Elsburg									
39 Kloof									
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga					1	6	8	10	11
45 Rd Lease									
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.11: Composition of Efficient Portfolios for 1980

E_p	4,35	3,94	3,62	3,17	2,62	2,27	2,00	1,86	1,75
σ_p	16,35	9,11	6,72	5,28	4,08	3,53	3,29	3,25	3,24
SHARE									
1 Dbn Dp									
2 E T Cons									
3 E R P M									
4 Ergo									
5 Grootvl									
6 Marvale					2	5	4	3	2
7 Randfnt									
8 Simmers		61	54	38	28	23	17	13	12
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels									
17 Af Lease									
18 Buffels									
19 Harties									
20 Sovaal									
21 Stilfnt				38	42	34	27	22	21
22 Vaal Rfs									
23 Zandpan					13	20	26	29	28
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena							5	7	7
30 Unisel									
31 Welkom									
32 W Holds						5	10	14	14
33 Blyvoor					9	4			
34 Deelkrl									4
35 Doorns			37	17	1				
36 Dries						8	11	12	11
37 Elands									
38 Elsburg									
39 Kloof									
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga	100	39	9	7	5	1			
45 Rd Lease									
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.12: Composition of Efficient Portfolios for 1981

E_p	0,23	0,19	0,13	0,06	0,04	-,02	-,08	-,19	-,40
σ_p	6,68	6,18	5,56	5,09	4,95	4,63	4,36	4,08	3,93
SHARE									
1 Dbn Dp									
2 E T Cons			3	2					
3 E R P M									
4 Ergo								4	11
5 Grootvl	100	83	64	32	26	9			
6 Marvale									
7 Randfnt									
8 Simmers								1	4
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels					4	13	15	12	
17 Af Lease									
18 Buffels				9	10	11	8		
19 Harties									
20 Sovaal									
21 Stilfnt									
22 Vaal Rfs							12	36	31
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena								6	11
30 Unisel									
31 Welkom									
32 W Holds									
33 Blyvoor									6
34 Deelkrl									
35 Doorns									
36 Dries				9	10	13	14	8	
37 Elands									
38 Elsburg									
39 Kloof		17	33	48	49	50	46	29	21
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									15
44 E. Dagga					1	4	5	4	1
45 Rd Lease									
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.13: Composition of Efficient Portfolios for 1982

E_p	2,78	2,73	2,55	2,42	1,85	1,53	1,33	1,00	0,80
σ_p	9,64	9,29	8,53	8,08	6,59	6,17	5,98	5,79	5,75
SHARE									
1 Dbn Dp		12	13	12	9	2			
2 E T Cons									
3 E R P M									
4 Ergo									
5 Grootvl									
6 Marvale									
7 Randfnt									
8 Simmers				4	23	27	26	18	13
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels							10	22	27
17 Af Lease									
18 Buffels									
19 Harties									
20 Sovaal					37	41	34	14	
21 Stilfnt									
22 Vaal Rfs								9	12
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine	100	88	61	44					
27 P Brand							1	2	
28 P Steyn									
29 St Helena									
30 Unisel									
31 Welkom									
32 W Holds								6	10
33 Blyvoor						2	4		
34 Deelkrl						13	17	19	20
35 Doorns									
36 Dries									4
37 Elands				6	12	6	2		
38 Elsburg									
39 Kloof									
40 Libanon			27	34	20	4			
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga									
45 Rd Lease						5	7	11	13
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.14: Composition of Efficient Portfolios for 1983

E_p	4,20	3,73	3,67	2,82	2,12	0,65	0,43	-,46	-,68
σ_p	18,78	12,67	12,50	10,67	9,33	6,79	6,49	5,55	5,43
SHARE									
1 Dbn Dp									
2 E T Cons									
3 E R P M									
4 Ergo									
5 Grootvl									
6 Marvale									
7 Randfnt									
8 Simmers				21	19	23	18	2	
9 Sallies									
10 Village				12	13	9	8		
11 Vlaks									
12 W R Cons		71	69	44	32				
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels									
17 Af Lease									
18 Buffels									
19 Harties									
20 Sovaal							4	31	39
21 Stilfnt									
22 Vaal Rfs									
23 Zandpan					20	59	63	59	46
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel									
31 Welkom									
32 W Holds									
33 Blyvoor									
34 Deelkrl								7	15
35 Doorns									
36 Dries									
37 Elands									
38 Elsburg									
39 Kloof									
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga	100	29	28	18	16	9	7	1	
45 Rd Lease			3	5					
TOTAL	100	100	100	100	100	100	100	100	100

(c) The range and magnitude of the average weekly standard deviations were found to differ significantly over the various periods.

2. Determination of the Optimal Portfolios as Defined by the Separation Theorem

The Separation Theorem discussed in Section 3.2.2 mentions that the optimal portfolio can be determined by finding the point on the efficient frontier which is a tangent to the line with the risk-free rate as y-intercept.

Figures 3.10 to 3.15 show the range of risk and return options along lines r_f to A with the introduction of borrowing and lending at the risk-free rate for the years 1978 to 1983 respectively.

It should be noted that the risk-free rate was taken to be the average of the prevailing 3-month bankers' acceptances rates over the respective years, and that these rates were divided by 52 in order to be comparable to the weekly returns used in the study. The percentage composition, weekly standard deviations and returns of the optimal portfolios, marked P in Figures 3.10 to 3.15 are shown in Table 3.15.

The salient features of the optimal portfolios are:

(a) The composition of the optimal portfolio differed significantly during each period.

(b) Relatively few gold mining companies are found to be

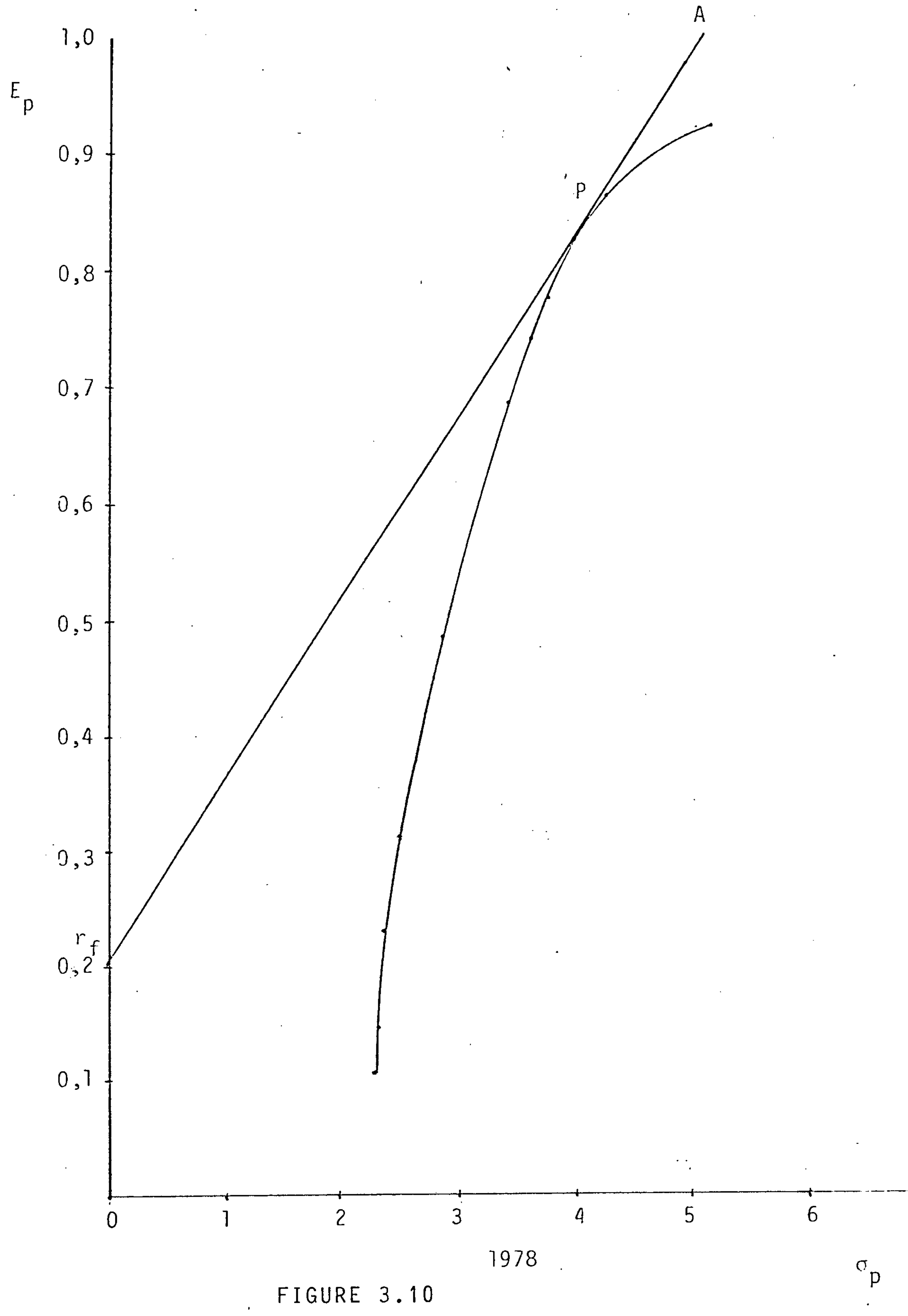
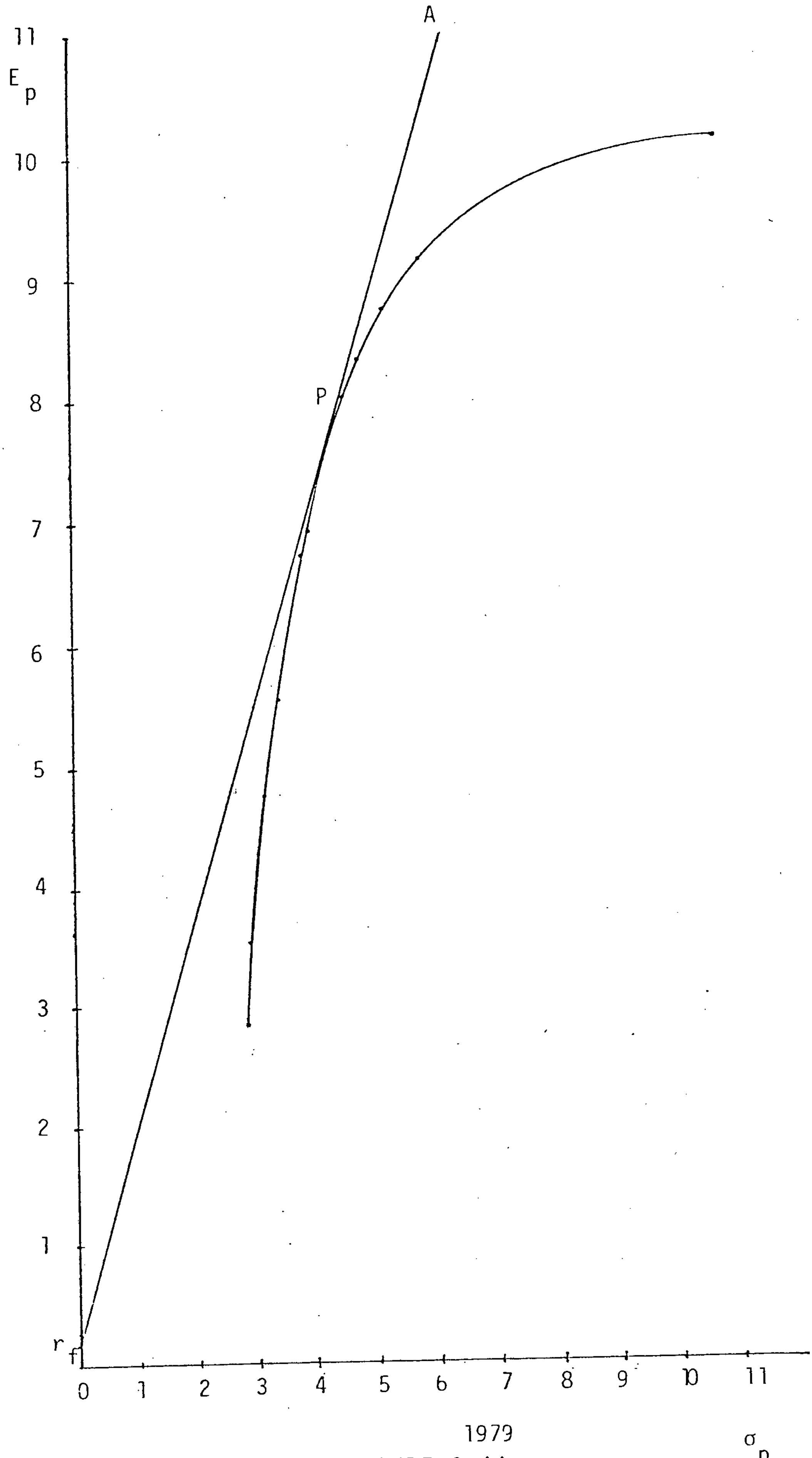


FIGURE 3.10


A
11
E_p
10
9
8
P
7
6
5
4
3
2
1
r_f
0
1
2
3
4
5
6
7
8
9
10
11
1979
σ_p

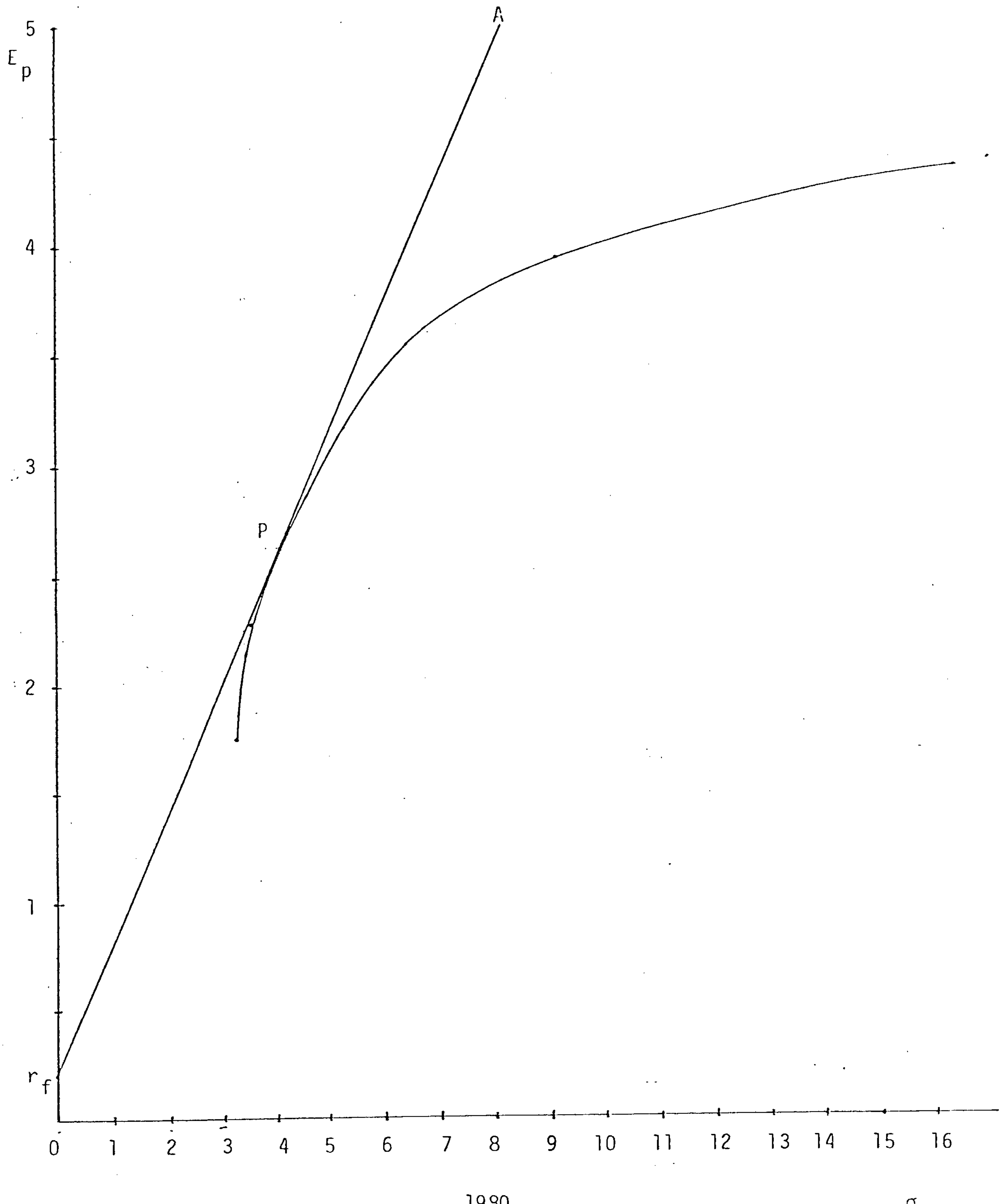


FIGURE 3.12

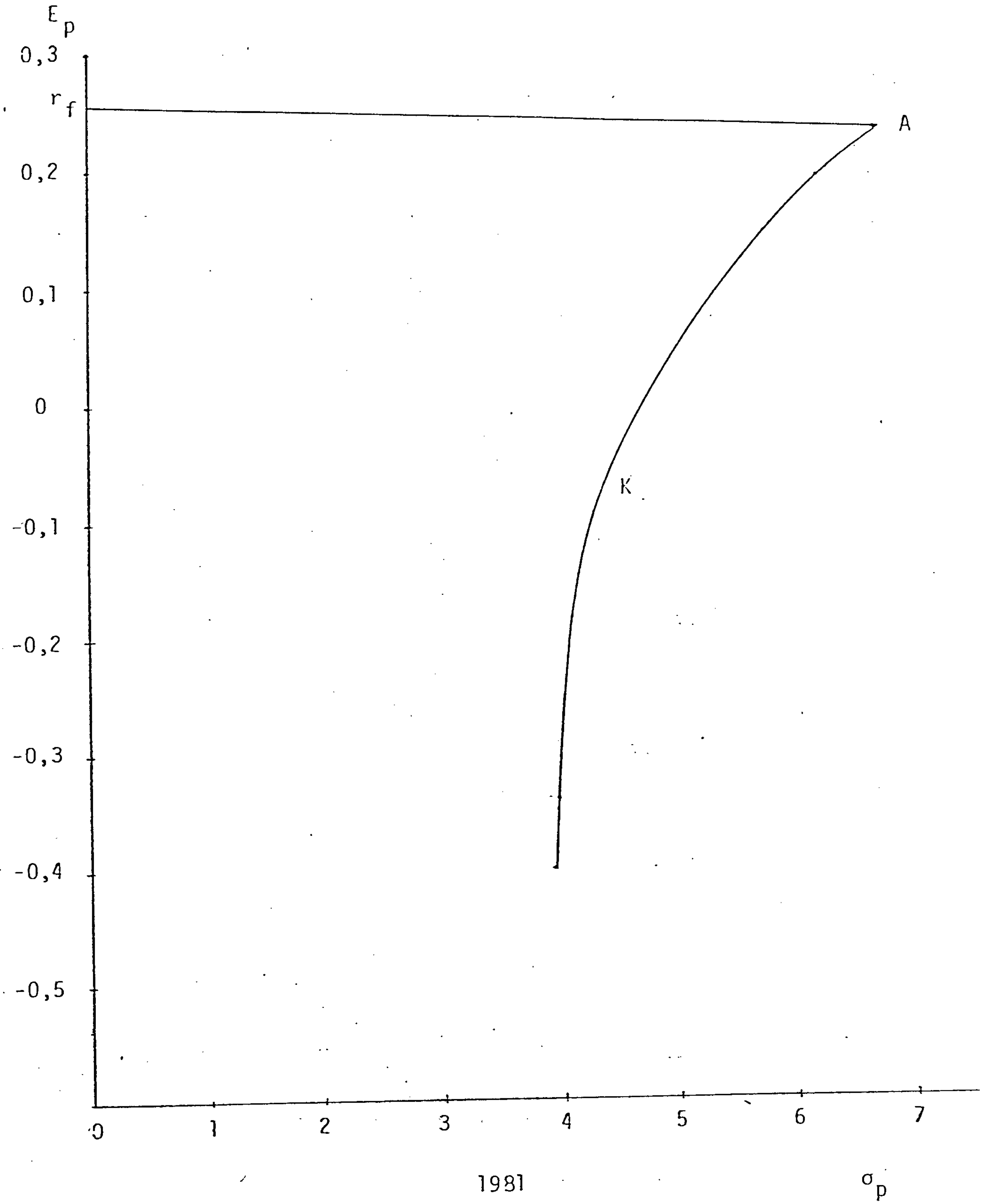


FIGURE 3.13

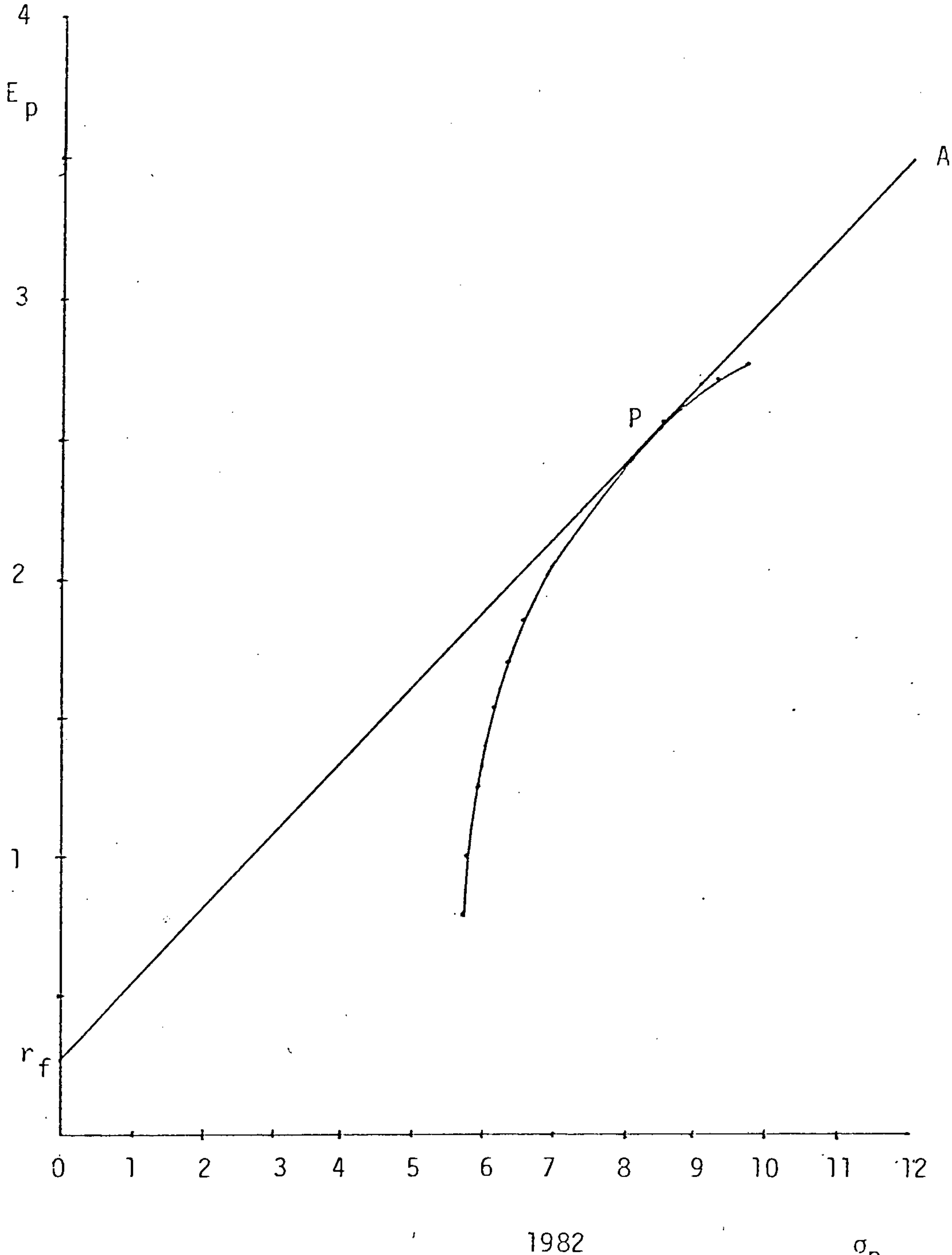
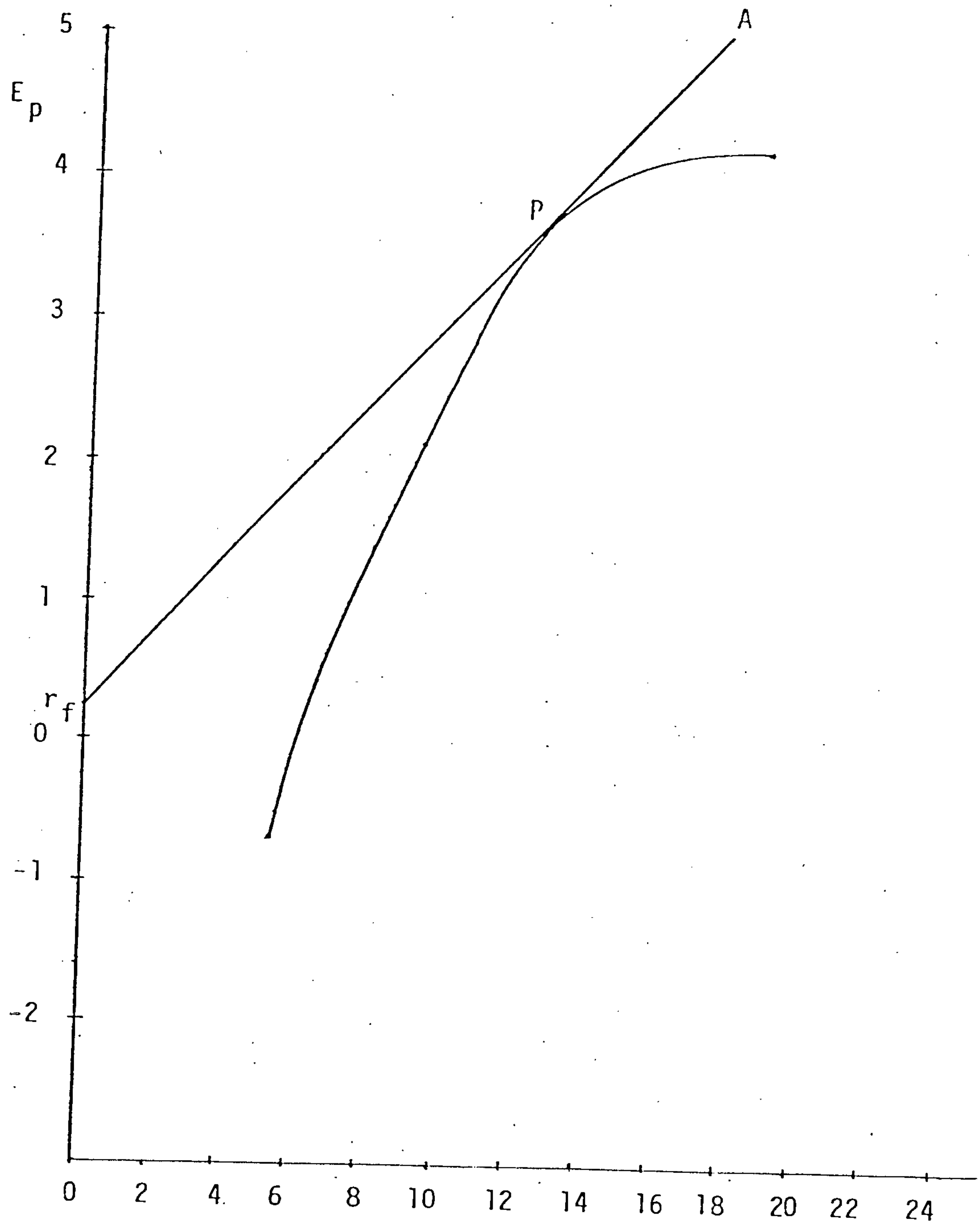


FIGURE 3.14



1983

FIGURE 3.15

TABLE 3.15: Composition of Optimal Portfolios

		1978	1979	1980	1981	1982	1983
E_p		0,83	7,95	2,62	0,25	2,48	3,67
σ_p		3,98	4,47	3,53	0	8,08	12,50
SHARE					Optimal to invest all funds at the risk-free rate here.		
1	Dbn Dp					12	
2	E T Cons						
3	E R P M		39				
4	Ergo						
5	Grootvl		21				
6	Marvale			2			
7	Randfnt						
8	Simmers		28	28		4	
9	Sallies		8				
10	Village		3				
11	Vlaks						
12	W R Cons						69
13	Bracken						
14	Kinross						
15	Leslie						
16	Winkels						
17	Af Lease						
18	Buffels						
19	Harties	27					
20	Sovaal						
21	Stilfnt	20	1	42			
22	Vaal Rfs						
23	Zandpan	2		13			
24	Freguls						
25	Harmony						
26	Loraine					44	
27	P Brand						
28	P Steyn						
29	St Helena						
30	Unisel						
31	Welkom						
32	W Holds						
33	Blyvoor			9			
34	Deelkrl						
35	Doorns			1			
36	Dries						
37	Elands	42				6	
38	Elsburg						
39	Kloof					34	
40	Libanon						
41	Venters						
42	W Areas						
43	Wstn Deep						
44	E. Dagga	9		5			28
45	Rd Lease						3
46	Kruger R						
TOTAL		100	100	100		100	100

present in the optimal portfolios, with a maximum of 7 different shares occurring in 1980.

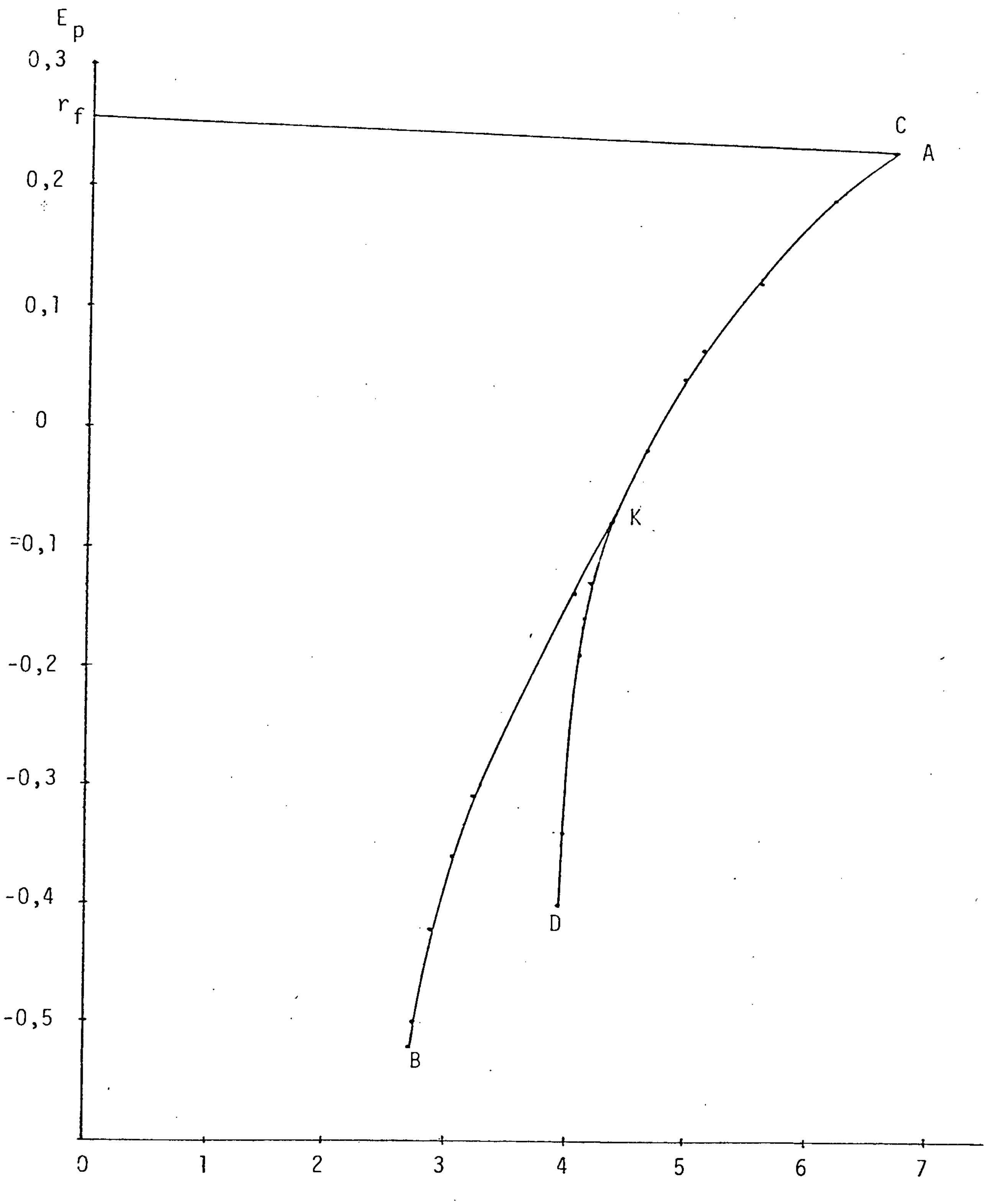
(c) During the bear market of 1981 it can be seen that it would have been more beneficial to invest funds at the risk-free rate than to invest in the gold share market.

(d) No gold share was found to be dominant in the optimal portfolio during all 6 years although some shares were found to be present in 3 out of the 6 periods.

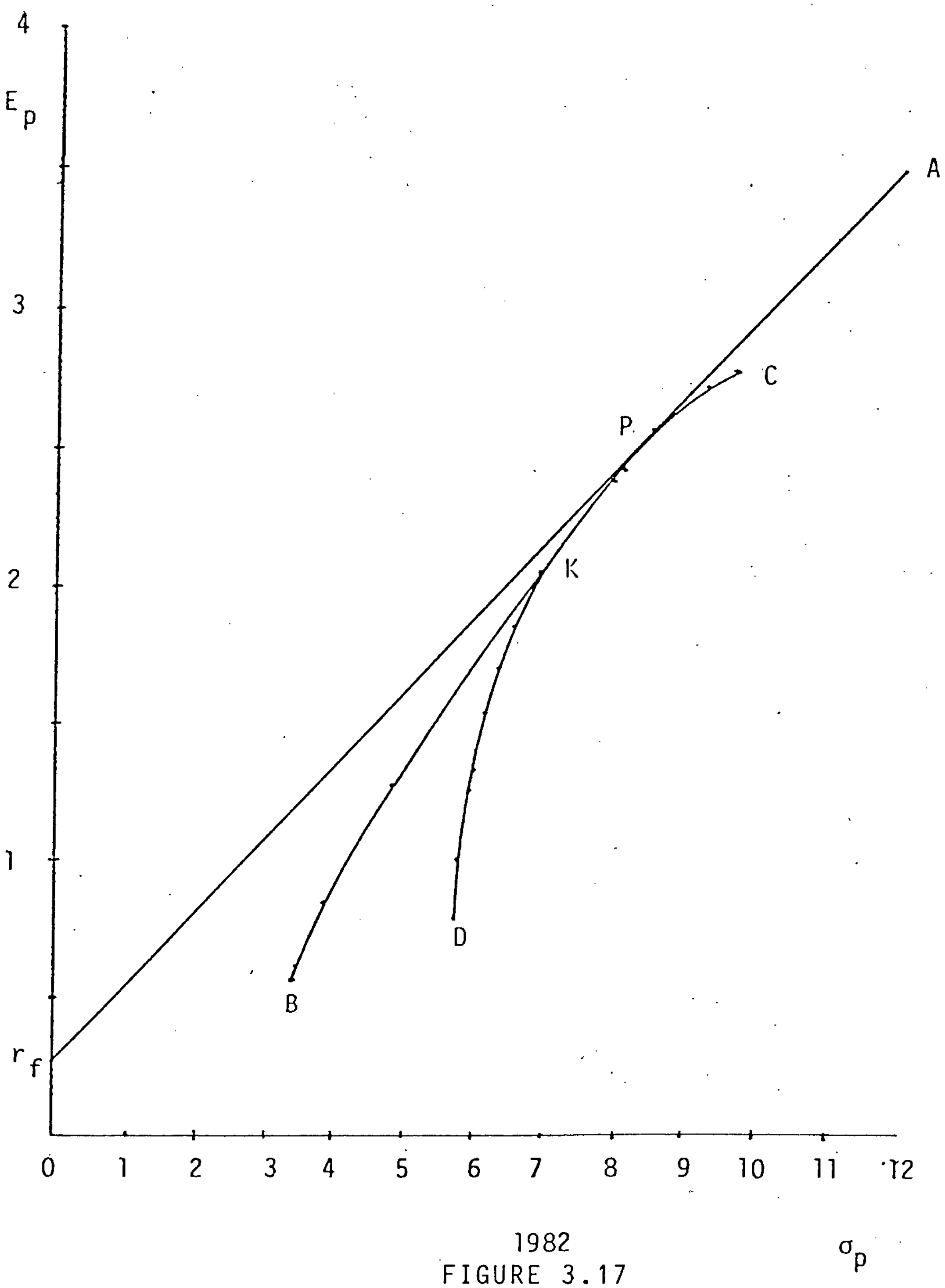
3. The Role of the Kruger Rand in Portfolio Selection

It is a common belief that Kruger Rands exhibit less market risk than the other gold shares quoted on the JSE. It is for this reason that one might be led to believe that Kruger Rands exhibit desirable risk reduction qualities for portfolio selection among gold shares. Efficient frontiers for the years 1981, 1982 and 1983 were thus redetermined considering Kruger Rands as well as all gold shares for portfolio selection.

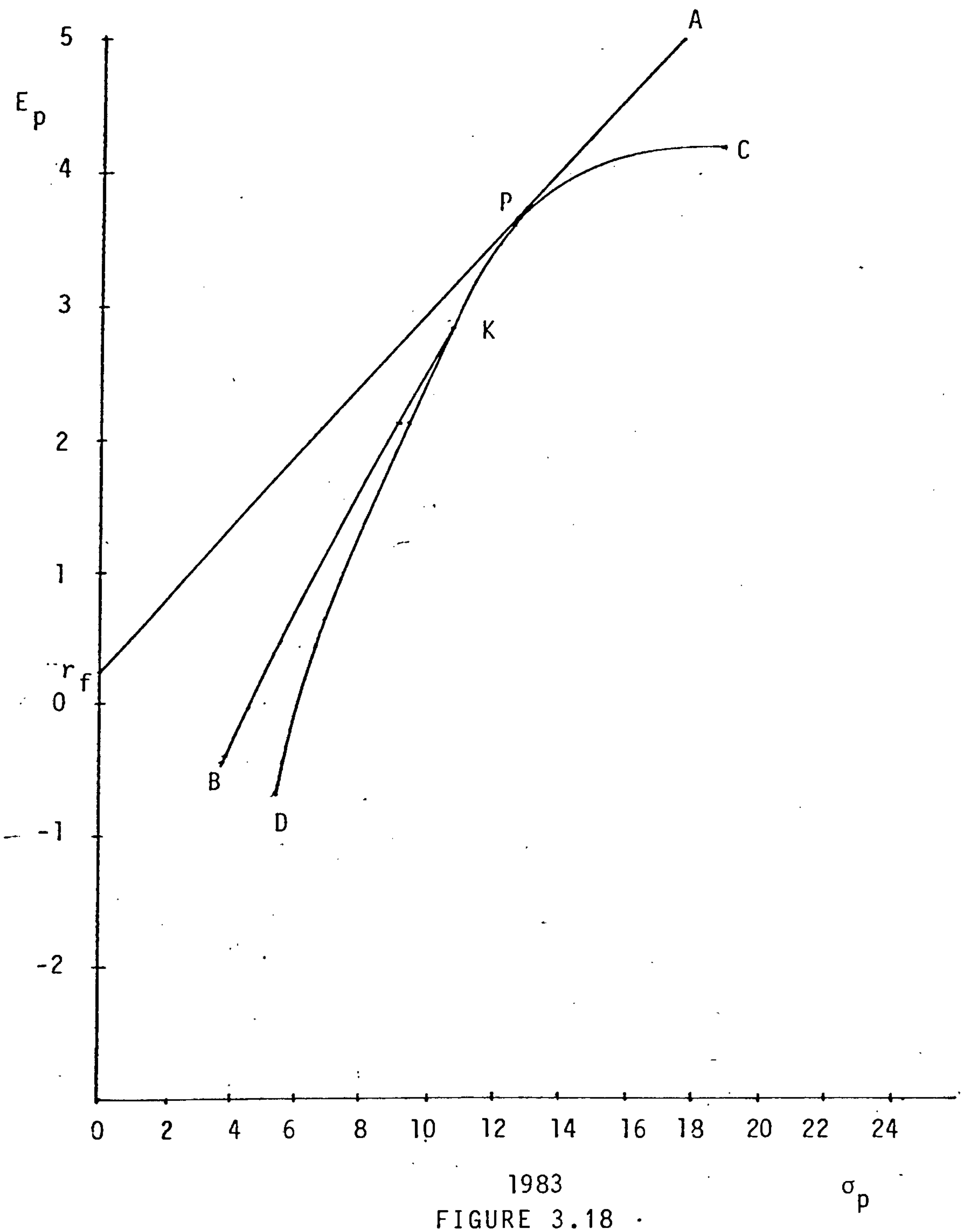
Figures 3.16, 3.17 and 3.18 show a comparison of the Efficient frontiers determined with and without considering Kruger Rand selection for 1981, 1982 and 1983 respectively, while Tables 3.16, 3.17 and 3.18 show the composition of a selected range of efficient portfolios considering Kruger Rands as well for these years. The curves extending from D to C show the efficient frontiers determined considering only the gold shares, while the curves extending through BKC



1981
FIGURE 3.16



1982
FIGURE 3.17



1983
FIGURE 3.18

TABLE 3.16: Composition of Efficient Portfolios including the Kruger Rand for 1981

E_p	0,23	0,19	0,14	0,06	0,04	-.14	-.31	-.42	-.52
σ_p	6,68	6,18	5,71	5,09	4,95	4,01	3,21	3,84	2,71
SHARE									
1 Dbn Dp									
2 E T Cons			3	2					
3 E R P M									
4 Ergo									
5 Grootvl	100	83	64	32	26	14	4		
6 Marvale									
7 Randfnt									
8 Simmers									
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels					4				
17 Af Lease									
18 Buffels				9	10	5			
19 Harties									
20 Sovaal									
21 Stilfnt									
22 Vaal Rfs									
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel									
31 Welkom									
32 W Holds									
33 Blyvoor									
34 Deelkrl									
35 Doorns									
36 Dries				9	10	13	13	10	2
37 Elands									
38 Elsburg									
39 Kloof		17	33	48	49	38	25	12	
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga					1	1	1		
45 Rd Lease									
46 Kruger R						29	57	78	97
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.17: Composition of Efficient Portfolios including the Kruger Rand for 1982

E_p	2,78	2,73	2,55	2,42	2,05	1,27	0,84	0,59	0,56
σ_p	9,64	9,29	8,53	8,08	6,96	4,80	3,82	3,44	3,41
SHARE									
1 Dbn Dp		12	13	12	8				
2 E T Cons									
3 E R P M									
4 Ergo									
5 Grootvl									
6 Marvale									
7 Randfnt									
8 Simmers				4	5	4	5	2	
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons									
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels									
17 Af Lease									
18 Buffels									
19 Harties									
20 Sovaal									
21 Stilfnt									
22 Vaal Rfs									
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine	100	88	61	44	33	13			
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel									
31 Welkom									
32 W Holds									
33 Blyvoor									
34 Deelkrl								5	3
35 Doorns									
36 Dries									
37 Elands				6	6	6	5		
38 Elsburg									
39 Kloof									
40 Libanon			27	34	30	19	10		
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga									
45 Rd Lease									
46 Kruger R					18	58	80	93	97
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 3.18: Composition of Efficient Portfolios including the Kruger Rand for 1983

E_p	4,20	3,73	3,66	3,49	2,12	0,45	-.04	-.40	-.43
σ_p	18,78	12,67	12,50	12,09	9,07	5,51	4,54	3,88	3,81
SHARE									
1 Dbn Dp									
2 E T Cons									
3 E R P M									
4 Ergo									
5 Grootvl									
6 Marvale									
7 Randfnt									
8 Simmers				7	7	1			
9 Sallies									
10 Village									
11 Vlaks									
12 W R Cons		71	69	62	39	15	7	1	
13 Bracken									
14 Kinross									
15 Leslie									
16 Winkels									
17 Af Lease									
18 Buffels									
19 Harties									
20 Sovaal									
21 Stilfnt									
22 Vaal Rfs									
23 Zandpan									
24 Freguls									
25 Harmony									
26 Loraine									
27 P Brand									
28 P Steyn									
29 St Helena									
30 Unisel									
31 Welkom									
32 W Holds									
33 Blyvoor									
34 Deelkrl									
35 Doorns									
36 Dries									
37 Elands									
38 Elsburg									
39 Kloof									
40 Libanon									
41 Venters									
42 W Areas									
43 Wstn Deep									
44 E. Dagga	100	29	28	25	16	6	2		
45 Rd Lease			3	6	4				
46 Kruger R					34	78	91	99	100
TOTAL	100	100	100	100	100	100	100	100	100

show the efficient frontiers determined considering the Kruger Rand as well.

The most notable features of these figures are:

(a) In none of the three periods considered was the line $r_f PA$ tangent to the curve on the segments BK, indicating that the Kruger Rand did not appear in the optimal portfolio in any of the periods considered. This is indeed a very surprising result as the Kruger Rand is widely believed to be important in portfolio selection among gold shares for insurance against downside risk. Further surprising evidence supporting the findings here can be presented, namely:

(i) the periods under consideration were predominantly bear markets where it is believed that Kruger Rands would have been better to hold instead of gold shares, however, this was not evidenced in the optimal portfolios,

(ii) the gold share returns used by the algorithm did not include dividends, implying that since no dividends are paid out to Kruger Rand owners the returns of the gold shares relative to the Kruger Rand are actually higher than the study indicates, without any associated additional risk, further substantiating the argument against Kruger Rands for portfolio selection.

(b) In 1981 Figure 3.16 shows that the optimal investment would have been to invest all funds at the risk-free rate (i.e. lend) and not to invest in gold shares at all. This result is clearly due to the severe bear phase of the gold bullion market during this period.

Finally, it can thus be concluded that evidence has been found that indicates that the Kruger Rand is not a good consideration for portfolio selection. However, it should be noted that the implication of this result could have a dramatic effect on the Kruger Rand market and therefore warrants a more detailed study.

Thus, on the basis of both empirical studies it was found that gold shares exhibited desirable qualities to warrant portfolio selection. However, during some periods this was found not to be the case.

CHAPTER 4

SHARE EVALUATION

The purpose of this chapter is to discuss traditional methods of share evaluation and to provide justification for a particular valuation method suitable for gold shares which will be implemented in Chapter 6.

4.1 Traditional Share Evaluation Models

Return on investment in common securities comes in two forms,namely, dividends and capital gains or losses.

The rate of return that investors expect from a given security over the next year ahead could thus be written as:

$$r = \frac{DIV(1)+P(1)-P(0)}{P(0)} \qquad (4.1)$$

where DIV(1) is the expected dividend per share;

P(1) is the price at the end of the year;

and P(0) is the price at the start of the year.

Note that P(1)-P(0) is the expected price appreciation per share. The value r, is often called the "market capitalization rate".

On the other hand if forecasts of dividend, price and the return offered by other equally risky securities are given, equation (4.1) can be rearranged to yield an expression for the current price

that is $$P(0) = \frac{DIV(1)+P(1)}{1+r} \qquad (4.2)$$

Clearly, in equation (4.2), P(1) can be expressed in terms of the following year's dividend, DIV(2) and price, P(2). Assuming also that r will be the same in the following year P(0) can be expressed as

$$P(0) = \frac{DIV(1)}{1+r} + \frac{DIV(2)+P(2)}{(1+r)^2} \qquad (4.3)$$

In fact the above equation can be expanded so that the current price, P(0), can be expressed as the total present value of the future stream of expected dividends plus some expected terminal price, P(H),

that is $$P(0) = \sum_{t=1}^{H} \frac{DIV(t)}{(1+r)^t} + \frac{P(H)}{(1+r)^H} \qquad (4.4)$$

Note, again it is assumed that the market capitalization rate remains constant. In general securities do not expire at some

In general securities do not expire at some given date, but can be viewed as having an infinite time horizon. The present value of the terminal price would thus approach zero as the time horizon tended to infinity and could therefore be ignored. The current price of a security in this instance could be expressed as the present value of a perpetual stream of cash dividends. This can be written as

$$P(0) = \sum_{t=1}^{\infty} \frac{DIV(t)}{(1+r)^t} \qquad (4.5)$$

A simplification of the above model can be achieved by assuming that dividends grow at a constant rate. Equation

$$P(0) = \frac{DIV(1)}{1+r} + \frac{DIV(1)(1+g)}{(1+r)^2} + \frac{DIV(1)(1+g)^2}{(1+r)^3} + \dots$$

$$= \sum_{t=1}^{\infty} \frac{DIV(1)[1+g]^{t-1}}{(1+r)^t} \qquad (4.6)$$

Since equation (4.6) is simply the sum of an infinite geometric series with first term; $\frac{DIV(1)}{1+r}$ and common ratio $\frac{1+g}{1+r}$, applying the formula for the sum of an infinite geometric series, equation (4.6) becomes

$$P(0) = \frac{DIV(1)}{1+r}/(1 - \frac{1+g}{1+r}) \qquad (4.7)$$

hence

$$P(0) = \frac{DIV(1)}{r-g} \qquad (4.8)$$

where g is the expected constant growth rate.

Clearly, g the anticipated growth rate will have to be less than r since as g approaches r the stock price will become infinite.

Equation (4.8) can be rearranged to obtain an expression for r, the market capitalization rate

hence $$r = \frac{DIV(1)}{P(0)} + g \qquad (4.9)$$

Brealey and Myers (1981) propose the following method for obtaining an estimate of g:

(i) compute the "plowback ratio (PR)" using the formula

$$PR = 1 - \frac{DIV(1)}{EPS(1)}$$

where $EPS(1)$ is the expected earnings per share.

(ii) compute the "return on equity (ROE)"

$$\text{where} \quad ROE = \frac{EPS(1)}{\text{Book equity per share}}$$

(iii) finally, g can be estimated by

$$g = PR \times ROE$$

Brealey and Myers (1981) suggest that a better estimate of r could be obtained by taking a large sample of securities of equivalent risk and using the average of the estimates for r instead of the individual security's r value.

Brealey and Myers (pp.49-50) further caution investors using the above constant-growth "discounted cash flow" (DCF) formulae by saying

> "*These simple, constant-growth DCF formulas are extremely useful rules of thumb, but they are no more than that. Naive trust has led many financial analysts to silly conclusions.*
>
> *First, remember the difficulty of estimating r by analysis of one stock only. Try to work with a large sample of equivalent-risk securities. Even that may not work, but at least it gives the analyst a fighting chance, because the inevitable errors in estimating r for a single security tend to balance out across a broad sample.*
>
> *Second, resist the temptation to apply the formula to firms having high current rates of growth. Such growth*

can rarely be sustained indefinitely, but the constant-growth DCF formula assumes it can. This erroneous assumption leads to an overestimate of r."

Clearly the assumption of constant growth for indefinite time horizons is not easily met in practice and secondly the accuracy of dividend forecasts need to be considered before applying any of the above formulae.

Firth (1977, p.22) suggests the use of a similar model, called the Goldman-Sachs model to overcome the problem of assuming indefinite constant growth rates. The model itself selects the time horizon for which the growth rate is relevant, thereafter the growth rate is taken to be equal to the average growth rate for a security of that risk class. The time horizon is selected using the following procedure:

1. A growth trend is computed using the previous 5 years earnings data as well as earnings forecasts for as many years as is possible.
2. The growth trend is extrapolated into the future until the expected earnings deviate by more than 7% from the trend. The time horizon up to this point in time is noted.
3. Steps 1 and 2 are repeated adding one more year of historical data until the recorded time horizon stabilizes (i.e. stops increasing). This becomes the horizon over which the growth rate is expected to last.

Thereafter the growth rate is adjusted to the average growth rate of firms with similar long-term growth prospects and levels of risk.

Concerning empirical evidence of the success of the Goldman-Sacks model, Firth (1977) concludes:

> *"The published results from using the model for evaluating utilities (for example electricity supply, telephone companies) have shown it to improve returns over those generated from a naive buy and hold policy (i.e. the market index). Unfortunately there have been no recent reports on the predictive ability of the model."*

It is felt, however, that it is extremely unlikely that a trading rule based on the "instinsic" share price as determined by the above model would yield consistently superior returns than the market. Unfortunately the published results of the model were not referenced by Firth, but it appears that the following factors were not considered. Firstly, the specific sectors of the market in the study could well have consisted of firms with higher than average debt-to-equity ratios which therefore increased the risk of the individual securities. Secondly, it is unlikely that portfolios selected by the trading rule displayed diversification benefits which could be obtained by holding the market portfolio.

It is therefore felt that a trading rule based on the Goldman-Sachs model is unlikely to yield portfolios with higher returns than the market portfolio without being subjected to higher risks. Brealey and Myers (1981) argue that simplistic share evaluation models based on constant growth will not generally yield a better estimate of a shares "intrinsic" share price than the market price of the share.

Another form (c.f. Brealey and Myers (1981, pp.51-52)) of the equations already discussed can be derived by considering the individual preferences of investors for either "income" or "growth" stocks.

Assume that a company pays all of its earnings out as dividends, in this case the company would not grow at all, and equation (4.9) would become

$$P(0) = \frac{DIV(1)}{r} \tag{4.10}$$

since g is equal to zero.

Also, since all the earnings are payed out as dividends, we have

$$EPS(1) = DIV(1)$$

and equation (4.10) can be written as

$$P(0) = \frac{EPS(1)}{r} \tag{4.11}$$

Further, assume instead that the company invests the earnings in some project. Then if the expected return on the project is also equal to r, equation (4.11) will still hold, as the reduction in value caused by no dividends in year 1 is exactly offset by the increase in value caused by the increased dividends in later years. That is, the net present value of the project will be equal to zero.

In general, however, projects with rates different from r must be accounted for, hence, Brealey and Myers propose the following formula:

$$P(0) = \frac{EPS(1)}{r} + PVGO \tag{4.12}$$

where PVGO is the present value of growth opportunities.

Thus equation (4.12) can be viewed as the capitalized value of average earnings under a zero-growth policy, plus the present value of growth opportunities.

With reference to equation (4.12) a "growth" stock is one which has a large PVGO relative to the capitalized value of EPS, alternately an "income" stock is one with a small PVGO relative to the capitalized value of EPS.

Unfortunately none of the models discussed in this section can be applied to the valuation of gold shares. The obvious reason for this is that future earnings, hence dividends and cash flows, are dependent on the future gold price which cannot be predicted with any degree of confidence. Clearly then any assumptions of constant growth in view of the volatile gold price would be untenable. Thus any further sophistication of models based on the discounted earnings, dividend or cash flow approach will not be discussed in this thesis.

4.2 Gold Share Evaluation Models

No known share evaluation models have been successfully applied to gold shares due to the unpredictable nature of future earnings. Many investors and analysts, however, value securities by estimating an appropriate yield or statistical multiplier for the security.

Barr (1981) conducted a study to determine the price of gold reflected by a gold share, termed the implicit gold price. Barr chose the gold share East Driefontein in the study on the basis of its long life, low cost profile and relatively stable grade of ore characteristics. Barr proposed the following dividend yield model for East Driefontein:

$$\text{Yield}_t = \frac{[\text{Implicit Gold price}_t(\$/\text{ounce}) - \text{Cost}_t(\$/\text{ounce})].k}{\text{Share price}_t(R)} \qquad (4.13)$$

where $k = \frac{195}{245} \cdot \frac{\text{R per \$ exchange rate}}{\text{R per \$ exchange rate at 3/12/79}}$

the dividend per share was R195 for 1979 and the average profit was \$245 per ounce of gold extracted over the same period.

The study was conducted using weekly data over the period, January 1978 to September 1980. Accordingly Barr made the following assumptions:

(i) cost changes were 12% per year

(ii) the relationship between dividend and profit was constant

(iii) tax rates remained constant.

The weekly implicit gold price was computed from equation (4.13) using three different yields, that is 8,10 and 12%.

Figure 4.1 duplicated from Barr's study shows the relationship between the actual and implicit gold price determined by the model for the above-mentioned yields.

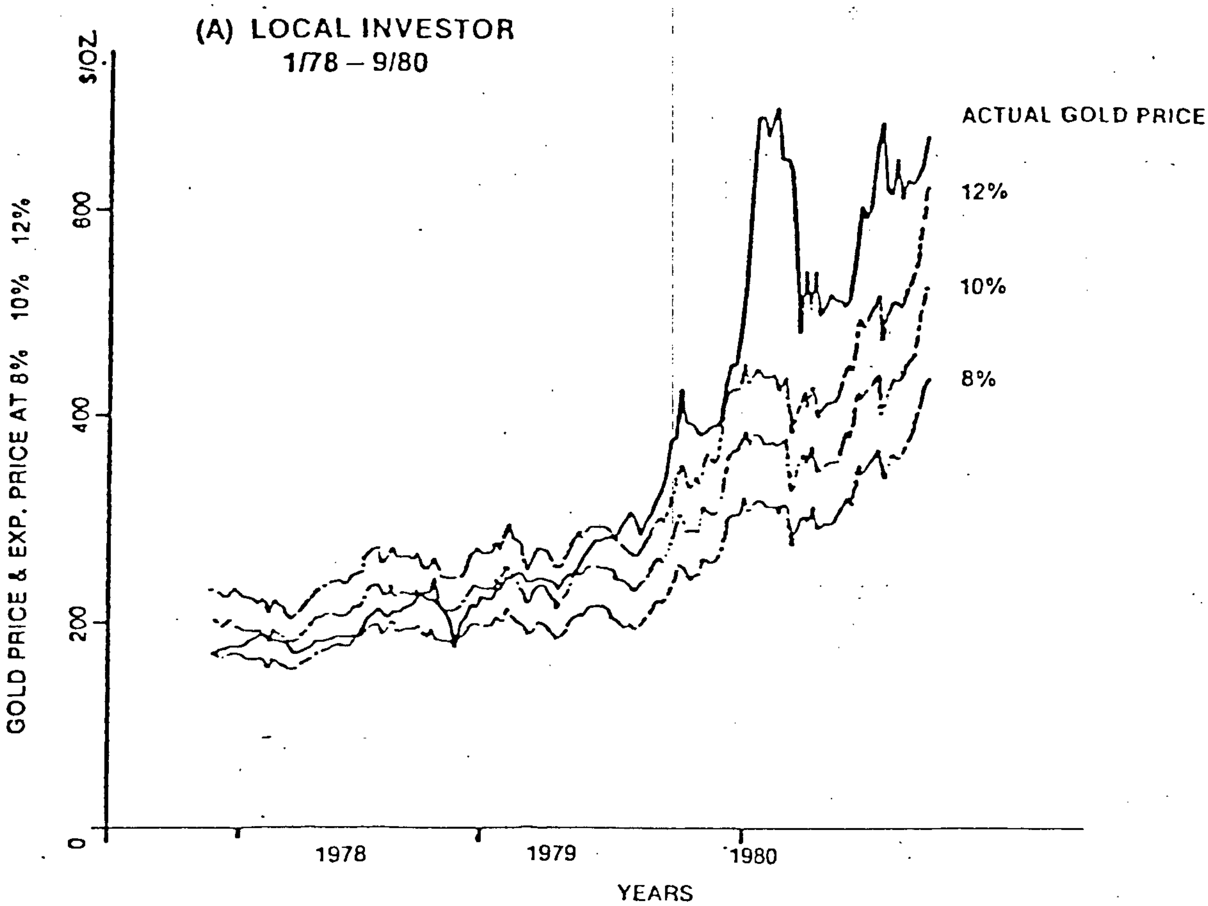


FIGURE 4.1

On the basis of his study Barr concludes that there is considerable evidence to support the hypothesis that the commodity and share market can react differently to the same information.

It is felt, however, that it is possible that a large proportion of the difference between the implicit and actual gold prices found by Barr might be due to the three strict assumptions pertaining to the model. Also this difference might be subject to further error for gold shares with more erratic cost changes and more variable grade profiles. It should also be noted that tax rates are not constant but are determined on a sliding scale basis for gold mines (this will be discussed in detail in Section 5.7).

Thus it was decided that a more sophisticated version of Barr's model should be considered. The degree of sophistication clearly depends on the ability to relax the assumptions made by Barr. Hence two different models will be considered. Only the formulation of the two models will be presented below and the actual implementation of the models is delayed until Chapter 6 as the components of the model will only be researched in the next chapter.

MODEL 1

Since an accurate contemporaneous estimate of cost is instrumental in determining the implicit gold price, this was the first assumption that was considered.

A discussion on the analysis of working costs for various gold mines is presented in Section 5.4, however a significant relationship for the estimation of cost was found to exist. MODEL 1 shown below is therefore similar to the model proposed by Barr (1981) except that the cost variable is estimated by a set of explanatory variables (see below). Secondly the units are expressed in rands instead of dollars to eliminate the variable effect of the exchange rate. Hence MODEL 1 is given as

$$\text{Yield}_t = \frac{[\text{Implicit Gold price}_t(\text{R/ounce}) - \text{Cost}_t(\text{R/ounce})].k'}{\text{Share price}_t(\text{R})} \quad (4.14)$$

where $k' = \dfrac{\text{dividend per share}}{\text{profit per ounce}}$

The assumptions are:

(i) cost changes occur due to changes in the contemporaneous gold price, lagged gold price and changes in time (this is assumed to embody general production cost increases due to rising prices)

(ii) the relationship between dividends and profit per ounce produced remains constant

(iii) tax rates remain constant.

Clearly the numerator of equation (4.14) when multiplied by k' yields an estimate of the expected dividend at time t.

<u>MODEL 2</u>

Here a more sophisticated model is proposed with both assumptions (ii) and (iii) being relaxed and with an estimate of the total earnings of a gold mine which includes all the relevant components of gold mine earnings.

An analysis involving the estimation of the relevant components of gold mine earnings is researched in Chapter 5. The findings of this analysis are incorporated in the assumptions of this model.

Hence Model 2 is given as:

$$\text{Yield}_t = \{[\text{Implicit Gold price}_t(\text{R/ounce}) - \text{Cost}_t(\text{R/ounce})].\text{Annual production}_t(\text{ounces}) + \text{Sundry revenue}_t(\text{R}) - \text{Tax}_t(\text{R}) - \text{Lease}_t(\text{R}) - \text{Capital expenditure}_t(\text{R})\} \times \frac{k''}{\text{Number of shares in issue}_t \times \text{Share price}_t(\text{R})} \quad (4.15)$$

where

$$k'' = \frac{\text{dividend per share}}{\text{earnings per share}}$$

Now the assumptions become:

(i) changes in cost production and capital expenditure can be explained by contemporaneous gold price, lagged gold price and time variables (to proxy inflation as before)

(ii) the relationship between dividend and earnings is constant.

Note that assumption (ii) is now more realistic since gold mines tend to distribute almost all of their earnings. Assumption (iii) has fallen away entirely as an exact treatment of gold mine tax is considered (c.f. Section 5.7).

Clearly the expression enclosed by square brackets in equation (4.15) is the estimated working profit per ounce of gold mined. This expression becomes the total working profit when multiplied by the annual production. The expression in "curly" brackets is thus an estimate of the total earnings of the mine which becomes the earnings per share when divided by the number of shares in issue. When this value is multiplied by k", the payout ratio, an estimate of the expected dividend at time t, is obtained.

CHAPTER 5

DETERMINANTS OF GOLD MINE PROFITABILITY

The object of assessing gold mine behaviour is to decide whether it is possible to obtain a fair and attractive risk adjusted return on capital invested in a gold share. A potential investor would be primarily concerned with the profitability of the gold mine, this naturally depends on the price obtained for gold offset against concomitant expenditure.

The level of risk associated with gold mine profitability is usually relatively large due not only to the fluctuation and uncertainty in the free market price of gold and rates of exchange but also to management, the variable nature of grade of ore milled, working costs, production rate, capital expenditure and taxation.

The above-mentioned variables are the major determinants of gold mine profitability and will be discussed in detail in this chapter.

5.1 The Gold Price

As in all commodity markets the gold price is determined by the market forces of supply and demand.

Of the components affecting supply and demand for gold, Potts (1982) argues that fabrication demand can be predicted with some degree of confidence. However demand for official or monetary purposes or hoarding are extremely difficult to predict and are thus responsible for the volatile gold price.

The structure of the gold market has changed considerably during the last 15 years. Prior to 1968 the US dollar dominated the international financial system and there was little incentive for private investors to purchase gold as the fixed price when discounted by the inflation rate (i.e. the real price) often tended to decline.

After the introduction of the so called "two-tier" market in March 1968 whereby central banks no longer fixed the gold price for private investors, gradual erosion of the US dollar as the major international financial asset occurred.

The value of the US dollar declined further after the closing of the United States "gold window" in August 1971 where the dollar/gold convertibility was officially terminated.

The increased pressure on the dollar in 1972 caused the fixed exchange rate system to break down and was replaced by system of generalised floating.

In late 1973 the large increase in the price of oil made the international financial system more volatile causing a further rise in the gold price. The Japanese Government allowed residents to purchase gold in 1973 and on the last day of 1974 the United States Government also allowed its residents to buy gold.

In 1975, both the United States Treasury and the IMF (under American influence) sold large amounts of gold in an attempt to suppress the superiority of gold as a monetary asset. This caused the price of gold to be periodically depressed.

The gold price increased rapidly in 1978 and 1979 in spite of the IMF and the US Treasury auctions. The introduction of the EMCF in 1980 whereby a proportion of the reserves are backed by gold caused the gold price to rocket and entrenched gold as a reserve asset (c.f. Main(1982)). Ariovich (1982) argues that there has been a structural change in gold markets since 1973 and on the basis of research concludes:

> *"Until 1973 fluctuations in industrial production were a major determinant of the gold price. Subsequent to 1973, however, it appears that fluctuations in US inflation and real interest rates were the major determinants of the gold price, while industrial production was only of minor importance."*

High real interest rates embodied in a world wide recession caused the gold price to decline in 1981 and 1982 reaching $296/ounce in June 1982. The gold price gradually increased to $500/ounce in January 1983 with the expectation of lower real interest rates. A dramatic $100/ounce crash in the gold price over two trading days occurred in late February 1983. Although there was much uncertainty in explaining the direct cause of the crash, Rolfe (1983) assessed the cause of the collapse in the following way:

> *"Though hard information is lacking on what happened in the US markets, the weakening oil price had already been discounted with the gold price slide from $500 to $470. Falling oil prices had already been going on for 10 days and had been predicted for several months. Bullion market sources say the central banks of heavily-indebted Latin American oil producers sold gold to realize ready cash ahead of yet more oil price cuts which will worsen further their ability to pay their way.*
>
> *In any event, as gold weakened in the US last Friday, extensive 'stop-loss' selling was triggered. The way the US investment community works, a sharp price fall can lead to speculators being sold out either because a price threshold has been breached, or because of failure to meet calls for more margin. Gold futures were down by the $25 limit and the market was only cleared on Monday when US selling orders were executed in Hong Kong, swamping the normally bullish Chinese."*

Figure 5.1 illustrates the changes in the price of gold in dollars per ounce since January 1970.

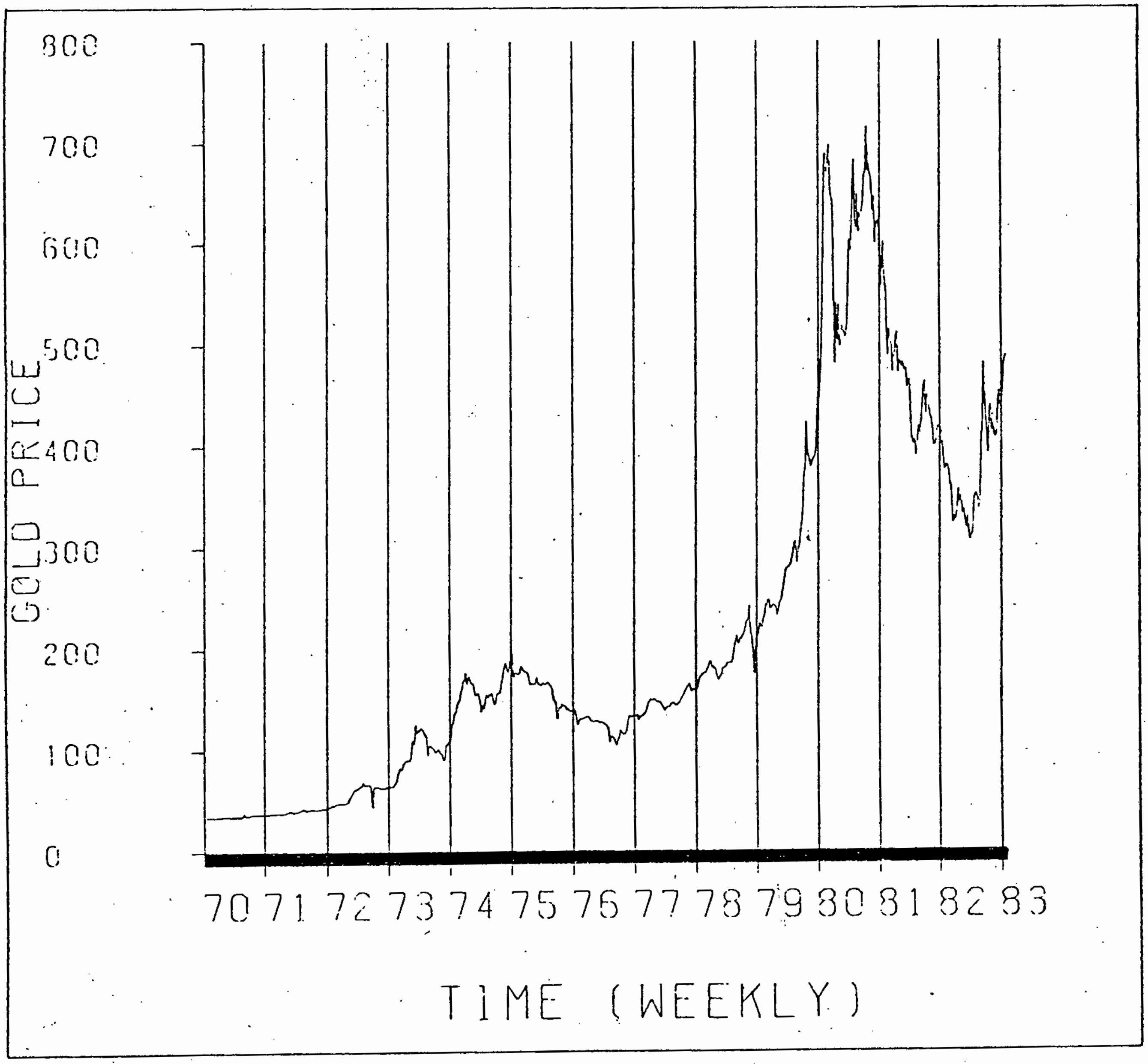


FIGURE 5.1

It is inevitable that the gold price will continue to remain volatile since the metal is widely used as a core holding in portfolios, which are periodically revised when the investment climate changes. The volatility of the gold price is further affected by the ability the international financial community has to mobilise funds rapidly and direct them towards those investment areas which appear to have the best prospects for financial gain.

5.1.1 Components of Gold Supply and Demand

Gold is an imperishable storeable commodity with rapidly diminishing mineable reserves.

Historically gold has been in demand both for hoarding and jewellery purposes, even in the days of the ancient Egyptians. More recently gold has become popular with investors seeking attractive returns on the gold market as well as for industrial, dentistry and electronic uses.

Table 5.1 below displays the components influencing the supply and demand for gold in 1980 and 1981.

Important components of fabrication demand include jewellery, dental demand and industrial demand.

(i) Jewellery is the major component of fabrication demand currently accounting for 25% of the world's above ground gold. Disposable income taste, fashion, prices, substitutes, tradition and marketing efforts are all determinants of jewellery demand which is a key factor in the long-term price of gold.

(ii) Dental demand is particularly sensitive to substitutes since higher prices strongly reduce demand.

(iii) Electronic demand is sensitive to general economic activity and is constantly influenced by new uses as well as by substitutes. The demand for welding, which accounts for a large proportion of gold in this sector, may be reduced as possible substitutes are constantly being researched.

(iv) Other industrial demand sectors include technology-intensive industries that consume gold and are sensitive to defence expenditure especially in the United States.

Figure 5.2 below illustrates the distribution of the world's above ground gold as at October 1982.

TABLE 5.1 Source: Strong (1982)		
SUPPLY	1980 Tons	1981 Tons
South African Production	675	658
Rest of Free World Production	271	304
Total Free World Production	946	962
Net Sales of Communist Bloc	90	283
TOTAL SUPPLY OF GOLD	1036	1245
Less: Net Official Purchases	230	260
GOLD AVAILABLE FOR PRIVATE FABRICATION AND INVESTMENT	806	985
DEMAND		
Average Price US$/oz	$612	$460
Jewellery Fabrication Demand		
- Developed Countries	273	373
- Developing Countries	(-150)	221
Official Coins	185	201
Electronics	86	85
Dentistry	62	62
Other Industrial & Decorative Uses	70	66
Medallions and False Coins	16	28
TOTAL FABRICATION DEMAND (A)	542	1036
Hoarding of Bars	8	280
Net Investment Demand	256	(-331)
TOTAL "INVESTMENT" DEMAND (B)	264	(- 51)
TOTAL DEMAND (A + B)	806	985

Distribution of the World's Above Ground Gold

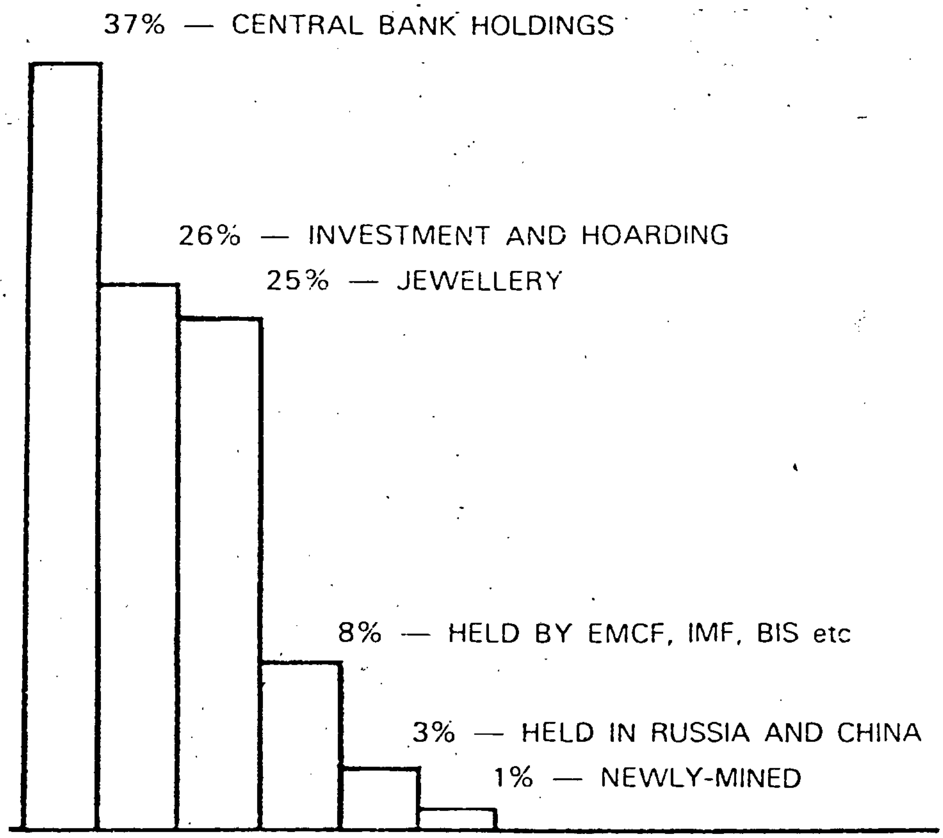


FIGURE 5.2

Source: Chamber of Mines' Newsletter, September/October 1982

5.1.2 Determinants of the Gold Price

Many researchers suggest that the major factors influencing the gold price are nominal interest rates and inflation (i.e. real interest rates), exchange rates, price of petroleum, political tensions, the prices of metals such as silver and platinum, which can, to some extent, be substituted for gold, and the general level of economic activity.

Ariovich (1982) conducted a study in an attempt to gauge the effect of inflation, real interest rates and the industrial production on the gold price. The data ranged from 1968 to 1981. Annual data consisting of the US inflation rate (CPI), the real interest rate in the US (the real interest rate used was the difference between the yield on long term government stock and the CPI) and the OECD Industrial production rate were used.

The test consisted of correlating the above three variables separately with the growth rate of the gold price over the entire period as well as from 1968 to 1973 and 1974 to 1981. The results indicate the inflation rate was the best explanatory factor over the entire period. For the two separate periods, however, the growth rate of the gold price was most highly correlated with the OECD industrial production rate for the period ranging from 1968 to 1973, whereas the inflation and real interest rates were found to be the best explanatory factors over the last period, i.e. 1974 to 1981.

Ariovich also computed the multiple regression equations having the growth rate of the gold price as the dependent variable, and the same above 3 variables as the independent variables. The equations were computed for the same periods as the above empirical test. The equations are listed in Table 5.2 below.

Ariovich concluded that the empirical evidence strongly supported the argument that gold markets have experienced a definite structural change since 1973. i.e. Prior to 1973

TABLE 5.2

Period	Equation	R^2	obs.
1968-81 associated t-statistic	Gold C = -2 + 3,5CPI - 0,36RI + 0,32Ip (-1,2) (3,0) (-2,5) (2,1)	0,6	14
1968-73 associated t-statistic	Gold C = -2,99 + 0,75Ip (-3,2) (5,3)	0,88	6
1974-81 associated t-statistic	Gold C = -3,36 + 4,98CPI - 0,34RI + 0,271Ip (1,8) (3,7) (-2,4) (1,7)	0,83	8

fluctuations in industrial production were a major determinant of the gold price and subsequent to 1973, US inflation and real interest rates were the predominant determinants of the gold price.

Unfortunately the above 2 empirical tests were based on very small sample sizes, i.e. 14, 6 and 8 respectively. The results of the two tests are, however, consistent indicating that there is some evidence supporting Arivoich's conclusion.

Brock (1981) conducted a study (commissioned by Anglo American Corporation) to forecast the price of gold during the period 1986 to 1988. Brock used a technique whereby judgemental probabilities are used in the analysis to represent the uncertainty of the political, sociological and economic factors that will affect the gold market in the future.

On the basis of these probabilities a set of demand and supply curves, relating quantity of gold supplied and demanded to the price were developed. These in turn are used to arrive at a gold price forecast.

The judgemental probabilities were obtained from interviews carried out in North America, the United Kingdom, Europe, Japan, Hong Kong, Singapore, Australia, the Middle East and South Africa. The people interviewed included central bankers, finance ministers, bullion dealers, international bankers, political analysts, economists, mining executives and fashion leaders.

Some interesting results discussed in Brock's (1981) report which are of relevance here, include the following:

1. Virtually everybody who was interviewed agreed that there would be six major determinants of investment demand in 1987, namely:
   - (i) The price of gold
   - (ii) Real interest rates, in particular those in Europe and the United States.
   - (iii) Real economic growth rates, particularly in the United States, Europe, Japan and the Association of South East Asian Nations (Asean).
   - (iv) The level of political tension.
   - (v) The rate of inflation in non-communist industrialised countries.
   - (vi) The relative strength of the United States dollar.

Brock also mentions two other possible developments that would further influence demand, i.e. the beginnings of a move in Japan toward private investment in gold and the possibility of large-scale institutional demand in the United States.

2. The future supply of gold, will continue to be dominated by South Africa and Russia. South African gold sales will depend on the price of gold, production levels, the potential for labour unrest and rapid rise in mine workers' wages, and the sales policy implemented by the South African Reserve Bank. Brock further mentions that Russian sales will be largely dependent on price, production levels, potential labour unrest, the need for foreign exchange for the possible construction of a natural gas pipeline from Russia to Europe, the poor agricultural situation and decreasing oil exports.

3. Brock concludes that there is a likelihood of a reasonably high price for gold in the future and, on the basis of the study, attaches the following probabilities to the given ranges of gold prices at different inflation rate scenarios in 1987:

(i) Nil inflation

Gold Price ($/ounce)	Probability
0 - $520	0,010
$521 - $550	0,080
$551 - $580	0,085
$581 - $610	0,185
$611 - $640	0,240
$641 - $670	0,225
$671 - $700	0,1250
$701 - ∞	0,050

(ii) 6% inflation

Gold Price ($/ounce)	Probability
0 - $738	0,010
$739 - $780	0,080
$781 - $823	0,085
$824 - $865	0,185
$866 - $908	0,240
$909 - $950	0,225
$951 - $993	0,1250
$994 - ∞	0,050

(iii) 9% inflation

Gold Price ($/ounce)	Probability
0 - $872	0,010
$873 - $922	0,080
$923 - $973	0,085
$974 - $1023	0,185
$1024 - $1073	0,240
$1074 - $1124	0,225
$1125 - $1174	0,125
$1175 - ∞	0,050

(iv) 13% inflation

Gold Price ($/ounce)	Probability
0 - $1083	0,010
$1084 - $1145	0,080
$1146 - $1208	0,085
$1209 - $1270	0,185
$1271 - $1332	0,240
$1333 - $1395	0,225
$1396 - $1457	0,125
$1458 - ∞	0,050

It should however be noted that Brock's study was published in 1981, and hence was conducted during times of high gold prices. It is felt that the judgemental probabilities computed on the basis of Brock's interviews might thus have been biased toward high gold prices in the future. In the past it has been evident that there has been a strong tendency for people to overestimate future gold prices in times of rising gold prices and visa versa. This was evidenced in June 1982 where the media published many articles on judgemental predictions, the majority of which predicted the future gold price at well below the $300 mark. In January 1983 when the gold price inclined to reach the $500 mark, the sentiment conveyed in the media was that the gold price would rise rapidly to over the $600 mark, again these judgemental forecasts were completely incorrect.

Fundamentally, it would appear that currently the three major factors influencing the gold price are, firstly, the inflation rate in the United States, which affects the confidence of investors in the Dollar, secondly, the real rate of interest earned on risk-free investments such as long-term federal government bonds, and lastly, to a lesser extent the general state of the world economy (which can to some extent be measured by the level of industrial production in the United States).

Figure 5.3 below shows the relationships between the above mentioned variables and the gold price.

Visual inspection of Figure 5.3 shows a rise of the inflation rate in 1978 reaching its highest peak in 1980 with the gold price, while real rates of interest became substantially negative.

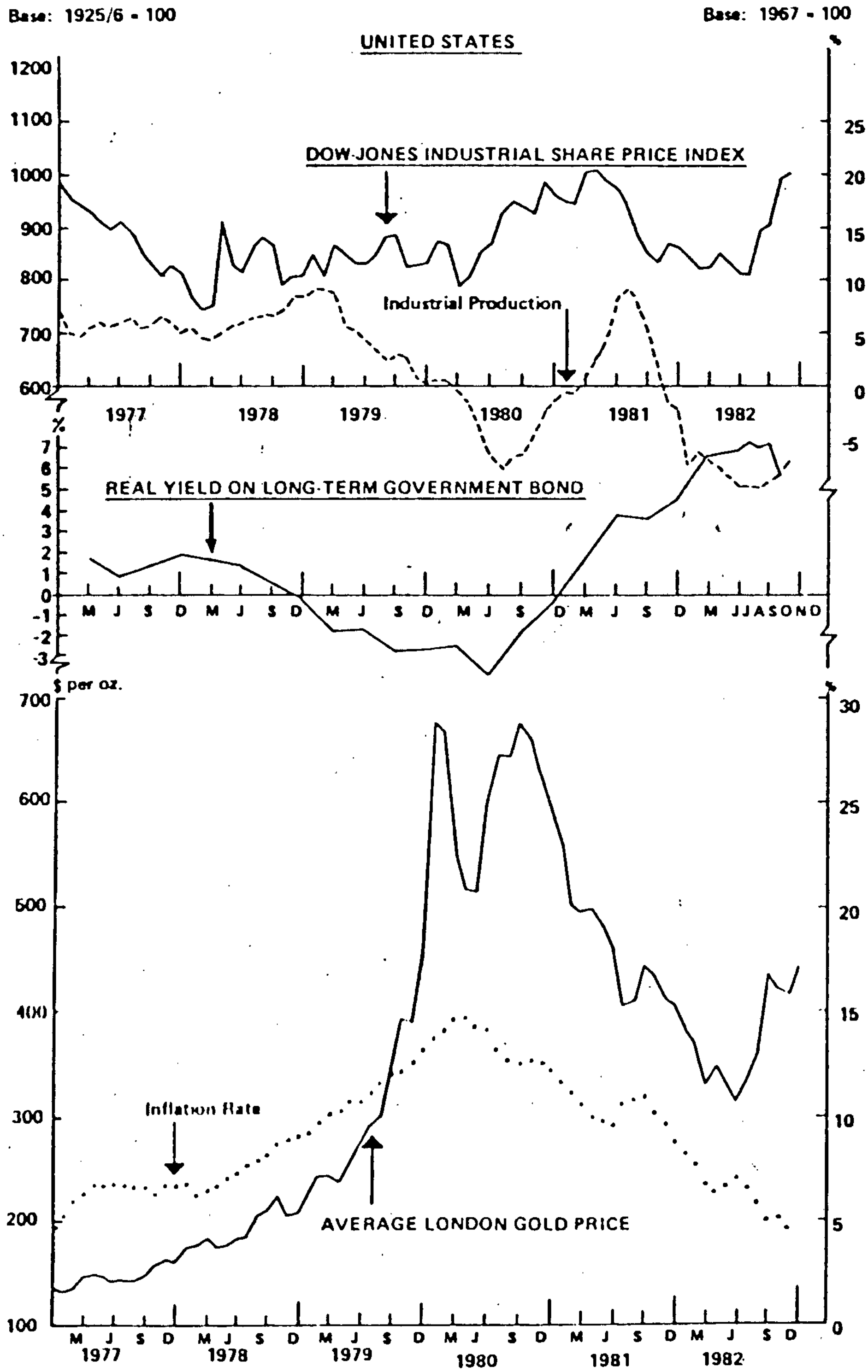


FIGURE 5.3

Source: Barclays Bank Brief January 1983

5.1.2.1 Inflation and Real Interest Rates in the United States

Since 1970, the price of gold has risen six or seven times more rapidly than dollar prices, clearly the gold price is not simply determined by US inflation rates. Many variables are involved as mentioned previously, however, the interactive effects of interest rates and inflation in the US are considered in isolation here.

Kantor and Rees (1981) explain the interaction between real interest rates and inflation by creating the following hypothetical situation: Under the assumption that no inflation occurred, consumable goods would remain at the same price in the future, however, real assets would be expected to appreciate at the required rate of return (yield). If this was not so investors would sell the real assets and the price would be forced down until it reached a value that would provide the required yield. It is assumed that holders of gold have a notion of some future price of gold in terms of the value of consumable goods that it can be converted into in the future. The standard present value formula would then apply

$$\text{i.e. Present value of gold} = \frac{\text{Future value of gold}}{(1+r)^n} \qquad (5.1)$$

Where n is the number of periods into the future and r is the nominal interest rate. Clearly as nominal interest rates rise so the present value of gold falls.

However, assuming now that inflation is present, it is expected that borrowers will be more willing to borrow and lenders will be less willing to lend, given the same interest rate as above (since borrowers can repay the loan to the lenders in "devalued" money). Accordingly interest rates would rise in line with the rise in inflation rates, causing the real interest rate (which is simply the difference between the nominal interest rate and the realized rate of inflation) to remain the same. This compensation in rates of interest and inflation would effectively leave the present value of gold unchanged when computed using the above present value formula.

However, Kantor and Rees (1981) claim this is not generally the case, and that real interest rates fall in a climate of rising inflation rates. This is attributable to the fact that the demand for loans for investment purposes in fact declines with increases in expected inflation. The reason for this phenomenon is that the lender is concerned only with the average rate of inflation, whereas the borrower, generally, has a more difficult task assessing the variability in prices associated with his specific venture (i.e. labour cost, raw materials costs, transport, etc.). Hence causing nominal interest rates to increase less rapidly than the inflation rate, causing the real interest rate to fall. This fall in the real interest rate would cause the present price of gold to increase when computed using equation (5.1).

The conclusion therefore is that the interaction between the gold price, inflation and real interest rates in the United States manifests itself in the following way: If an increase in the inflation rate is associated with increased uncertainty about the relative value of dollars, then this is the likely cause of a rise in the present gold price because the real interest rate in dollars is expected to fall. (This interaction is displayed in Figure 5.3.) Substantially positive real interest rates would constitute a safe return in the capital market, however, investors tend to shift from capital markets into real assets such as gold when the real interest rate becomes negative.

5.1.2.2 Exchange Rates

Strong (1982) argues that since a large proportion of funds held in investment portfolios are held in United States dollars, changes in the value of the US dollar can result in reallocation of the composition of portfolios, many of which include gold. Exchange rate movements, however, are closely related to the demand for the US dollar and hence to the movements of real interest rates. Depreciation of the US dollar is also associated with upward movements of the gold price while appreciation of the US dollar is associated with downward movements of the price.

5.1.2.3 Oil Prices

Movements of oil prices have in the past, and are currently, having a dramatic effect on the gold price.

Wolenik (1980, p.55) in a brief review of the gold price in the past says:

> "....... *the Arab oil cartel in 1974 imposed strigent price increases on oil. This added to inflation. It had another serious effect, however. In order to buy oil, we [US] had to send dollars abroad. Led by oil imports our trade figures went way out of balance. We were importing much more than we were exporting. (Americans had not lost their appetite for foreign goods. They were purchasing them in far larger numbers than foreigners were purchasing American goods.)*
>
> *The overall result was that suddenly there was an enormous glut of dollars abroad. The term 'Euro-dollar' became fashionable. It simply meant US dollars located in Europe. By the end of 1978 there were estimated to be an incredible $600 billion Euro-dollars.*
>
> *As the supply of dollars increased, their value relative to foreign currency decreased. People had little use for dollars. They wanted deutsche marks, Swiss francs - and gold.*
>
> *The value of all these currencies moved up relative to the dollar. Because some Europeans were turning to gold as a further dollar alternative, the price of gold also climbed steadily.*"

In early 1979 with the gold price around 240$/ounce the OPEC nations announced a steep increase in the price of oil. Wolenik (1980) believes that the new price increase had a different, but nevertheless dramatic effect on gold as it left the US, because of its domestic oil, in a relatively better position than the rest of the industrialized nations of the world. During the months of March, April and May 1979 it was evident that Europeans and other currency investors began to buy dollars, hence with the dollar strengthening, more people began to switch from gold to dollars. The gold price edged lower with more gold on the market. However, European countries, particularly Germany, anticipated that increased oil prices meant increased inflation and immediately raised interest rates as a method of cutting back on the money supply to reduce inflation. The US did not, however, react immediately.

Wolenik (1980) claims that in the US summer of 1979 the American business community realized that inflation was bound to affect the US dramatically. Anticipating higher interest rates as a method of dealing with inflation, they borrowed capital immediately causing the US reserve banking system to actually create new money to meet the demand of the borrowers. Thus the money supply during May, June, July and August in the US increased enormously pushing the inflation rate up to 13 percent.

Coupled with the hyper-inflation experienced in the US, the oil-producing nations having just instituted significant oil price increases were receiving more dollars for their oil, but were worth less. In an attempt to obtain real wealth for their oil they bought gold. Wolenik (1980, p.56) mentions:

"It has been estimated that in 1975 1 troy ounce of gold would buy about 10 barrels of oil. By 1979 1 troy ounce would buy over 15 barrels of oil."

As soon as oil-producing nations entered the gold market the price took off reaching a peak of $850/ounce in January 1980.

In February 1983, amidst uncertainty in the magnitude of the expected drop in the oil price, coupled with heavy gold sales worldwide, including computerized "stop-loss" selling orders, the gold price plunged by more than $100/ounce to below $400/ounce in only two trading days.

On the other hand a view appearing in an editorial in the Financial Mail (4 March 1983, p.915) mentions that the recent decline in oil prices might have an opposite effect:

"One view put forward early this year as Opec's grip on oil prices started to slip was that an oil price drop would lead to a worldwide banking crisis. The logic was simple enough: oil producer Mexico had borrowed $25 billion-odd, largely from American commercial banks which had been willing to lend any amount when oil prices were rising; advancing interest rates had impaired its ability

to service the loans, let alone repay capital; and *declining oil prices pared the country's foreign exchange earnings capacity and thus lessened its ability to repay its foreign borrowings. A default, it was claimed, could trigger bank collapses and a major banking crisis in which the only asset worth anything would be gold. Other heavily-borrowed oil countries, notably Nigeria, Indonesia and Venezuela, were thought to be not far behind Mexico."*

Rolfe (1983, p.371) substantiates the above view with the following comments:

"The world economic outlook is improved by lower oil prices, but the world banking system may deteriorate. US Treasury secretary Don Regan testified before Congress this week that an oil price of $25 would spell trouble for the banking system. Among the trouble spots: Mexico has just scraped up $5bn from over 500 banks as a key element in its $80bn debt 'rescheduling'. At an oil price of $25, it would need more money which some banks may refuse to provide.

Another: The US banking system has loans of over $40bn to its own oil-drilling industry. This is a disaster area which has already claimed one casualty, The Penn Square bank in Oklahoma, whose collapse started the run on gold last year."

It is thus obvious that changes in the oil price have a substantial effect on the gold price since it incorporates influential elements which can be seen to affect the demand for gold in many ways.

Firstly, high oil prices are associated with higher production costs, hence higher inflation, especially in the US which is a substantial importer of oil.

Secondly, the wealthy OPEC countries tend to invest large sums of their oil revenue in gold in an attempt to maintain the real value of income, further stimulating the gold price.

Thirdly, political crisis such as the recent Iran conflict with Iraq affects the oil market, which is essential for economic activity.

Lastly, approximately 40% of Russia's total exports consist of oil, hence changes in the oil price in international markets help to determine Soviet foreign income, and consequently strongly influence its gold sales. The majority of Russia's foreign income is accrued from oil and gold sales, hence at higher oil prices Russia is able to accrue more foreign income, thus needs to sell less gold to meet its foreign exchange needs. Clearly a large volume of gold sales would depress the gold price.

5.1.2.4 Political Tensions

It is evident that in the past political tensions have to some extent had an immediate impact on the price of gold.

Political events and the political tensions they cause are highly diversified and therefore have varying influences on the gold price.

Ariovich (1983) mentions five types of political events which are hypothesized to have some impact on the gold price, namely:

1. Political events which undermine the stability or reliability of the international financial systems: The recent debt crisis as well as the oil crisis can be cited as examples of political events which have undermined the international financial system in the past.

2. Political events which can change inflationary expectations: e.g. Changes in oil prices are noted to have an influence on inflationary expectations.

3. Political events which directly influence the value of the US Dollar: Since a large proportion of the world's wealth is held in US dollars or US dollar-related assets, a change in the value of the dollar could result in a change in the demand for real assets such as gold. Ariovich cites the following examples of this type of event:

   "Examples of political events which can influence the value of the US dollar are many: Domestic elections where Democrats compete with Republicans (as Republicans are considered

to be more conservative in their economic and social policies and it is therefore assumed that they will maintain the value of the dollar better than the Democrats); involvement in external wars; domestic social unrest."

4. Local political events which influence domestic, social or political systems: Ariovich (1983) cites the following example:

   "The recent change in political power in France in 1981, when the Socialists replaced the more conservative coalition, can be cited as a local political event which probably had some impact on the gold price. The declared policy of the Socialists to make employment the first priority in their economic policy, as well as their intention to expropriate some private property, such as private banks, raised probably both inflationary expectations and the level of anxiety, particularly amongst the wealthy in France."

5. Political events which can influence the flows of newly mined gold: Expectations about future flows of newly mined gold will be discounted in the spot price of gold, hence political events influencing expected future supply of gold have some impact on the gold price. The need for foreign currency by Russia, for example, influences the volume of gold sold by Russia. Labour

unrest in South African gold mines could have an impact on expectations about future flows of newly mined gold.

It is felt that generally the uncertainty associated with political tensions tend to influence investors to invest in real assets thus having a positive influence on the gold price. However, unless an event really causes a fundamental demand to hold more gold or gold-related assets for real value, the gold price will soon drop to a similar level as before.

5.1.2.5 Substitutes

To some extent gold can be substituted by silver and platinum. These markets are similar in the sense that all three metals are used for jewellery and decorative purposes. Platinum and silver are, however, influenced by real economic activity to a much greater extent than gold, which is more of an investment asset (c.f. Main (1982)). The price trends of the above three metals are highly correlated and are all traded on the futures market. Investment in any three can be regarded to some extent as alternative options.

5.2 South African Industry and Mine Management

It is a known fact that the state of South Africa's economy is largely dependent on its gold mining revenue. A movement of \$10/ounce in the gold price is estimated to effect foreign exchange earnings by R230 million .

Owing to the varying geological and operating conditions associated with the individual gold mines, changes in the price of gold will have a different impact on the factors influencing the profitability of individual mines.

The South African gold mines are, however, associated with mining finance houses that provide some or all of the development capital and usually have contracts with the mines to provide managerial, technical and other services. The six principal mining houses are:

Anglo American Corporation of SA Ltd (Anglo American)
Anglo-Transvaal Consolidated Investment Co Ltd (Anglovaal)
Gold Fields of SA Ltd (GFSA)
Rand Mine Ltd (Rand Mines)
General Mining and Union Corporation (Gencor)
Johannesburg Consolidated Investment Co Ltd (JCI)

Table 5.3 below displays the ranked percentage of profit and production associated with each mining house.

The Chamber of Mines of South Africa is an association of the above mentioned six mining finance houses, including 43 gold and 38 coal mines and 14 diamond, platinum, antimony, asbestos, manganese and copper mines. The Chamber of Mines is essentially an employer organization, and functions on a co-operative basis on behalf of its member groups. These functions include: the recruitment of black labour; the negotiation of all labour matters, including minimum wage rates

TABLE 5.3 Mining House Share of Gold Profits and Production (1979 figures)

	Output (Tons)	% of Total	R'000	Operating Profit % of total
Anglo American	262.0	38.2	1 279 352	41.1
GFSA	162.7	23.7	951 957	30.7
Gencor	106.6	15.6	248 044	14.1
Rand Mines	69.4	10.1	115.441	3.7
JCI	46.6	6.8	160 554	5.2
Anglovaal	37.9	5.5	159 003	5.1
Independent	1.2	0.1	1 347	0.1
	686.4	100	3 100 698	100

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

with recognised trade unions and associations; the administration of miners' training colleges and rescue training services; the provision of medical facilities and the administration of pension and benefit funds for the industry; representing the industry in dealings with the Government; the carrying out of advanced technological research; recovery of traces of precious metals from gold mines plants and other spheres of mutual interest; processing and marketing of uranium; the marketing of Krugerrands and the world-wide promotion of gold for jewellery and industrial purposes.

Main (1982) writes that some of the above functions are conducted by subsidiary companies on behalf of the Chamber of Mines. These include: the Employment Bureau of Africa (TEBA); Nuclear Fuels Corporation of South Africa (Nufcor); the Rand Refinery; the International Gold Corporation (Intergold);

to mine the higher grade ore only in times of lower gold prices. The tax structure will, however, be discussed in detail later in this chapter. This tax structure has been implemented to prevent shareholders from acquiring highest possible returns during times of high gold prices.

This structure may be in conflict with shareholders who prefer to minimise their risks by realizing their returns in as short a time as possible, however, this preference would greatly reduce the amount of payable ore reserves and hence the life of the mines.

The decision to change mining strategies to mine bodies containing different grades of ore will be largely dependent on the pay limits of the given areas. Storrar (1981) defines the pay limit as that value at which it is estimated that ore can be mined without profit or loss. Here the cost considerations include; the cost of mining, processing and marketing the gold.

The pay limit can be computed using the following formula:

$$\frac{\text{cost (Rand/ton milled)}}{\text{gold price (Rand/gram)}}$$

Since the above value is expressed in grams per ton it can be easily compared to the grade of ore milled.

The ore reserves are generally stated as being based on a certain gold price since higher gold prices allow mines to mine lower grade ore, thus extending the life of the mine by having greater quantities of payable ore reserves available for production at lower gold prices. The ore reserves are classified by the institution of Mining and Metallurgy as

(i) Proved reserve : this is the payable portion of ore which has been exposed and is available for mining immediately or within six months or a year at most.

(ii) Probable reserve : this is usually a zone of mineralization of which sampling values of the proved reserve are believed to exist, but with less certainty. The extent of this zone is fixed from local knowledge and experience as well as using sampling results in any boreholes that have penetrated it.

(iii) Possible reserve : this is a prospective new ore body beyond the zones of the probable and proved reserves, the estimates of tonnage and value are less certain as sampled information is meagre.

Since costs have increased more rapidly than the inflation rate, and independent of the gold price, this has caused a substantial reduction in the amount of payable ore reserved. Relatively small declines in the gold price also render substantial tonnage of low grade ore unpayable, a matter of grave concern for some mines.

Figure 5.4 below shows the relationship between the average grade of ore milled for the member mines of the Chamber of Mines and the weekly gold price with time as the independent varaible.

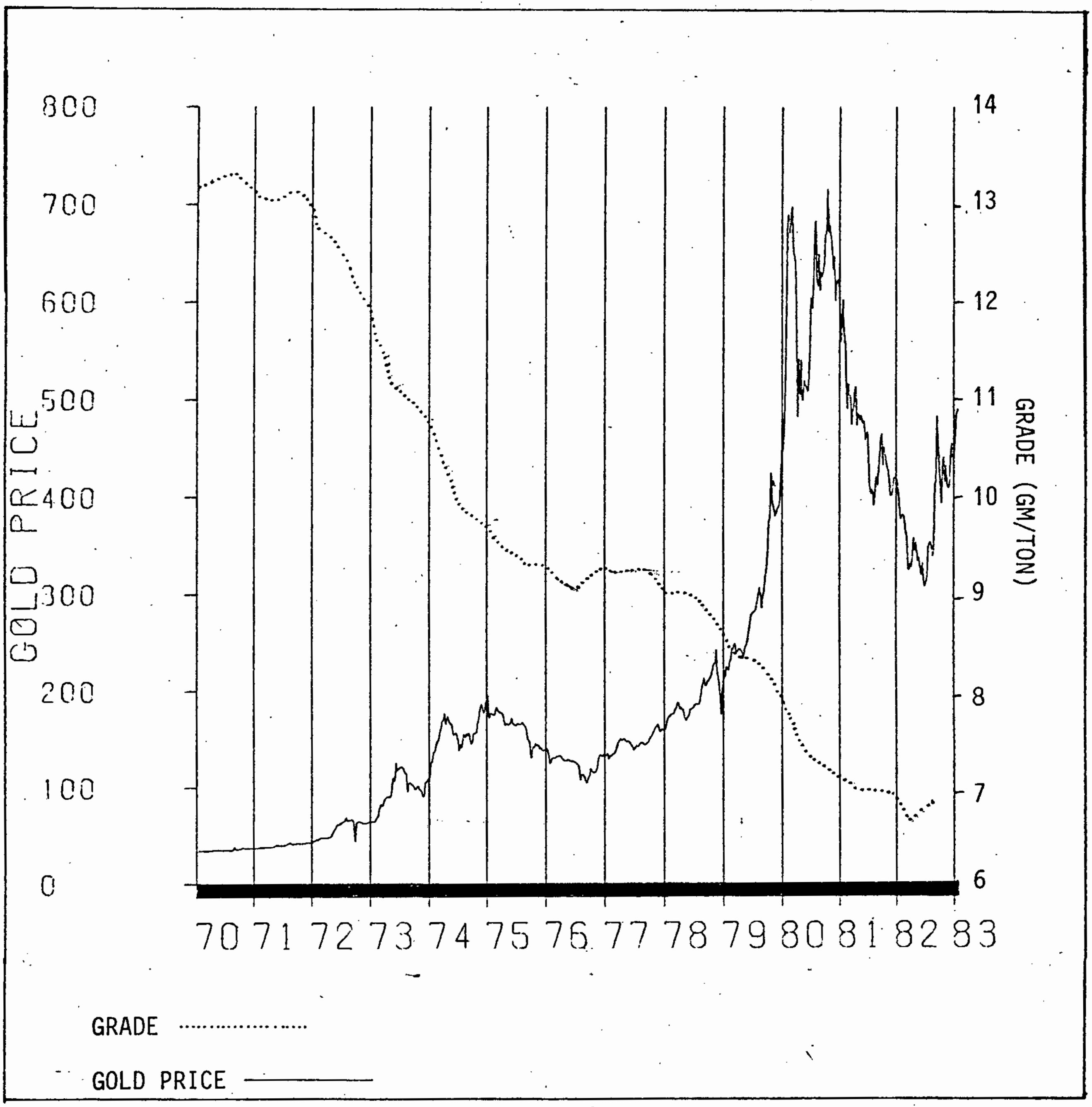


FIGURE 5.4

From the above graph it appears that grade decreases almost linearly with time, whereas the gold price appears only to have a minor effect on grade. The gold price effect is most noticeable on the graph during 1976 and 1977 where the average grade increased due to the lower gold prices in this period.

It is expected that in general the grades do not change instantaneously with marked changes in the gold price but react rather to some lag in the gold price. In Section 5.4.2 it was found that working costs were most highly correlated with the average of the previous four quarterly gold prices. It is thus expected that the grade would exhibit a similar lagged relationship with the gold price.

A standard multivariate regression analysis was performed having the average quarterly grade as the dependent variable, with time and the lagged average gold price as independent variables. The data used consisted of quarterly observations ranging from the first quarter of 1973 to the third quarter of 1982.

The aim of the analysis was to determine the magnitude of the effect of time and the gold price on grade, both together and individually.

The regression equation was found to be:

$$\text{grade}(t) = 12{,}3466 - 0{,}0977(t) - 0{,}0023\,\frac{\sum_{k=t-4}^{t-1} GP(k)}{4}$$

The grade is measured in grams per ton and the time variable begins with the 1st quarter of 1970 being equal to 1 and increases by 1 unit for every quarter thereafter. The gold price is measured in rands per ounce.

The multiple R^2 value associated with the above equation shows that 94,91% of the variation in the grade is accounted for by the joint effect of time and the gold price.

The salient remarks concerning the regression coefficients are that both are negative, implying that grade effectively decreases through time and is also adversely affected by an increased gold price. This gold price effect, as was discussed earlier, is due to the tax structure.

To determine the magnitude of the effects of each variable on grade holding the other variable constant, the partial correlation coefficients were computed.

The correlation between grade and time holding the gold price constant was found to be -0,8450, whereas the correlation between grade and the lagged gold price holding time constant was found to be -0,3887, showing that the lagged gold price had less influence on the changes in grade than the time variable. It should be noted, however, that the gold price still has a significant effect on the grade of ore mined, but that time is the major component of the diminishing grade of ore being milled. This is caused by the diminishing ore reserves over time causing lower grade ore to be exploited.

5.4 Working Costs

The profitability of working an ore body depends largely on the grade of ore, the net revenue received for the product and the working costs. The effect of working costs on pay limits, ore reserves and hence grade was mentioned in Section 5.3. The influence of working costs on production, capital expenditure and income tax will be discussed in Sections 5.5, 5.6 and 5.7 respectively. In this section working costs will be discussed and an attempt will be made to identify and estimate costs for various mines.

Figure 5.5 shows the quarterly average working cost expressed in rands per kilogram of gold mined from 1970 to the second quarter of 1982.

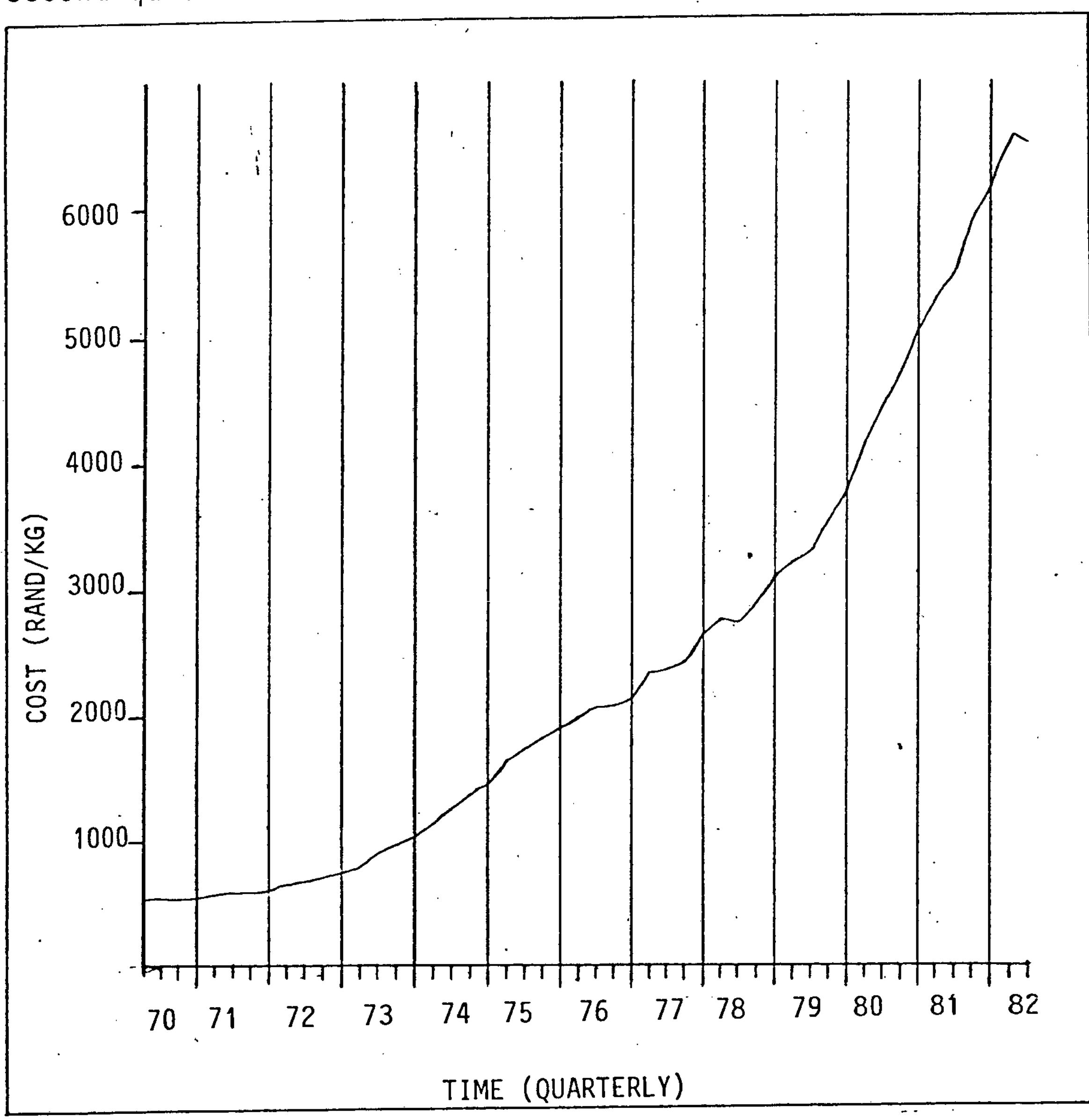


FIGURE 5.5

5.4.1 Components of Working Costs

Briefly, working costs include all the costs associated with the mining and milling of gold ore. Costs are usually expressed in rand/ton milled or dollars/ounce produced, the distinction here is that the former cost refers to the cost in terms of the mass of rock milled, whereas the latter cost is expressed in terms of the mass of gold produced.

Joughin (1972) classified the breakdown of working costs either in terms of category, or according to process or function in the following proportions:

Category	%	Function	%
White wages	27	Stoping	30
Black wages	13	Development	12
Ropes, pipes, hoses, steel, belts, etc	12	Transport	6
Electric and mechanical equipment	9	Hoisting	9
Electric power	9	Ventilation	2
Chemicals, cement, water, etc.	6	Underground services	8
Food and clothing	6	Mine general services	12
Timber	6	Reduction	7
Explosives	6	Mine, other	4
Building and other	6	Management and administration	10
	100		100

Storrar (1981) defines development work as any tunnelling operation performed for exploration, exploitation or both. Development work precedes stoping, where stoping operations are carried out on sections of the reef found to be payable by development operations.

Working costs for South African gold mines have increased on average from R7,87 per ton milled in 1971 to R48,04 by the third quarter of 1982, this is an annual average increase of 17,9 per cent, whereas the Consumer Price Index had increased by an average of only 12 per cent per year over the same period. Costs have thus increased at a far greater rate than the rate of inflation due mainly to the rise in costs associated with labour, stores and materials, and power and water.

(i) Labour Costs

The sharp increase in working costs are attributable not only to the high inflation rate in South Africa but also to a large extent to the increase in labour costs, especially over the period 1973 to 1976 where wages of black mine workers increased by 180 per cent.

Unskilled labour costs have increased at a much faster rate than skilled labour costs, where unskilled rates increased by 23,7 per cent per annum, from R1,37 in 1971 to R11,53 per ton milled in 1981. This constituted an average increase in wages from R18,40 to R210,80 per month. Also the total number of unskilled workers increased from 371 853 in 1971 to 421 874 in 1981.

The unskilled labour has traditionally been performed by the black labour force, however, in the past two years there has been a movement of black workers into skilled work enhanced by the implementation of the Wiehahn Commission report recommendations.

Skilled labour costs have increased by 12,1 per cent per annum from R2,40 per ton milled in 1971 to R7,52 per ton milled in 1981. The average monthly wage rate for skilled workers increased from R386,60 to R1294,00 per month and the number of skilled people employed increased from 36 633 to 41 494 over the same period. Table 5.3 shows the proportional contribution to costs per ton milled in 1971 and 1981.

TABLE 5.3: Proportional contribution to costs per ton milled

	1971	1982
Skilled labour	30,5%	18,1%
Unskilled labour	17,4%	27,7%
Stores and Materials	34,4%	35,1%
Power and Water	9,4%	9,7%
Other	8,3%	9,4%

Source: Chamber of Mines Newsletter, June/August 1982

Table 5.4 below shows the actual allocation of costs expressed in rands per ton from 1939 to 1979.

TABLE 5.4

	1939 R	1948 R	1957 R	1963 R	1975 R	1979 R
White labour charges	0,65	0,94	1,64	1,86	4,04	5,69
Black labour charges	0,44	0,52	0,80	0,91	4,51	8,19
Stores and materials	0,79	1,06	1,85	2,20	5,59	10,30
Sundry costs	0,26	0,34	0,72	0,89	2,62	5,98
Total cost per t/milled	2,14	2,86	5,01	5,86	16,76	30,16

Source: Storrar (1981)

The increase of 65% in black wages over 1974 and 1975 coupled with a further 22% increase in 1980 has caused the wage gap between black and white workers to narrow considerably from 18:1 in 1970 to 7:1 in 1980.

The wage factor is clearly the major component of the increase in working costs and thus has a pronounced effect on gold mine profitability.

(ii) Stores and Materials

The actual stores and materials costs per ton milled was R2,71 in 1971 and R14,58 in 1981 constituting an increase of 18,3 per cent per annum, whereas the proportional contribution to cost per ton milled has only increased by 0,7% as shown in Table 5.4.

Unsuccessful attempts at explaining the actual increase of stores and materials costs using the Production (Wholesale) Price Index have been made. It has been concluded that the nature of the stores used and the buying practices associated with gold mining are unique to the gold mining industry. A Store Price Index therefore is currently being formulated, which will be unique to the industry.

(iii) Power and Water

Here the actual usage per ton of ore milled was R0,74 in 1971 rising to R4,03 in 1981; an increase of 18,5 per cent. The change in the proportional contribution to cost per ton milled over the period was minimal.

The actual increase in cost per ton is attributable to an increase in units used from 11 376 178 000 kWh in

1971 to 17 480 847 990 kWh in 1981 coupled with an increase of 15,5 per cent per annum in the unit price of electricity.

5.4.2 Estimation of Cost

The formulation of cost equations is necessary for the share evaluation model that is developed in Chapter 6 where accurate contemporaneous estimates of working costs are required.

The Data

The same eight mines chosen by Harwinkel (1982) to typify a cross-section of gold mines will be used in this analysis. Harwinkel's selection was made on the basis of the following classification of gold mines given by the Chamber of Mines:

1. New ventures
2. Life over 25 years
3. Life between 15 and 25 years
4. Life of ± 10 years
5. State assisted mines

Accordingly the following mines were selected:

Category 2 - Kloof and Western Deep Levels

Category 3 - Kinross and Winkelhaak

Category 4 - Blyvooruitzicht and Grootvlei

Category 5 - ERPM and Venterspost

It should be noted that mines belonging to Category 1 were not selected as insufficient data is available for these mines.

The data consisted of quarterly observations of costs for the eight mines as well as averages of the Chamber of Mines members expressed in rands per ton milled ranging from the beginning of 1970 to the third quarter in 1982. The data was collected from the Chamber of Mines "Quarterly Analysis of Working Results."

The model which will be developed in Chapter 6 requires the cost data to be expressed in rands per ounce of gold mined, hence the following transformation was used.

$$\text{cost}(r/oz) = \frac{\text{cost}(r/ton)}{\text{grade}(g/ton)} \times 31{,}10348^{*}$$

*1 ounce troy = 31,10348 grams

The actual time range over which the costs were analysed ranged from the 1st quarter of 1973 to the 3rd quarter of 1982, since only after 1973 did the gold price begin to display volatile tendencies.

The gold price data will be expressed in units of rands per ounce for the cost analysis.

Analysis of Average Cost

In order to find the best approach to fitting cost equations to the eight individual mines an analysis was performed on the average costs. The behaviour of cost over time for the individual mines all seem to exhibit similar trends over time, hence justifying the use of a similar technique for equation fitting.

The gold price and the time variable will be used as independent variables to measure the working costs (quarterly data will be used).

(i) <u>The Gold Price</u>

In Section 5.3 the effect that the gold price has on grade and hence costs was discussed and in Section 5.1.2 the association between the gold price and inflation (hence costs) was also discussed.

Firstly it was necessary to determine whether the quarterly gold price had a contemporaneous, lagged or some function of a lagged effect, on the quarterly working costs.

Simple correlation coefficients were computed at different lags where the gold price data was in units of rands per ounce. Figure 5.6 shows the graph of the simple correlations between costs and different lags of the gold price. It is evident from this graph that after lags of four quarters the correlation coefficient begins to decline. Correlations of various combinations of lags of the gold price against time were computed in an attempt to determine the periods over which the gold price had the most influence on cost. These correlations are listed in Table 5.5.

From Table 5.5 it can be seen that combination 8 representing the average of the previous four quarterly average gold prices yields the highest correlation with cost, and will therefore be used in the model for the identification of cost.

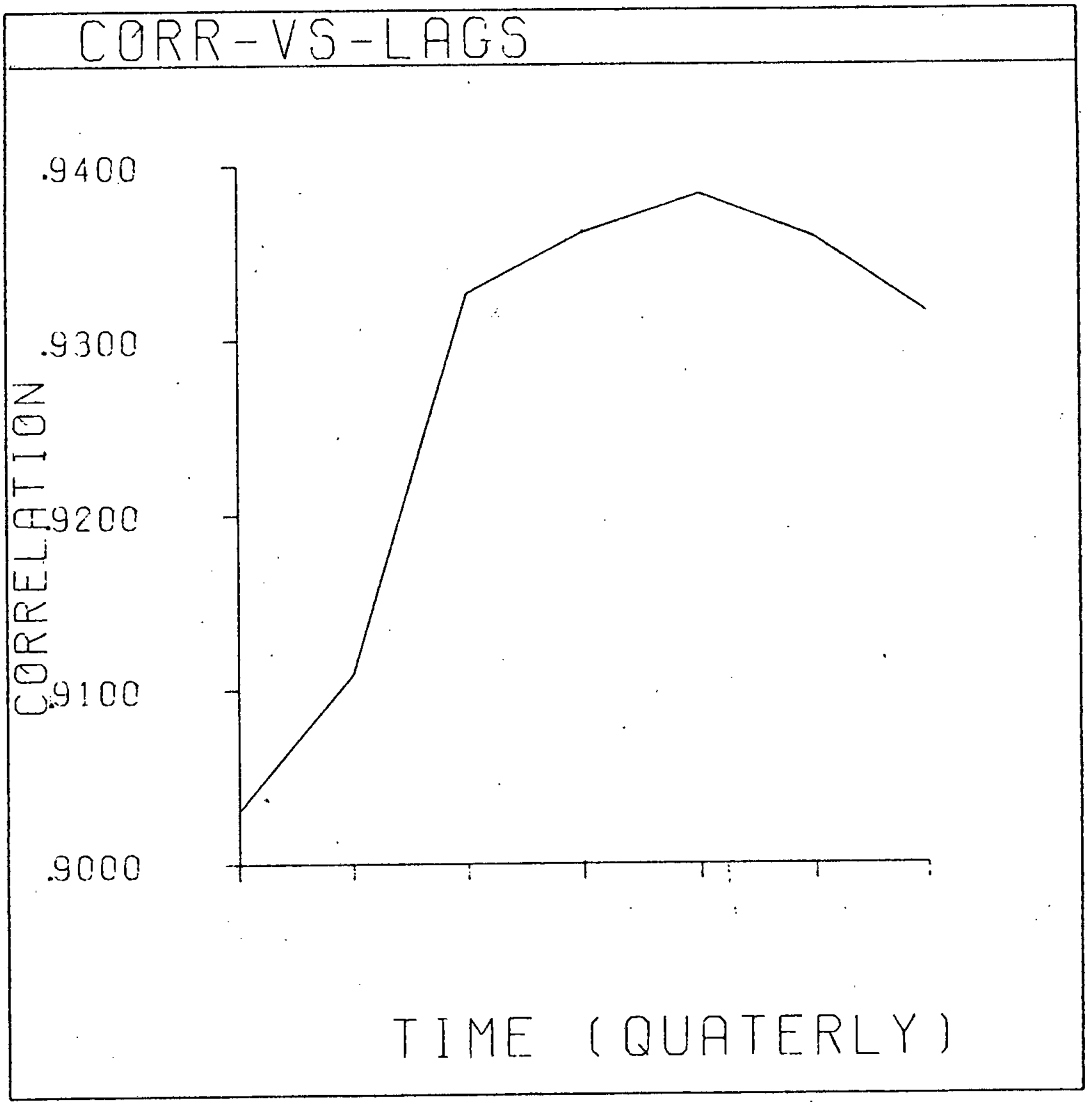


FIGURE 5.6

(ii) The Time Variable

Visual inspection of Figure 5.5 depicting the relationship between cost and time shows a possible exponential trend of cost against time. Hence an exponential factor will be included for the time variable in the identification of costs.

TABLE 5.5

Combination of lagged gold price (GP)	Correlation with Cost (t)
1. [GP(t-1)+GP(t-2)]/2	.9275
2. [GP(t-2)+GP(t-3)]/2	.9403
3. [GP(t-3)+GP(t-4)]/2	.9474
4. [GP(t-4)+GP(t-5)]/2	.9477
5. [GP(t-4)+GP(t-6)]/2	.9488
6. [GP(t.6)+GP(t-7)]/2	.9359
7. [GP(t)+GP(t-1)+GP(t-2) +GP(t-3)]/4	.9420

For the remainder of the cost analysis the time variable begins with the 1st quarter of 1970 being equal to 1 and increases by one unit for every quarter thereafter.

The Cost Model

Assuming that the best relationship between cost and the gold price occurred at the average of the previous 4 lags of the gold price and the contemporaneous cost and that time was exponentially related to cost (as discussed above), it was then necessary to determine if the effect of time and the gold price on cost was additive or multiplicative. Thus the following 2 models were considered:

The multiplicative model:

$$\text{cost}(t) = \beta_0 e^{\beta_1 (t)} \left[\frac{\sum_{k=t-4}^{t-1} GP(k)}{4}\right]^{\beta_2} \tag{5.2}$$

The additive model:

$$\text{cost}(t) = \beta_0 + \beta_1 e^{\beta_2 (t)} + \beta_3 \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \tag{5.3}$$

(i) <u>The multiplicative model</u>:

In order to estimate the coefficients β_0, β_1 and β_2 in (5.2) the log transformation was used to linearize equation (5.2), i.e.

$$\log(\text{cost}(t)) = \log \beta_0 + \beta_1 (t) + \beta_2 \log\left[\frac{\sum_{k=t-4}^{t-1} GP(k)}{4}\right] \tag{5.4}$$

The data was transformed accordingly, and β_0, β_1 and β_2 were estimated using a standard multivariate least squares regression procedure. The estimates of the beta's were substituted into equation (5.2) to obtain:

$$\text{cost}(t) = 7{,}2594 . e^{0{,}0414 (t)} \left[\frac{\sum_{k=t-4}^{t-1} GP(k)}{4}\right]^{0{,}2150} \tag{5.5}$$

with associated R^2 value equal to 0,9914.

(ii) <u>The additive model</u>

No single transformation exists that can be applied to (5.3) to obtain a linear form, hence a two-stage procedure was implemented to linearize (5.3).

Firstly β_2 was estimated separately by the model

$$\text{cost}(t) = \beta_1 e^{\beta_2 (t)} \tag{5.6}$$

taking logs to linearize

$$\log(\text{cost}(t)) = \log \beta_1 + \beta_2(t) \tag{5.7}$$

The data was transformed accordingly and β_2 was found (using least squares regression procedure) to be 0,05371 with an associated R^2 value of 0,9866.

Secondly, having acquired β_2, $e^{\beta_2(t)}$ was computed for each associated time point, thus rendering equation (5.3) suitable for regression analysis since the above transformed time variable makes equation (5.3) a linear equation.

The least squares technique applied in the second stage yielded estimates for β_0, β_1 and β_3. These estimates were substituted into equation (5.3) obtaining:

$$\text{cost}(t) = 3{,}3421 + 12{,}1425\ e^{0{,}05371(t)} + 0{,}0613\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \tag{5.8}$$

The associated R^2 value is 0,9960.

Even though the R^2 values obtained for both models indicate that both are very good fits, the R^2 value of the additive model is marginally higher, thus the technique used to estimate the additive model for the average cost above will also be used to estimate the cost functions for the individual mines. This can be justified by comparison of the plots of the total and individual mines.

Figure 5.7 displays the graph of the predicted average costs using equation (5.8) and the actual costs using the additive model discussed above.

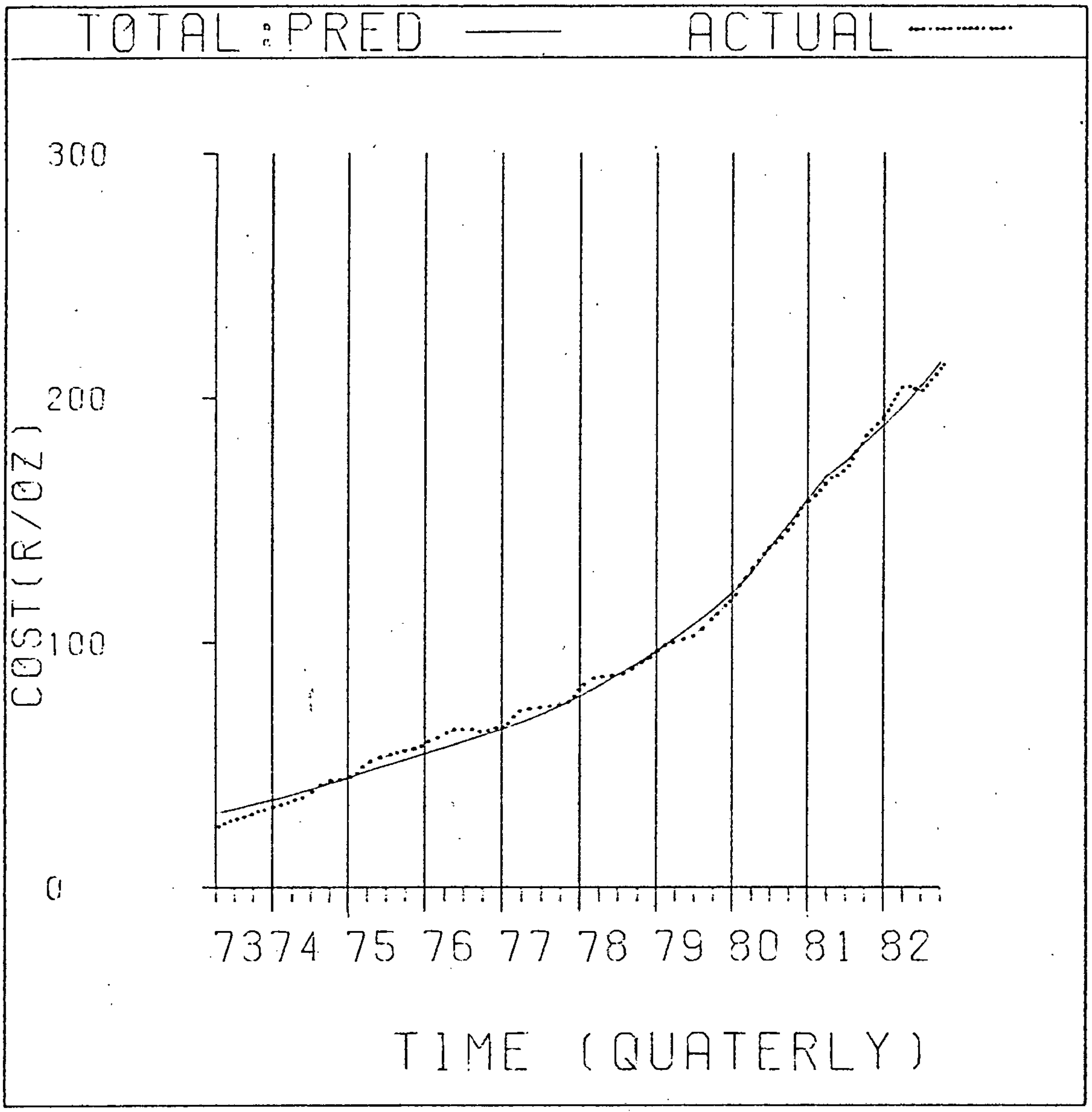


FIGURE 5.7

The remainder of this section includes the prediction of costs for each of the eight selected mines using the technique discussed for the average cost.

5.4.2.1 <u>Blyvooruitzicht Gold Mining Company (Blyvoor)</u>

The cost equation for the Blyvooruitzicht Gold Mining Company was found to be:

$$cost(t) = 8{,}2592 + 7{,}6974\ e^{0{,}06122(t)} + 0{,}0750\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.9)$$

The R^2 value associated with the estimation of the above model is 0,9711. Figure 5.8 shows the actual and predicted costs using the above equation.

The partial correlation of costs with time (exponentially adjusted) holding the lagged gold price fixed was found to be 0,8604, while the partial correlation of cost with the gold price (lagged as above) was found to be 0,3478.

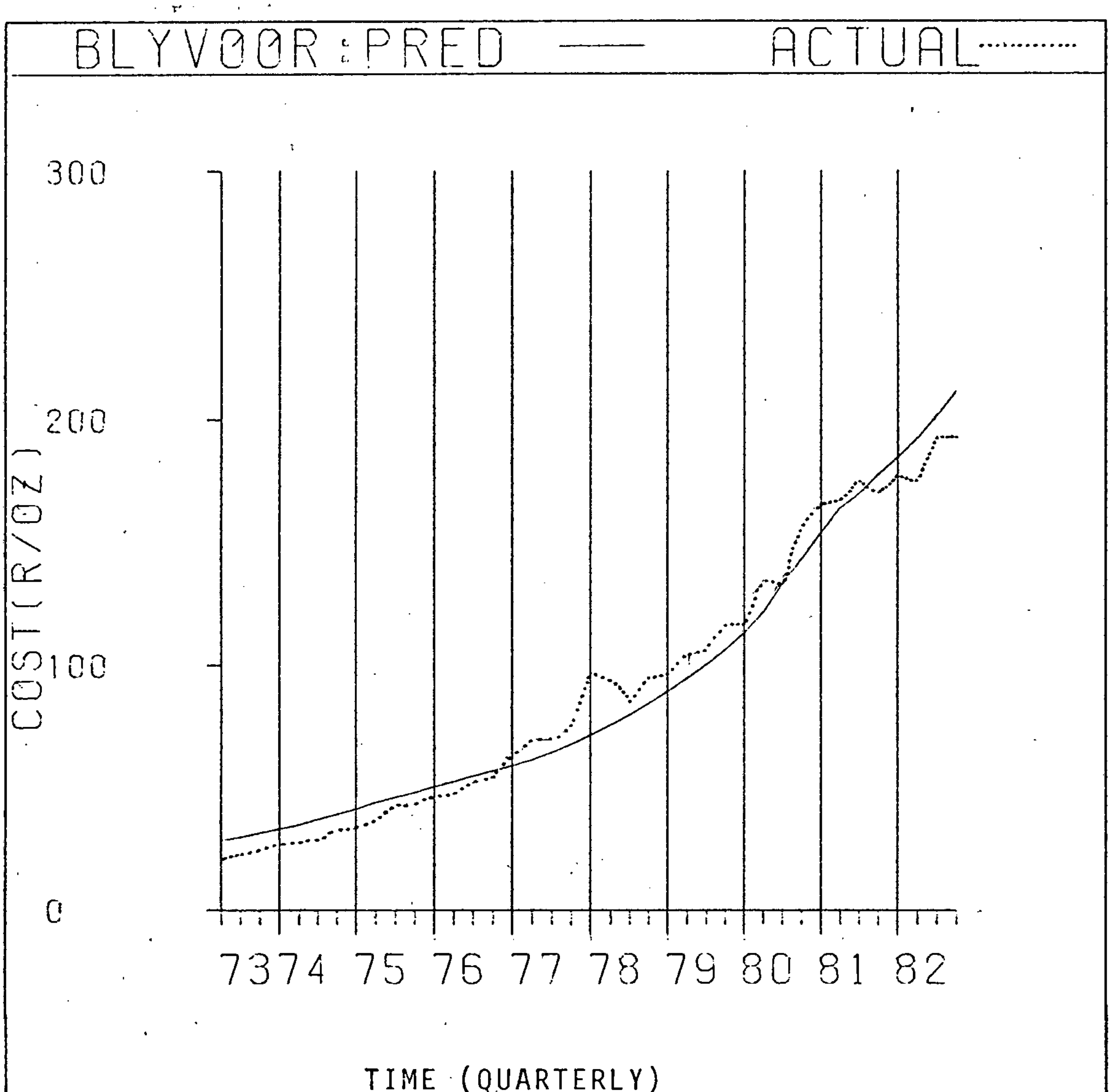


FIGURE 5.8

5.4.2.2 East Rand Proprietary Mines (ERPM)

Here the cost equation was estimated as:

$$\text{cost}(t) = 9{,}2595 + 23{,}8908\ e^{0{,}05704(t)} + 0{,}0297\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \tag{5.10}$$

The associated R^2 value is 0,9834. (Figure 5.9 shows the actual and predicted costs using the above equation.)

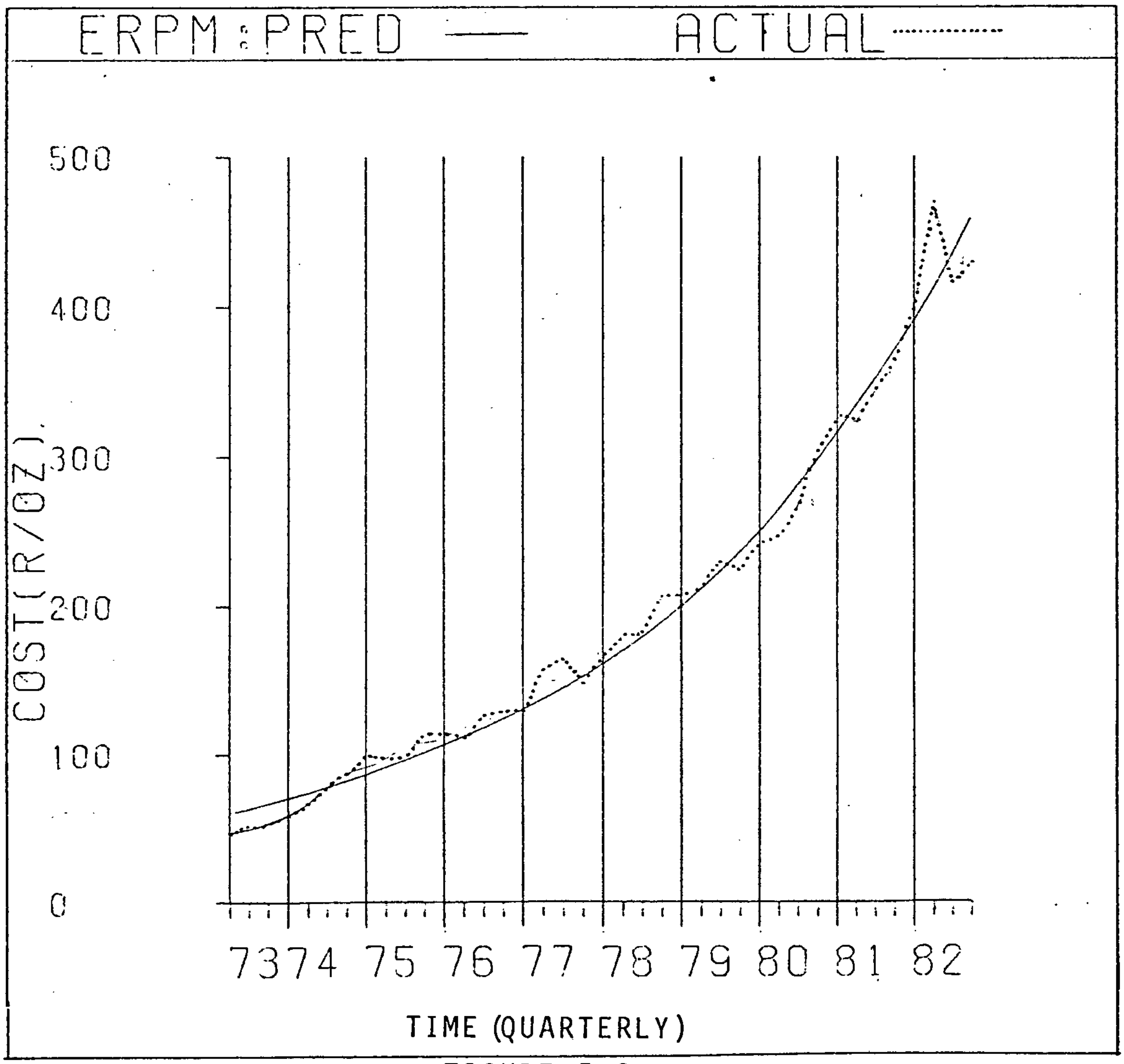


FIGURE 5.9

The partial correlation of cost with time holding the gold price constant was found to be 0,9341, while the partial correlation of cost with the gold price (as in the above model) with time fixed was only 0,0917.

5.4.2.3 Grootvlei Proprietary Mines (Grootvlei)

Here the cost equation was estimated as

$$\text{cost}(t) = 12{,}5337 + 13{,}0431\ e^{0{,}04868(t)} + 0{,}1993\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.11)$$

with R^2 value equal to 0,9832. (Figure 5.10 shows the actual and predicted costs associated with the above equation.)

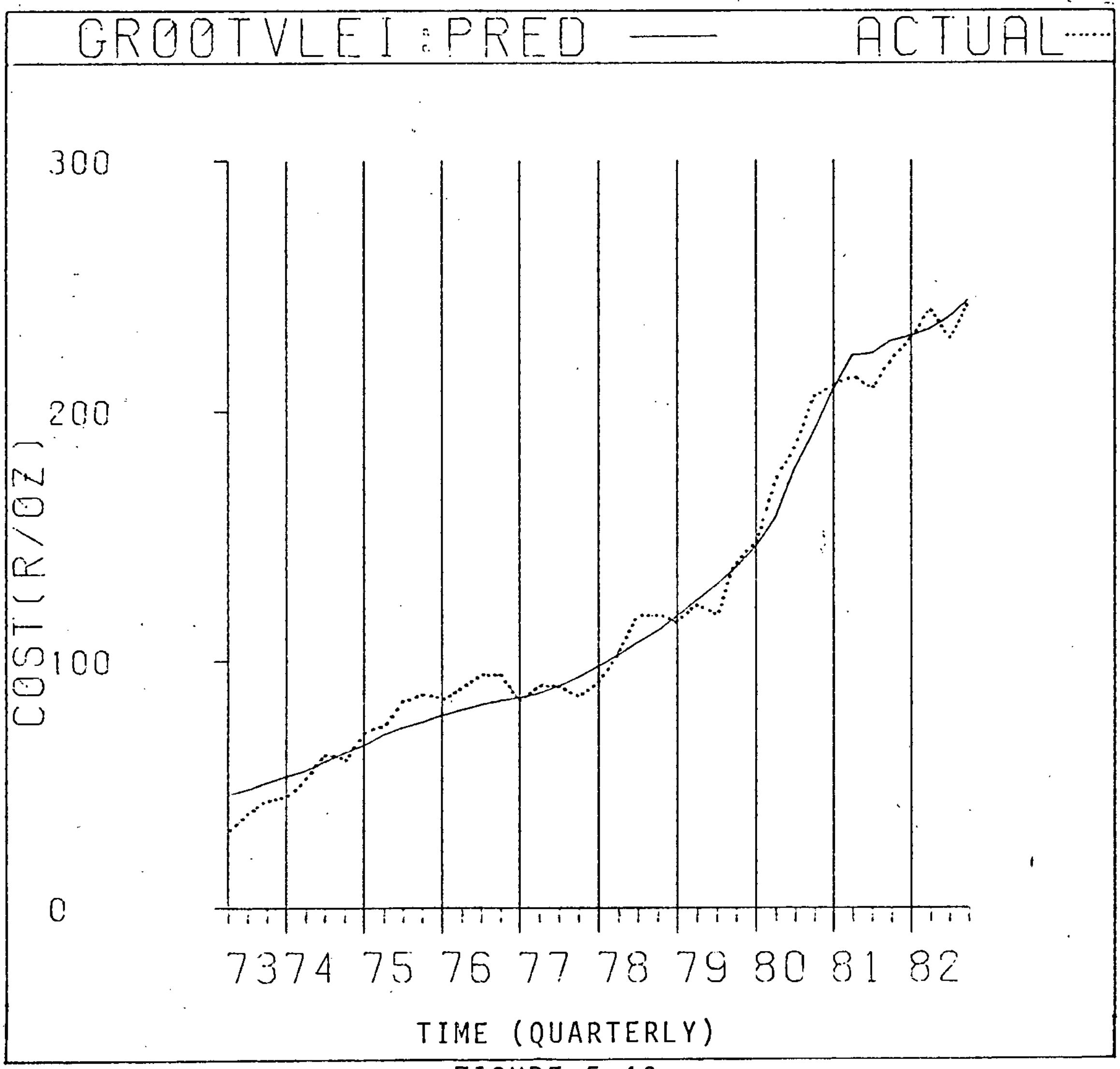


FIGURE 5.10

The partial correlation of cost with time holding the lagged gold price constant is 0,8527 and the partial correlation of cost with the lagged gold price with time constant is 0,7474.

5.4.2.4 Kinross Gold Mining Company (Kinross)

The cost equation for Kinross Gold Mining Company was found to be

$$\text{cost}(t) = 0{,}1298 + 11{,}4377\ e^{0{,}056065(t)} + 0{,}0360\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.12)$$

The R^2 value associated with the above equation is 0,9951. (Figure 5.11 shows the actual and predicted costs estimated using the above equation.)

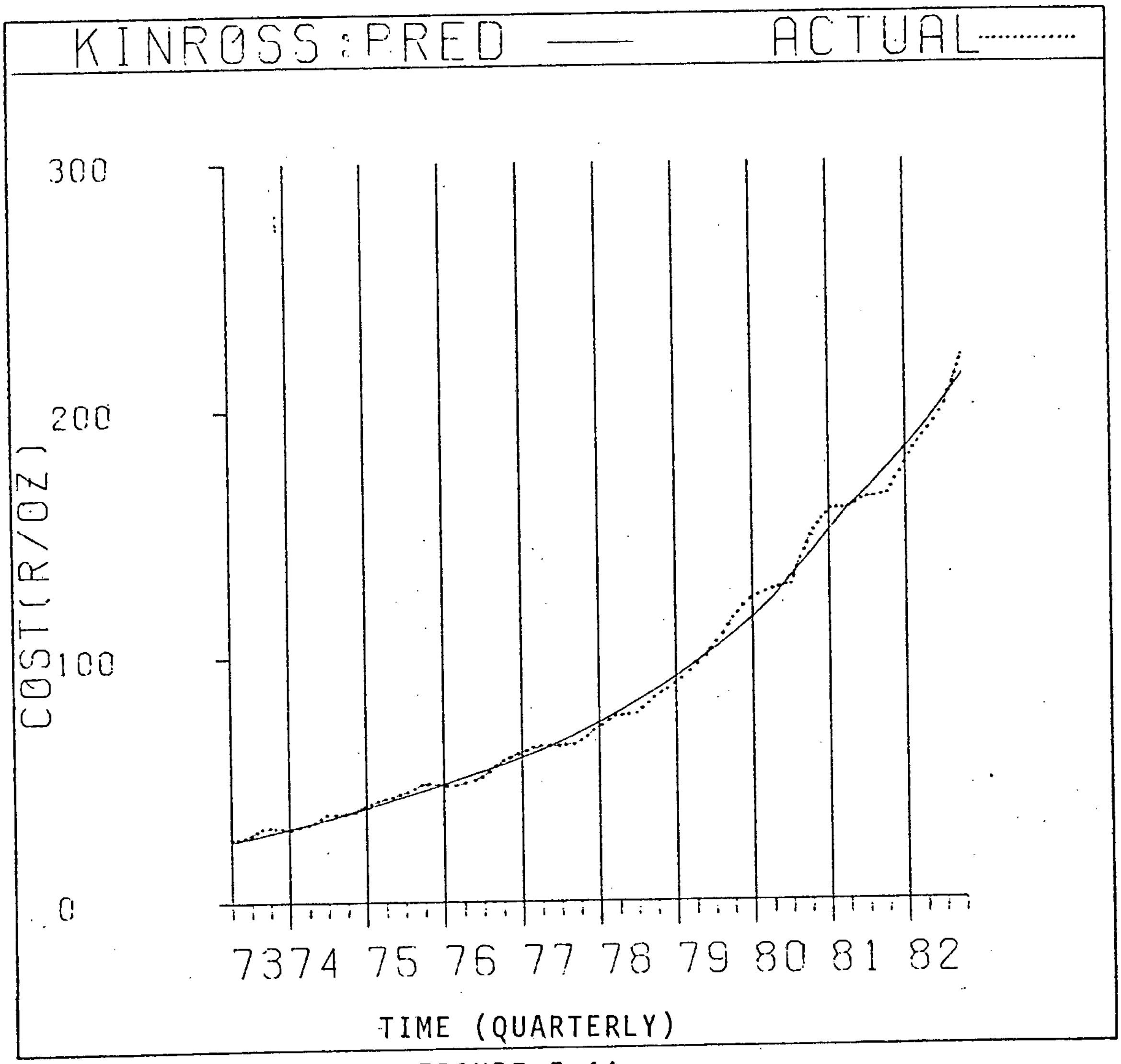


FIGURE 5.11

The partial correlation of cost with time holding the gold price constant was found to be 0,9773, while the partial correlation of cost with the gold price keeping time constant was found to

5.4.2.5 Kloof Gold Mining Company (Kloof)

The cost equation was found to be

$$\text{cost}(t) = 7{,}2426 + 17{,}1824\ e^{0{,}04071(t)} - 0{,}0275\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.13)$$

with R^2 value of 0,8778. (Figure 5.12 shows the predicted and actual costs using the above equation.)

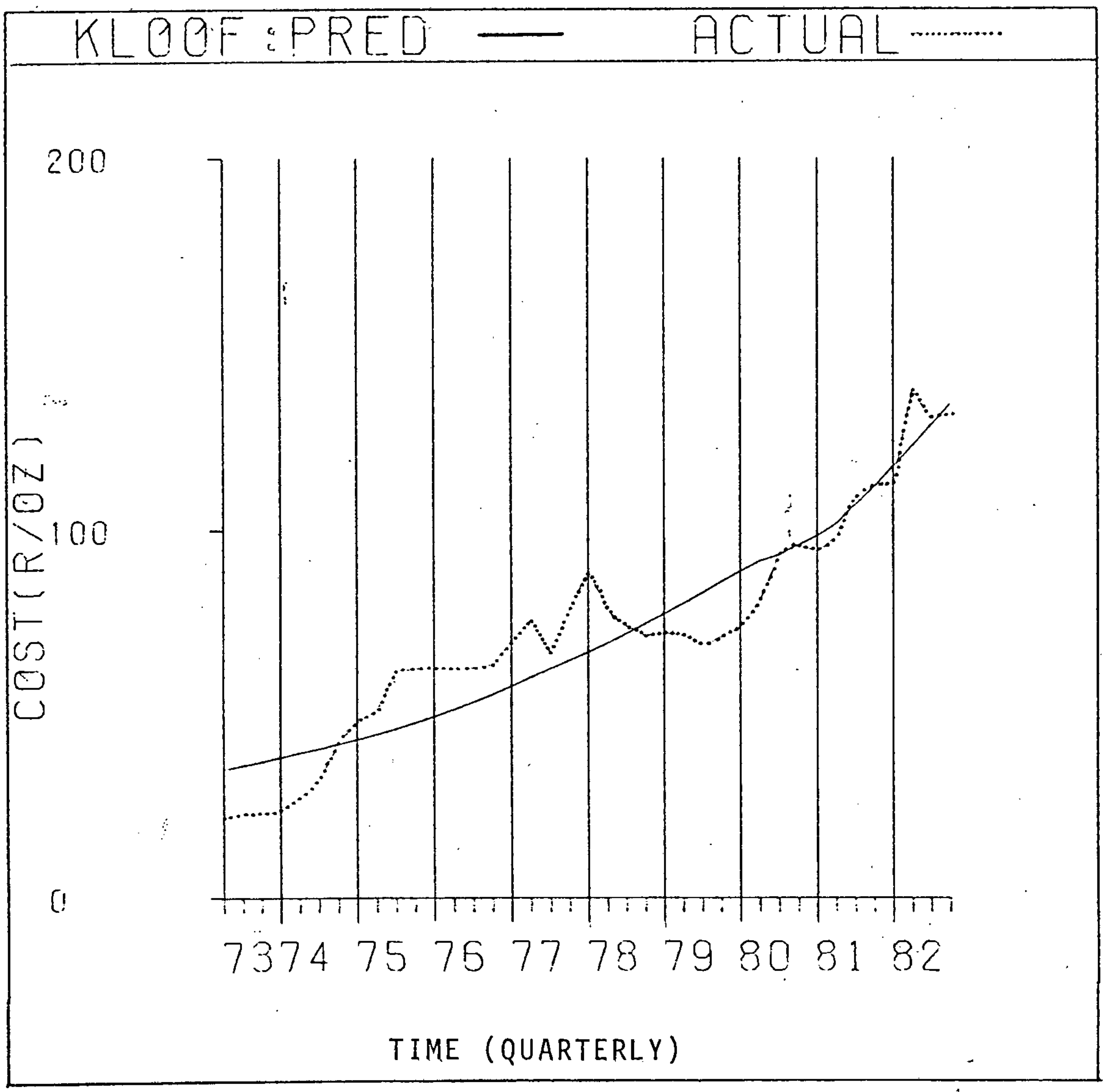


FIGURE 5.12

The partial correlation between cost and time holding the gold price constant was found to be 0,7360 while the partial correlation between cost and the lagged gold price was found to be -0,1243. The negative correlation between cost and the lagged gold price and hence the negative gold price coefficient in the cost equation is rather surprising, however, its existence can be justified as Kloof Gold Mining Company uses a longwall (as opposed to scattered) mining procedure which does not enable efficient changes to one of different grades during periods of marked differences in the gold price. Secondly, the negative value of the gold price coefficient is very small and has an almost negligible impact on the estimation of costs.

5.4.2.6 Venterspost Gold Mining Company (Venters)

Here the cost equation was estimated as:

$$\text{cost}(t) = 13{,}3370 + 14{,}7380\ e^{0{,}05768(t)} + 0{,}2260\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.14)$$

The R^2 value is 0,9775. (Figure 5.13 shows the actual and predicted costs using the above equation.)

The partial correlation of cost with time holding the gold price constant is 0,8562, and the partial correlation between cost and the lagged gold price holding time constant is 0,5704.

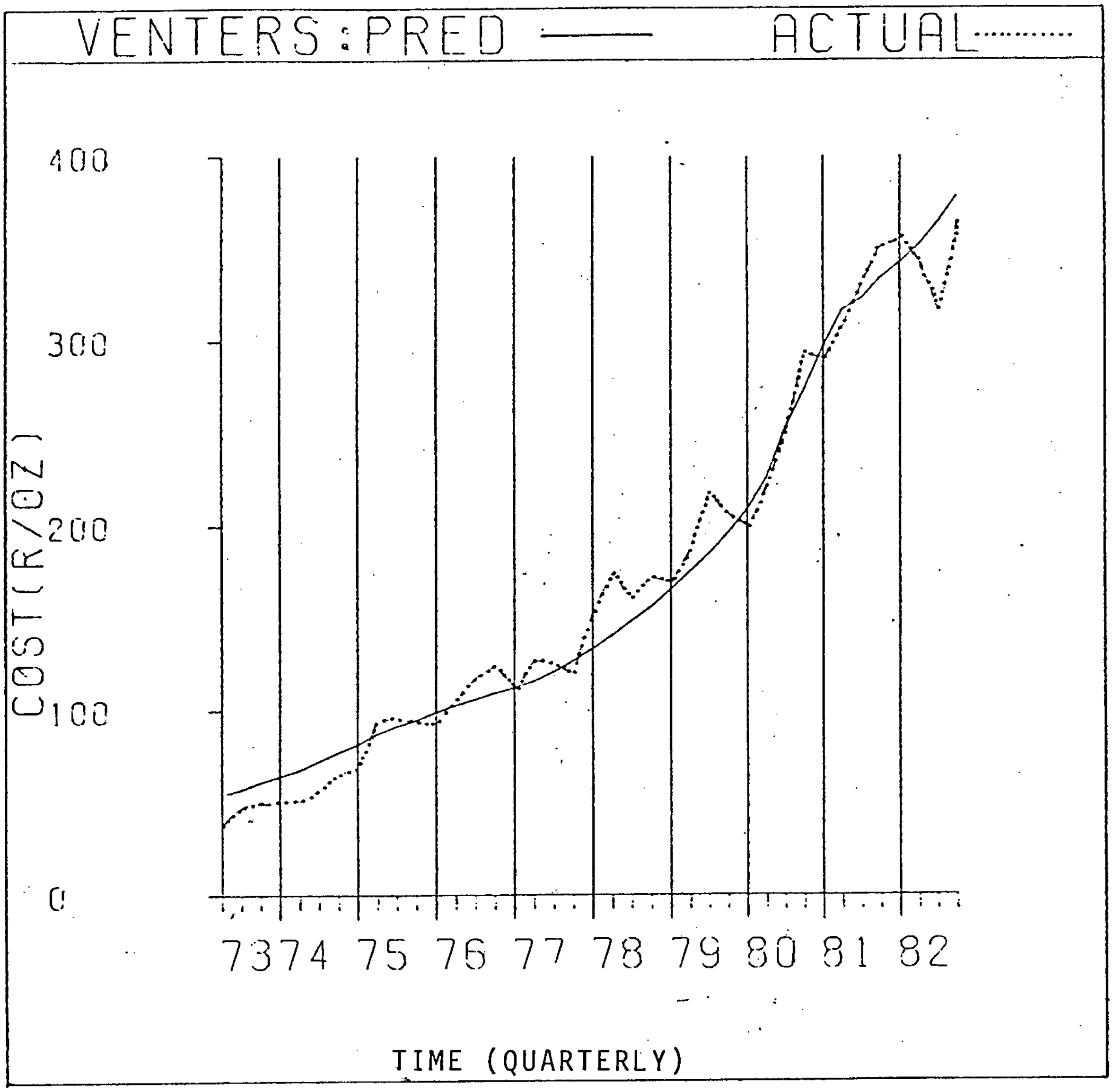


FIGURE 5.13

5.4.2.7 Western Deep Levels Ltd (Westdeep)

The estimated cost equation is:

$$\text{cost}(t) = 1{,}7021 + 9{,}9864\ e^{0{,}05399(t)} + 0{,}0281\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.15)$$

with R^2 equal to 0,9648. Figure 5.14 below shows the actual and predicted costs using the above equation.

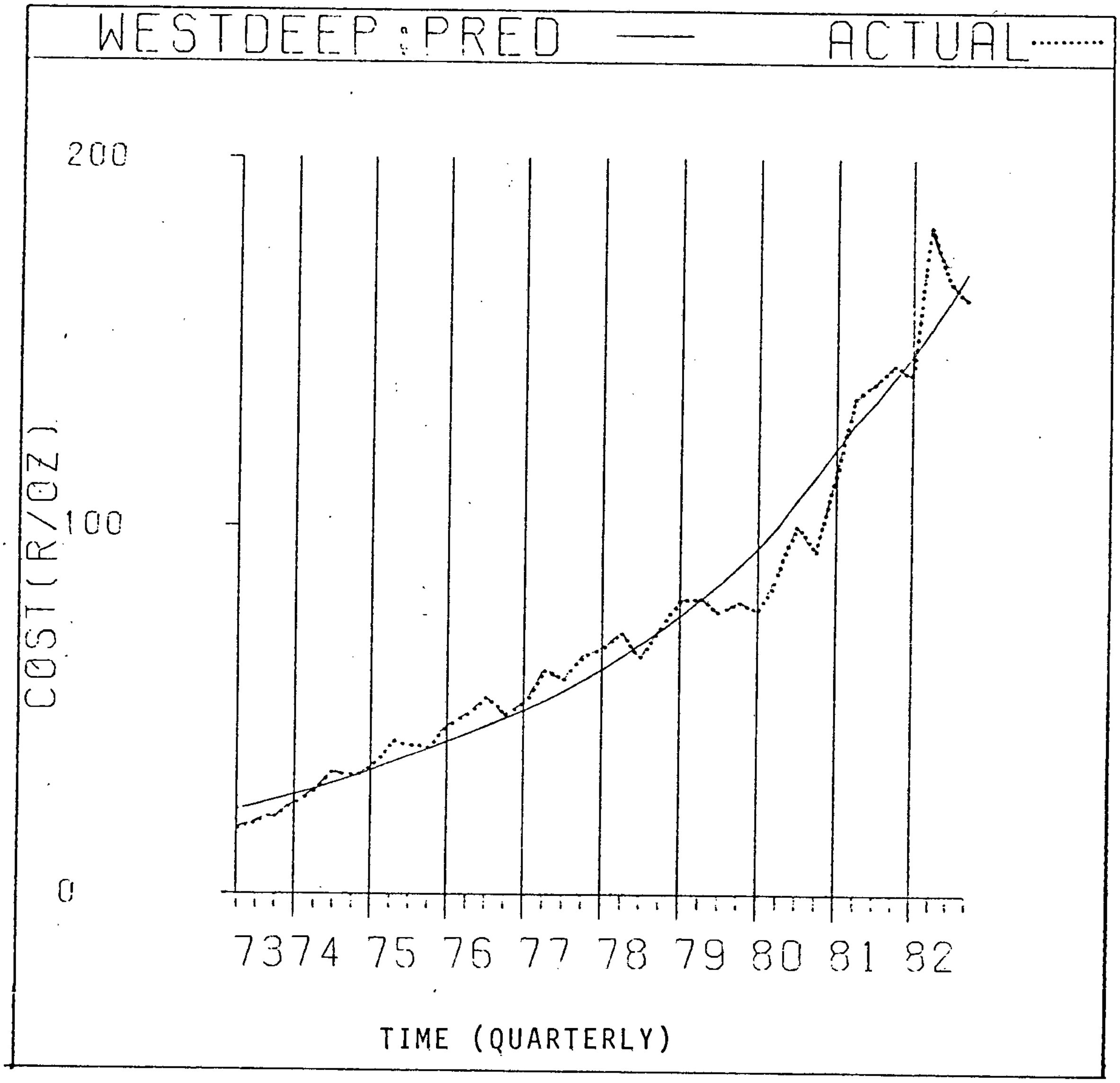


FIGURE 5.14

The partial correlation between cost and time holding the lagged gold price constant was 0,8614 while the partial correlation between cost and the lagged gold price holding time constant was found to be 0,1579.

5.4.2.8 Winkelhaak Mines Ltd (Winkelhaak)

Here the cost equation was estimated as:

$$\text{cost}(t) = -1{,}5441 + 12{,}5363\ e^{0{,}04777(t)} + 0{,}250\ \frac{\sum_{k=t-4}^{t-1} GP(k)}{4} \qquad (5.16)$$

with R^2 equal to 0,9882. (Figure 5.15 below shows the actual and predicted costs using the above equation.)

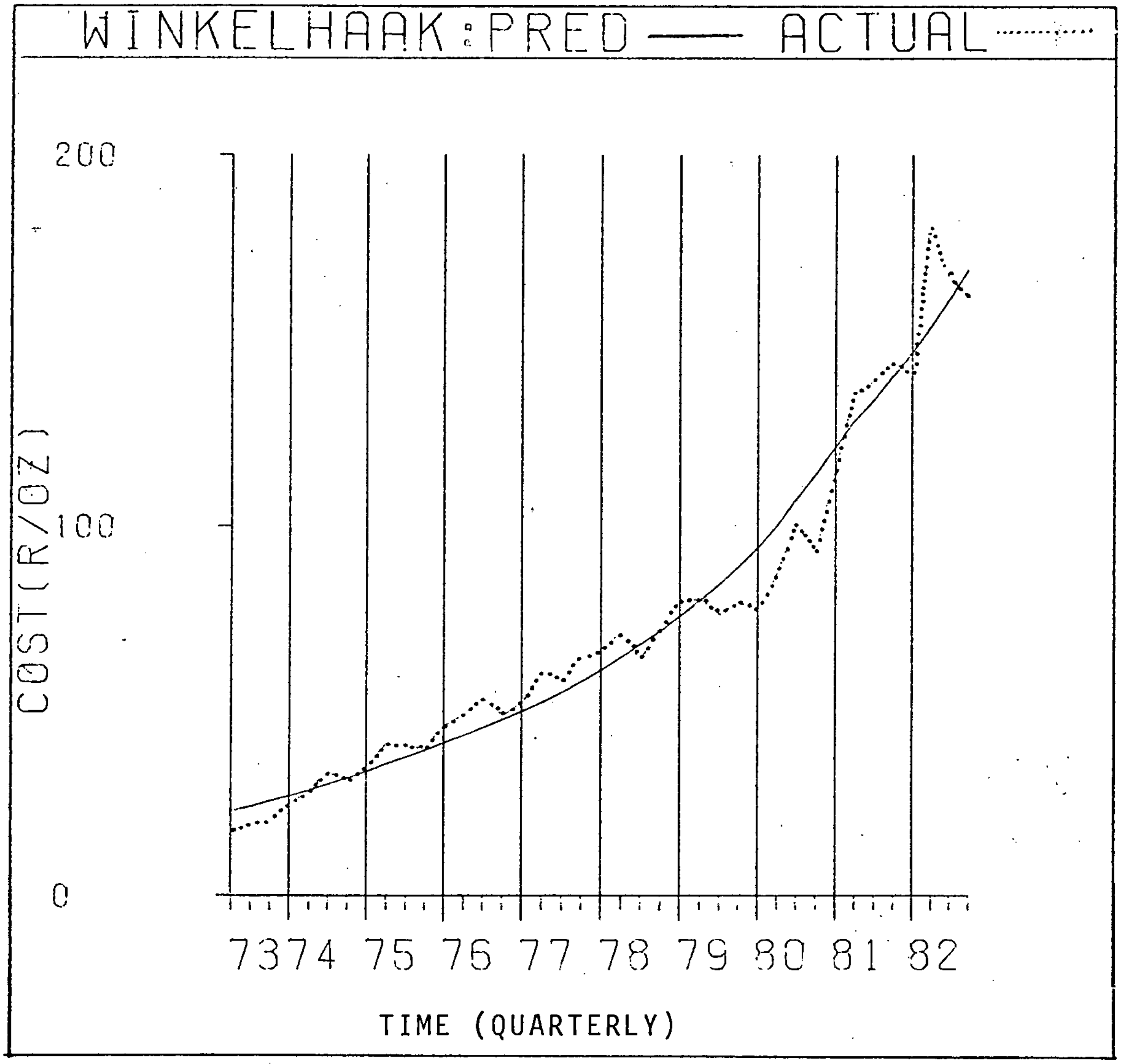


FIGURE 5.15

The partial correlation of cost with time holding the lagged gold price constant was 0,9482 while the partial correlation between cost and the lagged gold price holding time constant was found to be 0,2722.

Summary

Firstly the cost equations for the eight individual mines all appeared to have similar trends and represented the data well, as can be seen by the high R^2 values. Secondly the time variable was the dominant variable in all the equations as can be seen in Table 5.6 below.

TABLE 5.6

Mine	Cost equation R^2 value	Partial Correlations	
		Cost and Time gold price fixed	Cost and gold price time fixed
Blyvoor	0,9711	0,8604	0,3478
ERPM	0,9834	0,9341	0,0917
Grootvlei	0,9832	0,8527	0,7474
Kinross	0,9951	0,9773	0,3983
Kloof	0,8778	0,7360	-0,1243
Venters	0,9775	0,8562	0,5704
Westdeep	0,9648	0,8614	0,1579
Winkelhaak	0,9882	0,9482	0,2722

The cost equations analysed in this section were all in units of rands per ounce of gold mined. Cost equations in units of dollars per ounce mined using a contemporaneous quarterly gold price variable were also determined. An additive model was used here as well, i.e.

$$\text{cost}(t) = \beta_0 + \beta_1 e^{\beta_2 (t)} + \beta_3 GP(t) \qquad (5.17)$$

The quarterly cost and gold price data were adjusted by the quarterly average US dollar/rand exchange rate. A list of the beta's and R^2 values for the estimated costs of the individual mines are given in Table 5.7 below.

Comparison of Table 5.6 above and Table 5.7 below shows that the rand/ounce cost equations generally have marginally higher associated R^2 values than the corresponding dollar/ounce cost equations shown below. This is to be expected due to the high degree of variability of the exchange rate, thus causing more volatile dollar/ounce cost data when adjusted by the exchange rate.

TABLE 5.7

Mine	R^2	Cost Coefficients - dollars/ounce			
		β_0	β_1	β_2	β_3
Blyvoor	0,9762	0,294	11,471	0,056	0,109
ERPM	0,9803	7 350	27,846	0,054	0,150
Grootvlei	0,9659	10,571	14,439	0,049	0,215
Kinross	0,9864	0,698	12,663	0,050	0,132
Kloof	0,8579	10,256	17,784	0,041	0,007
Venters	0,9739	1,995	23,373	0,056	0,150
Westdeep	0,9562	2,030	13,613	0,050	0,029
Winkelhaak	0,9782	2,706	14,839	0,041	0,074

Cost equations in units of rands per ton of ore milled were also estimated previously using the same equation (5.17). The beta's and R^2 values associated with costs expressed in rands per ton of ore milled are tabulated in Table 5.8 below.

The interesting characteristics in comparison here, are the coefficients of the gold price variables, although they are relatively small, they are almost all negative. The reason for the negative gold price coefficients is due to the fact that periods of higher gold prices enable mines to mill lower grades of ore, which are generally more accessible, thus causing the cost per ton of ore milled to decline and *vice versa* (although the cost per ounce of gold mined increases at lower grades).

TABLE 5.8

		Cost Coefficients - rands/ton of ore milled			
Mine	R^2	β_0	β_1	β_2	β_3
Blyvoor	0,9845	-0,310	7,835	0,041	-0,006
ERPM	0,9527	2,293	5,238	0,051	-0,007
Grootvlei	0,9899	-0,485	3,260	0,044	0,003
Kinross	0,9896	-0,809	4,982	0,040	-0,001
Kloof	0,9750	0,744	7,948	0,042	-0,011
Venters	0,9817	-0,497	7,201	0,041	-0,007
Westdeep	0,9786	0,862	6,800	0,046	-0,008
Winkelhaak	0,9824	-0,988	5,211	0,035	-0,002

5.5 Production

Gold has always been a scarce commodity, therefore any increase in the supply of newly-mined gold will be derived mainly from more efficient exploitation of existing, known or suspected deposits.

Figure 5.16 shows the quarterly totals of tons of ore milled from the 1st quarter of 1970 to the 4th quarter of 1983. It can be seen that the tonnage of ore milled has increased from 18 211 000 tons to 23 902 000 over this period.

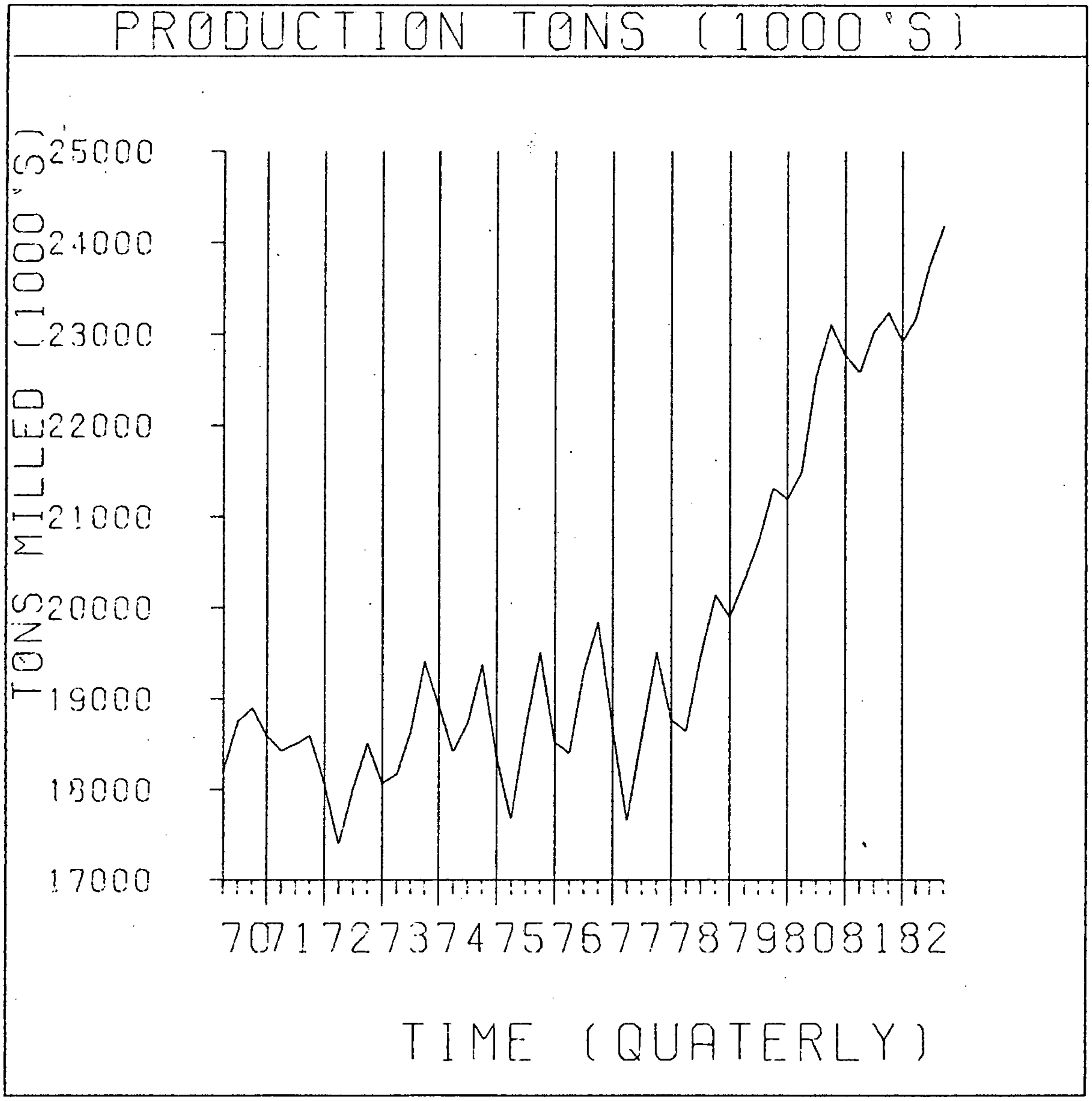


FIGURE 5.16

Figure 5.17, however, shows that the actual number of ounces of gold produced has decreased from 7 800 000 ounces in the 1st quarter of 1970 to 5 200 000 ounces in the last quarter of 1982.

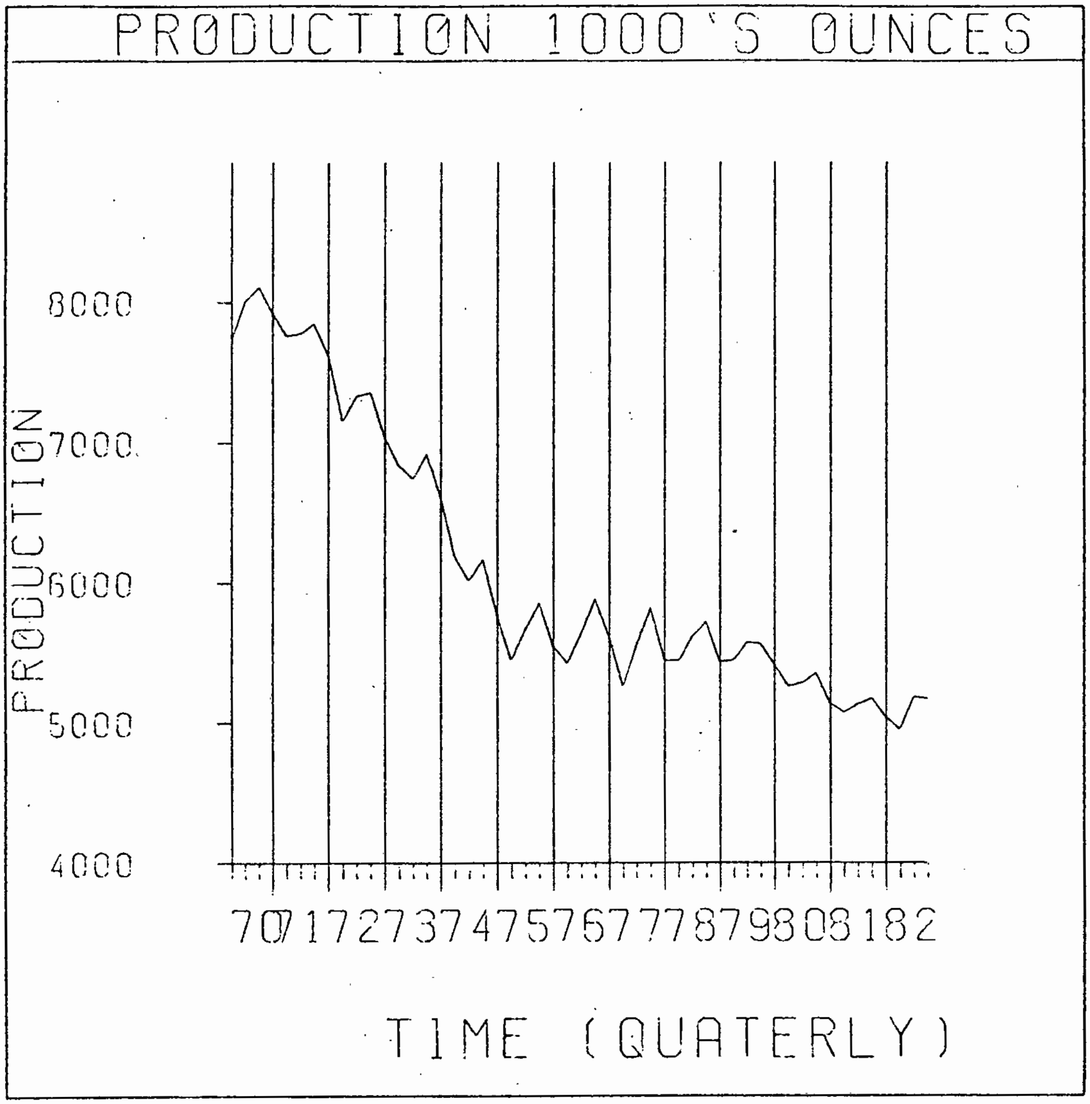


FIGURE 5.17

The reason for the increase in tons of ore milled, yet decrease in the total production of gold is due to the fact that the industry is mining lower grades, therefore extracting fewer grams of gold in relation to the tons of ore milled. The average grade of ore has decreased from 13,28 grams per ton in 1970 to 6,76 grams per ton in 1982, as can be seen from Figure 5.4.

Two factors have led to the decrease in the grade of ore milled, firstly, higher gold prices have made it payable to mine the lower grade ores which were previously unpayable and left in the ground. Secondly, many of the mines have already exhausted much of their higher grade reserves and are now mining their lower grade areas.

It should, however, be noted that although higher gold prices may lead to a fall-off in gold production, higher gold prices also enable the industry to mine lower grade ores, thus extending the lives of gold mines, which means that in total more gold will be extracted.

The Chamber of Mines Economics Department (1980) conducted a study to determine future trends in South African gold production. Two different gold prices scenarios were used:

(i) a price of \$305 an ounce in 1980 rising to \$407 an ounce by 1984, and thereafter rising at the same level as working costs until the year 2000.

(ii) a price of \$450 an ounce in 1980 rising to \$554 an ounce in 1984, and then remaining constant in real terms until the year 2000.

Under both scenarios South African gold production was estimated to remain around 700 tons a year until 1987, and then fall off gradually to about 350 tons a year in the year 2000.

Further projections by the Chamber of Mines estimate that the cumulative total of gold likely to be produced by known gold mines in South Africa up to and beyond the year 2030 at a real gold price close to present levels will be about 15 000 tons.

5.5.1 Estimation of Production

The production of gold as explained above is influenced to some extent by the gold price. Also, production has decreased through time as can be seen from Figure 5.17, hence these variables will be considered in the estimation of production.

In order to derive estimates for the share evaluation model, which will be implemented in the next chapter, the following model incorporating contemporaneous and lagged gold price variables, as well as time variable, was considered:

$$\text{Annual production}(t) = [\alpha_1 + \alpha_2 \text{ Weighted average gold price}(t) + \alpha_3 \text{ gold price}(t) + \alpha_4(t)] \times 1000 \qquad (5.18)$$

?

$$\text{where Weighted average gold price} = [4.\text{gold price}(t-1) + 3.\text{gold price}(t-2) + 2.\text{gold price}(t-3) + \text{gold price}(t-4)] \frac{1}{10}$$

To express the data in ounces produced annually, the following transformation was used on the quarterly data:

$$\text{Annual production}(t) = \sum_{k=0}^{3} \frac{\text{tons milled}(t-k) \times \text{grade}(t-k)}{31,10348} \qquad (5.19)$$

The coefficients of equation (5.18) found by using least squares regression for the eight individual mines are shown in Table 5.9 below. The data included quarterly observations from the 1st quarter of 1973 to the last quarter of 1983.

TABLE 5.9

Production Mines	Intercept α_1	Gold Av. α_2	Gold Price α_3	Time α_4	F-Ratio
Blyvoor	1241,3670	0,5004	-0,0235	-19,1311	125,416
ERPM	605,9126	0,3834	0,1711	-10,8205	32,544
Grootvlei	180,2051	-0,0552	0,1006	0,3054	4,562
Kinross	431,3414	-0,0315	-0,1040	-1,5895	36,014
Kloof	779,6869	0,00717	1,3857	-8,7422	8,353
Venters	398,1798	0,06718	0,0867	-6,0694	68,179
Westdeep	2055,2714	-0,2452	1,2538	-23,5688	50,013
Winkelhaak	556,8128	-0,1417	0,06589	-1,3904	22,203

All the F-ratios given in Table 5.9 can be seen to exceed the critical F value of 2,87 at the 5% significance level, indicating that a significant linear relationship was found to exist at this level. It should, however, be noted that Grootvlei has a low F ratio and that the hypothesis of a significant linear regression would have been rejected at the ½% level here.

Figures C.1 to C.8 in Appendix C show the graphs of the actual and estimated production levels for the eight individual mines.

5.6 Capital Expenditure

Capital expenditure includes the initial capital costs of bringing a new mine to production and thereafter can be divided into three categories: (c.f. Harwinkel (1982) p.95)

(i) Absolutely essential to maintain operations of the mine.

(ii) Desirable expenditure, but which could be deferred if necessary.

(iii) Expenditure related to expansion of operations and luxury projects.

Figure 5.18 shows the total quarterly gold mine capital expenditure expressed in millions of rand. It is evident from the graph that capital expenditure tends to be increasing, reaching a recent peak of R395,1 million in the third quarter of 1981.

Brown (1982) gives a total for capital expenditure of R5730,7 million for gold and uranium mining from 1972 to 1982, but adds:

"Perhaps of more pertinence is the growth of capital expenditure. It has escalated from R106,4 million in 1973 to R1211,9 million in 1981, falling slightly to an estimated R1062 million in 1982."

Brown continues: *"But the main reason for the growth was the upward trend in the gold price, which gave the gold mining industry a new lease of life and provided the retained earnings to finance substantial additions to capital stock and new mining ventures."*

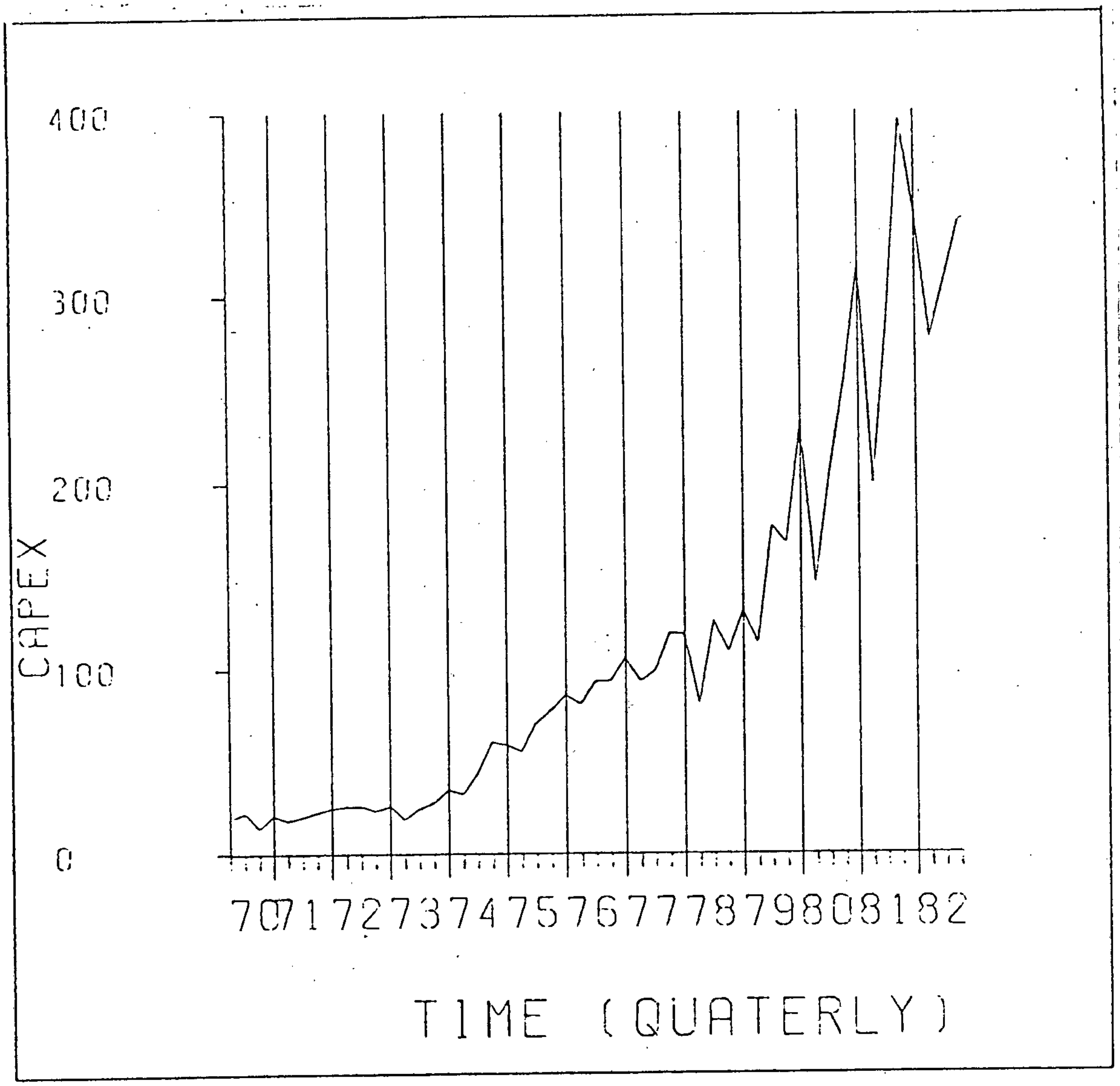


FIGURE 5.18

Capital Expenditure for a New Mine

The costs of building a new mine have increased dramatically. Brown (1982) estimated that the cost of opening a new medium sized gold mine has increased by between 300 per cent and 400 per cent over the past decade.

Kettel (1982) estimated the cost of building a new mine as being in excess of R450 million, which can be divided proportionally as:

shaft sinking	30,6%
accommodation	21,1%
treatment plant	14,0%
equipment	12,8%
sundries	9,2%
services	7,4%
refrigeration	4,9%
	100%

As a result of the rising gold price in the seventies, three new gold mines were recently established, namely, Unisel, which cost R79 million to bring to the production stage, Deelkraal, which cost R150 million and Elandsrand, which reached the pre-production stage at a cost of R183 million (c.f. Supplement to Financial Mail, 30 May 1980).

Capital Expenditure Absolutely Essential to Maintain Operations

This category includes the replacement of all equipment worn out during mining use, including shaft equipment, rails, cables, pumping facilities, fans, etc. These amounts are generally relatively small but nevertheless will continue to be incurred throughout the life of the mine, and can be considered as ongoing capital costs.

Table 5.10 extracted from Brown's (1982) report shows that out of a total of R2740 million worth of stores consumed in 1981, R982 million or 35,84% was on capital account.

Table 5.10

	Capital account	% age of total	Working cost a/c	% age of total	Total stores
1968					R320,1m
1969					R330,1m
1970	R75,6m	21,46%	R276,9m	78,54%	R352,5m
1971	R82,4m	22,31%	R287,0m	77,69%	R369,4m
1972	R64,5m	17,4%	R306,0m	82,6%	R370,5m
1973	R76,1m	17,36%	R362,4m	82,64%	R438,5m
1974	R140,9m	24,41%	R436,1m	75,59%	R577,0m
1975	R245,8m	31,58%	R532,4m	68,42%	R778,2m
1976	R335,5m	33,94%	R653,2m	66,06%	R988,7m
1977	R330,8m	28,85%	R816,0m	71,15%	R1146,8m
1978	R397,3m	27,98%	R1022,6m	72,02%	R1419,9m
1979	R590,6m	32,22%	R1242,2m	67,78%	R1832,8m
1980	R838,8m	35,79%	R1505,1m	64,21%	R2343,9m
1981	R982,0m	35,84%	R1758,0m	64,16%	R2740,0m

Further, Brown provides a rough breakdown of the product types consumed on capital account in 1981.

TABLE 5.11

Product type	% of capital account
building and construction	35,9%
plant and machinery	21,9%
electrical machinery and spares	13,1%
iron and steel products	6,7%
piping, tubing and fittings	4,3%
building materials	2,8%
electrical cable and wires	2,1%
furniture and fittings	1,9%
tools	1,0%
belting and requisites	0,7%
timber and timber products	0,7%
cement and concrete	0,6%
chemicals	0,6%
non-ferrous metal products	0,5%
other	7,2%

Desirable Capital Expenditure, Which Could Be Deferred If Necessary

This category includes capital which should be spent but could be deferred. Examples from this category include expenditure such as improvements to employee living amenities.

Capital Expenditure Related to Expansion of Operations and Luxury Projects

This category includes expenditure on future expansion projects. Generally these projects are only contemplated in periods of rising gold prices whereby grades of ore, that were previously uneconomic to mine at lower gold prices, now become payable.

Table 5.12 extracted from Brown's (1982) report shows the relationship between capital invested in mining (all sectors) and capital invested elsewhere in the economy.

TABLE 5.12

	Contribution of gold & uranium mining to GNP	Gross domestic fixed investment		Ratio Mining/ Manufacturing	Ratio Mining/ Total
		Mining and quarrying	Manufacturing		
1973	8,2%	R277m	R1043m	1:3,7	1:18
1974	9,5%	R443m	R1222m	1:2,7	1:14
1975	8,2%	R746m	R1471m	1:2	1:11
1976	6,6%	R868m	R1521m	1:1,8	1:10,6
1977	6,9%	R755m	R1681m	1:2,2	1:12
1978	8,7%	R816m	R2064m	1:2,5	1:12,3
1979	10,8%	R1209m	R2489m	1:2	1:9,6
1980	17,2%	R1726m	R3618m	1:2,1	1:8,8
1981	11,7%	R1878m	R4353m	1:2,3	1:9,7

Sources: Chamber of Mines of South Africa and South African Reserve Bank

It is interesting to note that the ratio of fixed investment in mining to fixed investment in manufacturing has remained reasonably constant at a ratio of 1:2 over the past 10 years. However, the ratio of fixed investment in mining to total fixed investment in the economy has gradually increased from approximately 1:18 in 1973 to 1:9,7 in 1981.

Brown concludes that mining has become a more important component of national investment and is therefore of growing significance to the suppliers of capital goods. Brown mentions that for every R1000 worth of gold sold a gross input of R341 is required from the rest of the economy. Hence, Brown argues, that the total 1981 South African gold output of R8556,6 million would have required gross inputs of R2918 million from the rest of the economy.

5.6.1 Estimation of Capital Expenditure

Capital expenditure for gold mines, as far as expenditure on expansion and new projects is concerned, is extremely difficult to predict using past data alone. Not only does it depend on the gold price, but more important on the availability of projects specific to the individual mines. Clearly sustained high gold prices favour expansion as not only does it render more quantities of ore payable, but it also assists in generating capital necessary for expansion.

Since the availability of projects and amount of capital required to finance projects is unique to every mine, the best estimate for future capital expenditure would be obtained from the management of the individual mine itself.

However, in the absence of any reliable estimate of capital expenditure based on future projects, an attempt will be made here to find a reasonable relationship between capital expenditure and other related variables on the basis of past data.

The Capital Expenditure Model

It was initially felt that capital expenditure might be explained in terms of some function of lagged working profit and the gold price alone. On the basis of this intuition a profit variable was created using the following transformation:

$$\text{Working Profit}(t) = \frac{1}{4}\left[\sum_{k=t-4}^{t-1} \text{Gold price}(k) - \sum_{k=t-4}^{t-1} \text{Cost}(k)\right](\text{r/ounce}) \tag{5.20}$$

where the data points were recorded quarterly and were all expressed in rands per ounce. From the above equation it is clear that the profit was computed at a lag of one quarter, and that the previous four quarters profit was averaged over the four quarters.

The contemporaneous average quarterly gold price was used as the other independent variable.

A stepwise regression procedure was implemented with capital expenditure (expressed in R1000's) as the dependent variable and lagged profit (rands per ounce) and the average quarterly gold price (rands per ounce) as independent variables.

$$\begin{aligned}\text{Capital expenditure}(t) = \alpha_1 &+ \alpha_2 \text{ Working Profit}(t) \\ &+ \alpha_3 \text{ Gold Price}(t)\end{aligned} \tag{5.21}$$

The significant regression coefficients and associated R^2 values obtained using the above model are shown in Table 5.13 below.

The salient features of Table 5.13 are firstly, the fairly low R^2 values obtained and secondly, that the lagged profit variable appeared to be predominantly the most significant variable in terms of explanation of capital expenditure in the above model.

TABLE 5.13

Mine	Y-intercept α_1	lagged profit α_2	gold price α_3	R^2
Blyvoor	876,494		7,616	0,5386
ERPM	-517,185	43,445	12,618	0,7526
Grootvlei	-65,817	5,205		0,3799
Kinross	484,288	6,941		0,1148
Kloof	1863,289	17,917		0,5632
Venters	371,604	5,961		0,3911
Westdeep	450,107	91,261		0,6419
Winkelhaak	-186,965	6,149		0,5714

The R^2 values obtained in Table 5.13 were thought to be unsatisfactory hence it was decided that the above model warranted further research.

Since capital expenditure is to some extent an on going expense, and since the initial expenses incurred for projects might be expected to be incurred for a longer duration than one quarter, it was decided to include a further independent variable, i.e. a capital expenditure variable lagged by one quarter.

Further the profit variable previously expressed in rands per ounce was modified to include the production level, i.e. the total profit.

Hence the general form of the modified model is:

$$\text{Capital expenditure}(t) = \alpha_1 + \alpha_2(\text{Capital expenditure}(t-1))$$
$$+ \alpha_2\left[\frac{1}{4}\sum_{k=t-4}^{t-1}\text{Gold price}(k) - \frac{1}{4}\sum_{k=t-4}^{t-1}\text{Cost}(k)\right]\cdot\left(\sum_{k=t-4}^{t-1}(\text{Ounces produced}(k))\right)$$
$$+ \alpha_4(\text{Gold price}(t)) \qquad (5.22)$$

A multivariate regression analysis was performed to estimate the coefficients of the above model for the eight individual mines. The data used consists of 40 quarterly observations on each variable beginning with the last quarter of 1972 and ending with the third quarter of 1982. The coefficients for each of the eight mines are shown in Table 5.14 below.

TABLE 5.14

Mine	Y-intercept α_1	lagged Capex α_2	profit α_3	gold price α_4	R^2
Blyvoor	224,3128	0,7285	0,0025	1,6267	0,8157
ERPM	-513,3315	0,3442	0,0852	8,4999	0,8061
Grootvlei	-36,9399	0,8752	0,0052	0,2476	0,7310
Kinross	-729,8761	1,7019	-0,0152	4,0656	0,8466
Kloof	688,4666	0,6989	0,0071	-0,3678	0,7552
Venters	151,1512	0,3398	0,0173	0,5214	0,4882
Westdeep	-942,5713	0,1745	0,0238	31,0305	0,6232
Winkelhaak	-48,2789	0,9625	0,0027	-0,1239	0,9113

The salient characteristics of these cost equations are that all the R^2 values have increased significantly from the R^2 of the previous model. This is due to the addition of the lagged capital expenditure variable.

A stepwise regression procedure was used to test which of the variables were significant in explaining capital expenditure for the individual mines:

(i) The lagged capital expenditure variable was found to be significant for all the individual mines with the exception of Western Deep Levels.

(ii) The lagged profit variable was found to be significant for only ERPM, Kloof and Venterspost.

(iii) The gold price variable was found to be significant for Blyvoor, ERPM, Kinross and Western Deep Levels.

The share evaluation models which will be implemented in Chapter 6 unfortunately require estimates for capital expenditure at any point in time, hence the above equations which yield estimates only at quarterly intervals can not be used. The models also require annual estimates of capital expenditure, hence the capital expenditure data was transformed into moving annual totals of capital expenditure. The following formulation was used for its estimation.

$$\text{Annual capex}(t) = \left[\alpha_1 + \alpha_2 \sum_{k=t-4}^{t-1} \frac{(t-k)\text{Gold price}(k)}{10} + \alpha_3 \text{ Gold price}(t) + \alpha_4 e^{\alpha_5 (t)}\right] \times 1000 \qquad 5.23)$$

It should be noted that the lagged capital expenditure variable had to be omitted since only quarterly values would be available, secondly, an exponential time variable was included as it is expected that capital expenditure increases at a similar rate to costs.

The coefficients found by least squares regression for the eight individual mines, using equation (5.23), are shown in Table 5.15 below.

TABLE 5.15

Mine	α_1	α_2	α_3	α_4	α_5	F Ratio
Blyvoor	3047,5536	6,1560	-8.9868	630,5693	0,06726	35,901
ERPM	-4842,3143	147,1241	-103,8238	624,3388	0,07605	83,585
Grootvlei	202,8634	1,6441	-5,3387	15,1889	0,12201	85,177
Kinross	-120458,83096	20,9539	-19,2690	121910,000	0,00064	1,829
Kloof	-2673,8521	22,2727	-40,0526	5603,5045	0,03966	48,113
Venters	795,4100	21,8623	-13,7162	24,8006	0,05198	20,263
Westdeep	-8786,2710	8,2055	-2,2158	5003,4480	0,06503	186,993
Winkelhaak	-1660,9165	7,1893	-6,2725	564,0607	0,05301	26,866

Inspection of Table 5.15 and Figures D.1 to D.8 in Appendix D show that only Kinross has an F ratio lower than the critical limit of 2,87 at the 5% significance level. Only in the absence of a reasonable estimate from a reliable source is it suggested that the above equation for Kinross Mine be used.

5.7 State's Share of Profits and Taxation

The State, although empowered to undertake mining operations itself, has allowed private enterprise to exploit the Republic's mineral resources. In return the State imposes a royalty or lease considerations, whereby the State gains without subjecting any public funds to risk.

The gold mining profits are also subjected to income tax as is the case for all companies in the Republic. The Income Tax Act is formulated so that generally a higher rate of taxation is imposed on the profits of gold mining companies, however, embodied in the formulation is the incentive to extend the life of the mines to a maximum. On the other hand the State has been cautious not to demand too great a proportion of the profits, especially in view of the high risks associated with gold mining enterprises.

Figure 5.19 shows that the total amount of tax and the State's share of profits received by the State from gold mining operations reached a peak of R1166.3 million associated with the high gold price in the first quarter of 1980, while in the second quarter of 1982 the State received only R295.4 million as a result of the lower gold price in this period.

In this section both the general structure of lease and tax payments will be discussed. The structure of these payments vary according to how these mines are classified.

Classification of Mines

The formulae for the lease consideration as well as the income tax payment varies according to the following classification of mines:

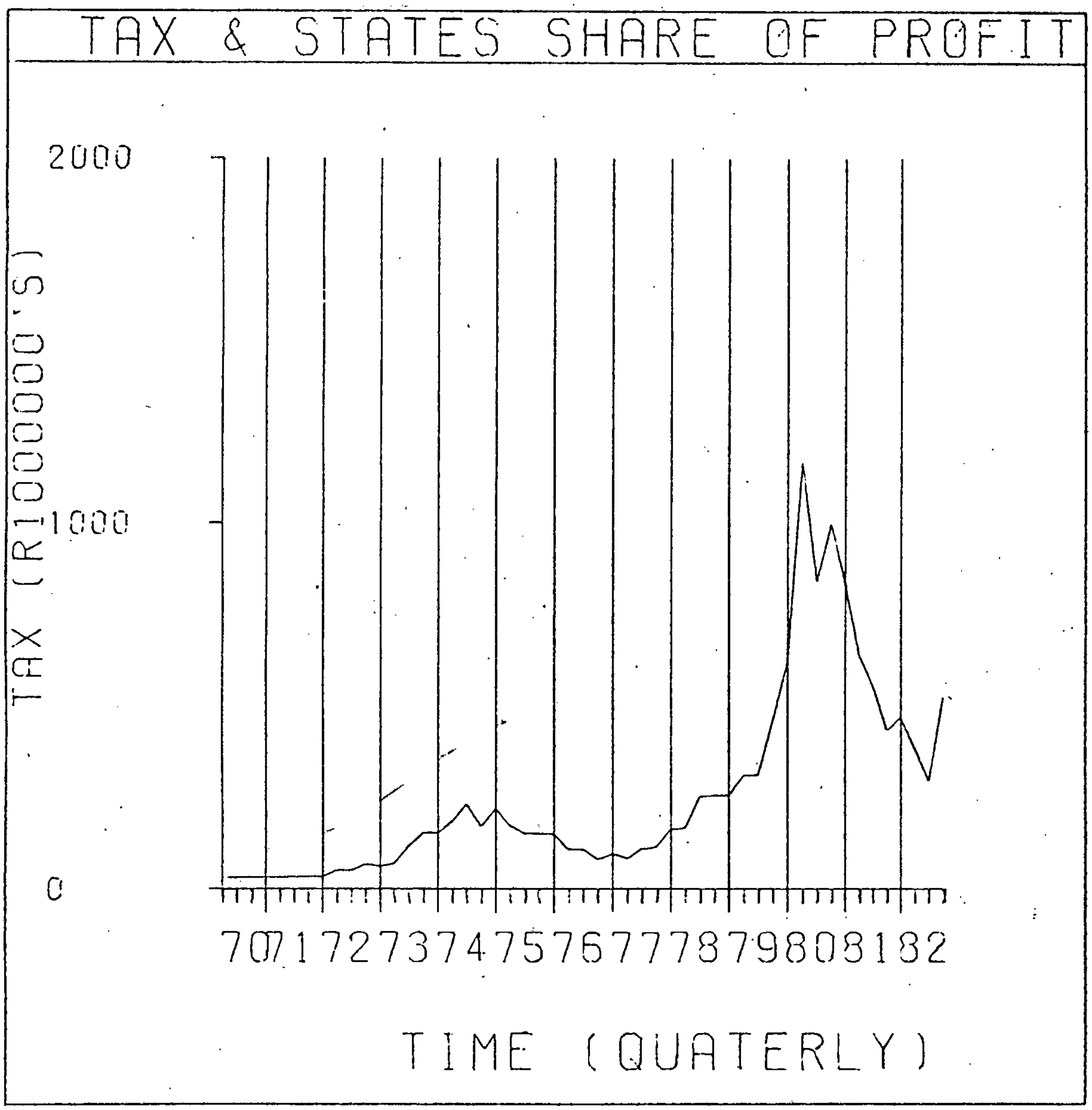


FIGURE 5.19

1. New gold mine : Lease granted after 28 February 1946. Commenced production before 20 March 1963.

2. New deep level gold mine : Lease granted after 30 June 1956 with the principal object to mine below 7500 feet. At least 7 years will elapse from the date of commencement of shaft sinking to the date of deep level production.

3. Other deep level gold mine : A producing gold mine (other

than a 'new deep level gold mine') with the principle object of mining below 7500 feet from surface. Mining below such elevation has, or will, commence within 5 years.

4. Post 1966 gold mine : Lease granted after 17 August 1966.
5. Post 1973 gold mine : Lease granted after 1 January 1974.

Gold mining leases generally stay the same over the entire life of the mine provided no major change in the lease area occurs, in which case the lease formula may be adjusted.

Some mines have, however, been granted larger lease areas and have thus been called "supermines". Examples of these are (c.f. Harwinkel (1982) p.99)

1. Merging of Randfontein and Western Areas lease areas.
2. St Helena and Beisa lease area consolidation.
3. Southvaal as an extension of Vaal Reefs.
4. Erfdeel/Dankbaarheid area which is to be developed in part from the merged Western Holdings/Welkom/Free State Saaiplaas.
5. East and West Driefontein merger.

The following terminology will be used in this section and therefore warrants explanation (c.f. Storrar (1981) p.391-395).

1. Capital expenditure - This includes expenditure on shaft sinking, mine equipment, development, general administration and management (including interest on mining

loans) prior to the commencement of production.

2. Mining revenue - This is comprised of the total revenue received from sales of gold, uranium and other minerals.

3. Working costs - This includes all expenditure, other than of a capital nature incurred in the production of income including interest charges, royalties and the share of profits payable to the State on lease considerations, but not tax payments. Mining companies are not granted allowances for depreciation, however, a capital redemption allowance is permitted (a benefit not granted to non-mining companies).

4. Capital expenditure redemption allowance - These deductions are in lieu of wear and tear of machinery etc including payments for the use of patents, land, buildings, expertise, machinery etc. Any amounts received from the sale of assets (the cost of which has been recognised as capital expenditure) must be deducted from the capital expenditure incurred in the given year. The unredeemed balance of capital expenditure is reduced each year by the profits for that year. Generally 100% of current capital expenditure and 100% of unredeemed capital expenditure is allowed.

5. Special capital allowance - Further special capital allowances are permitted in addition to the capital expenditure redemption allowance. This special capital allowance is calculated as a percentage of redeemable capital expenditure at the following rates for tax calculations:

New deep-level gold mines	5%
Other deep-level gold mines	5%
Gold mines granted leases after 30/3/1963	6%
Post 1966 gold mines	8%
Post 1973 gold mines	10%

The above allowance is only deductable during the period a mine has an assessed loss or in the case of a "other deep level gold mine" for 10 years after this classification.

For the lease calculation a capital allowance of 6% (only 5% for mines granted leases before 1 October 1967) is calculated on the unredeemed balance of capital expenditure and on current capital expenditure.

6. Net revenue - mining revenue less costs.
7. Taxable income - the portion of revenue remaining after all allowable costs and allowances have been deducted.

5.7.1 Structure of Lease Payments

The formula for the State's share of profits or lease consideration is based on a sliding scale and has the general form:

$$y = a - \frac{ba}{x}$$

where

y is the percentage of profits payable to the State after deducting the capital redemption allowance and the capital allowance;

$x = \frac{P}{R} \times 100$, where P is the profit less capital redemption allowance only, and R is the mining revenue;

a is a predetermined constant based on the estimated return on capital invested using estimates of grade, costs, the pioneering aspect and the amount of risk involved, the value of a is generally between 10 and 30, however, a return of 10 to 15 per cent is considered to be reasonable;

b is also a predetermined constant usually 6 or 8.

In addition to the above formula an amount of $1\frac{1}{4}\%$ of the State's share of profits is also payable to the State in lieu of stamp and transfer duties.

Storrar (1981, p.397) uses the following hypothetical example of a lease calculation for a 1968 gold mine for the year 1977:

1. Lease formula: $y = 25 - \frac{150}{x}$
2. Lease - allowance on capital expenditure: 6%
3. Unredeemend balance of capital expenditure as at beginning of 1977: nil
4. Unredeemed balance of capital allowance as at beginning of 1977: R1 666 084
5. Capital expenditure during 1977: R100 000
6. Working revenue during 1977: R24 000 000
7. Working costs: R17 440 000

	Rand	Rand
Working profit (R24 000 000-R17 440 000)		6 560 000
Redemption allowance:		
Unredeemed capital expenditure	nil	
Current capital expenditure	100 000	100 000
Profit for x in formula		6 460 000

$$x = \frac{6\ 460\ 000}{24\ 000\ 000} \times 100 = 26{,}916\ 66\%$$

$$y\% = (25 - \frac{150}{26{,}916\ 66}) \times 100 = 19{,}427\ 24\%$$

Capital allowances	Rand
On unredeemed balance of capital expenditure	nil
Unredeemed balance of capital allowance	1 666 084
Capital allowance on unredeemed balance of capital allowance = 6% of R1 666 084	99 965
On current capital expenditure = 2,75% of 100 000	2 750
Total capital allowance (Rl 666 084 + R99 965 + R2 750)	1 768 799
Profit to which y in formula is applied	4 691 201
Lease amount = 19,42724% of R4 691 201	911 371
Add $1\frac{1}{4}$%	11 392
Total lease payable	922 763

5.7.2 Taxation

The lease consideration is deductable as a cost for income tax purposes and therefore the lease calculation must precede the determination of income tax. Also, the lease consideration is paid yearly whereas tax is paid half-yearly.

Mining taxation is calculated according to the age of a mine

Post 1966 mines : $y = 60 - \frac{480}{x}$

Pre 1966 mines : $y = 60 - \frac{360}{x}$

where y is the percentage of taxation on taxable income and x is the ratio of taxable income less the State's share of profits to mining income.

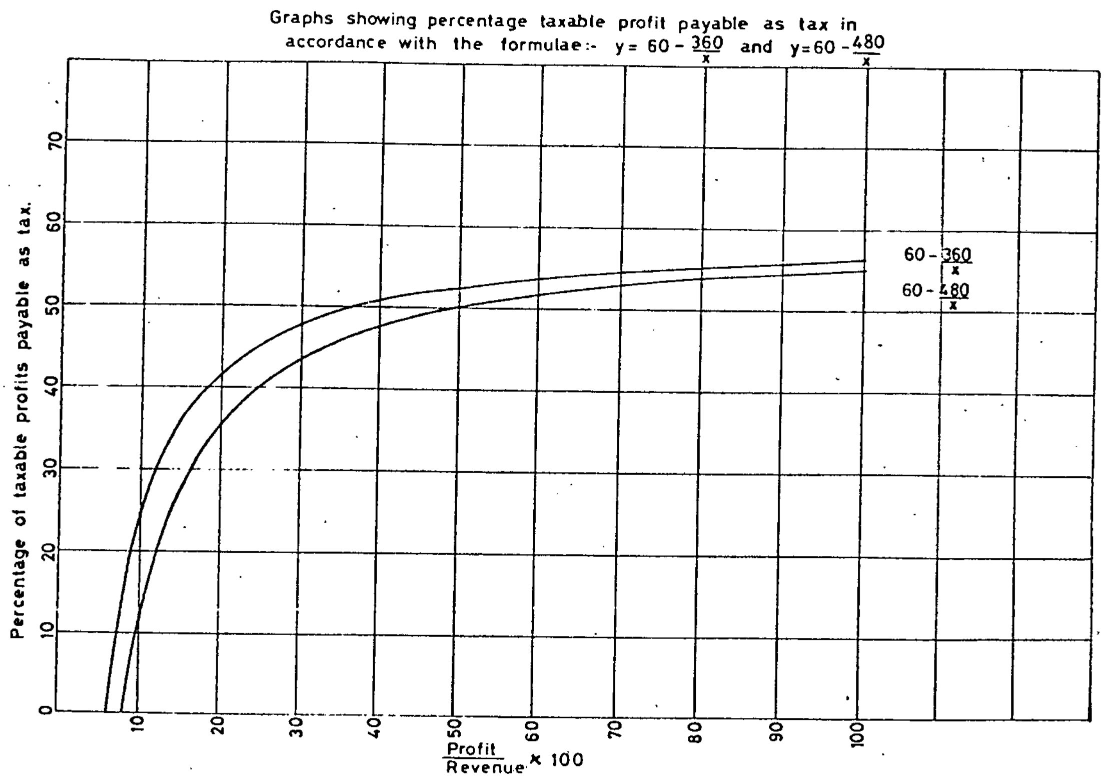


FIGURE 5.20

Source: Storrar (1981)

Figure 5.20 shows the percentage of taxable profits payable as tax for the two formulae against the x value.

Gold mines are allowed to deduct 100% of current capital expenditure and 100% of the unredeemed balance of capital expenditure from assessable income. In addition special capital allowances are permitted on the unredeemed balance of capital expenditure as well as a capital allowance on current capital expenditure.

Clearly when a mine is involved in heavy capital spending especially at the beginning of its life, such reductions help appreciably to alleviate the strain on a company's financial reserves at a time when help is most needed.

The same example used by Storrar (1981) for the lease calculation will be used to explain a typical tax calculation. The additional information required for the calculation of tax is given below:

1. Tax allowance on capital expenditure : 8%
2. Tax formula for a post 1966 mine : $60 - \frac{480}{x}$
3. Unredeemed balance of capital expenditure plus capital allowance at 8% as at beginning of 1977; R3 003 920

Tax calculation

	Rand	Rand
Working profit		= 6 560 000
Redemption allowance		
Unredeemed capital expenditure plus capital allowance	3 003 920	
Capital allowances	nil	
Total redemption allowance		3 103 920
Lease consideration		922 763
Taxable income		2 533 317
Revenue		24 000 000

$$x \text{ in the formula} = \frac{2\ 533\ 317}{24\ 000\ 000} \times 100$$

$$= 10{,}555\ 49\%$$

y in the formula = 14,526 03%

Tax payable = 14,526 03% of R2 533 317		367 990
Add surcharge (say) 5% of 367 990		18 400
Add loan levy 2½% of 367 990		9 200
Total payable		395 590

5.7.2.1 Assisted Mines

It has been announced that a new scheme whereby less State assistance will be given to mines will be implemented in 1984.

The existing scheme, however, was introduced in 1968, when a number of old mines were in danger of closing down and possibly flooding neighbouring mines.

Assisted gold mines, which have a taxable income and are thus liable for income tax, are taxed at a rate determined by the formula:

$$y = 68 - \frac{601}{x}$$

or the standard formula: $60 - \frac{360}{x}$,

whichever results in the lower tax.

Where the assistance formula results in a negative tax amount, this amount is paid tax-free to the company as a tax credit. The amount of assistance calculated in this manner is limited for any one year to 25 per cent of the gross income.

To qualify for assistance, a mine must have a remaining life of 8 years or less with a significant increase in life following State assistance. A mine is classified as an assisted gold mine by the Minister of Mineral and Energy Affairs, in consultation with the Minister of Finance, on the basis of recommendations made by the Mining Leases Board.

Table 5.16 below shows a comparison of the percentage of taxable profit payable as tax for the various formulae:

TABLE 5.16

$x = \frac{P}{R} \times 100$	$y = 60 - \frac{360}{x}$	$y = 60 - \frac{480}{x}$	$y = 68 - \frac{601}{x}$
x	y%	y%	y%
100	56,4	55,2	62,0
90	56,0	54,7	61,3
80	55,5	54,0	60,5
70	54,9	53,1	59,4
60	54,0	52,0	58,0
50	52,8	50,4	56,0
40	51,0	48,0	53,0
30	48,0	44,0	48,0
20	42,0	36,0	38,0
10	24,0	12,0	7,9
9	20,0	6,7	1,2
8,838	19,3	5,7	0,0
8	15,0	0,0	
7	8,6		
6	0,0		

Table 5.17 below, extracted from the Chamber of Mines Newsletter (May 1979), shows the total number of mines which qualified for assistance. Some of them may not actually have received any direct subsidy in a particular year, but did qualify for tax relief.

In 1981 five mines applied for a total of R26,9 million in State assistance, but this represented only 1,2% of the total estimated tax bill paid by the industry.

TABLE 5.17

MINES QUALIFYING FOR ASSISTANCE			
Year	Number of Mines (1)	Assistance Received (2) R1000	Gold Produced kgs
68	16	6832	91132,6
69	20	8638	107059,4
70	21	15974	120455,3
71	20	16035	137130,6
72	18	9202	109041,3
73	17	1176	92037,6
74	16	1180	75505,2
75	16	19560	65893,5
76	16	40943	73113,1
77	12	32340	63925,6
78	12	27529	62201,7

The following quotation taken from the October 1981 Chamber of Mines Newsletter mirrors the success of the scheme at that time:

" *A measure of the success of the State Assistance scheme is that during the period of its operation, up to the end of 1980 the gold mines which received assistance of R180,7 million subsequently paid R288 million in tax and lease payments to the State. Furthermore, in the same period these mines produced gold to the value of R3460,5 million.*"

CHAPTER 6

IMPLEMENTATION OF THE GOLD SHARE EVALUATION MODELS

6.1 Introduction

When valuing gold shares many investors tend to think in terms of the gold price that a gold share is "implying", (termed the implicit gold price) at certain expected yields. For example, if an investor feels that a certain gold share has an implicit gold price lower than the actual gold price at his desired expected return for that share, he may consider buying the share. A further advantage of buying the share in this situation is that the share would still be expected to attain the desired expected return even if the gold price declined to the implicit gold price.

Occasionally in the media statements like: "*the gold shares are discounting a much higher/lower gold price*" are found. Sometimes actual implicit gold prices have been quoted, for example, the following quotation appeared in the Cape Argus on the 26 February 1983.

> "*When bullion slumped to below \$470, gold shares, which had been discounting a price of \$600, tumbled on heavy overseas selling and knocked much of the confidence out of the market.*"

Another quotation appeared in the Sunday Times on 26 June 1983, here the view of a representative of Mining Portfolio Management was expressed.

> *"From his point, with most gold shares discounting a bullion price of around $500, unless an uptrend in the metal does develop within the next 5 to 10 trading days, they must begin to look distinctly vulnerable."*

It is evident that although there is a tendency for investors to view gold shares in terms of their implicit gold price, these estimates appear to be purely subjective and no mention is made of expected yield in the media. Also subjective estimates of implicit gold prices of shares determined by comparing past share prices at similar gold prices could be subject to error, since fundamental determinants of gold mine profitability other than the gold price have a major impact on earnings. These determinants of gold mine profitability were discussed in the previous chapter.

In Chapter 4 two gold share evaluation models were proposed namely, MODEL 1 and MODEL 2. In this chapter these two models will be used to determine the weekly implicit gold price of the gold shares over the period January 1979 to March 1983 for various expected yields.

It should be noted that under the assumption of a perfectly efficient market, theoretically any difference between the actual and implicit gold price would be due either to a model misspecification, or perhaps a different yield expected by the market other than the yield used in the model.

6.2 MODEL 1

In order to determine the implicit gold price of a gold share using MODEL 1 (discussed in Section 4.2) the implicit gold price was solved for in equation (4.14). Hence the expression becomes

$$\text{Implicit gold price}(t) = \frac{\text{Yield}(t).\text{Share price}(t)}{k'} + \text{Cost}(t) \qquad (6.1)$$

where $k' = \dfrac{\text{dividend per share}}{\text{profit per ounce}}$

Weekly estimates of cost were generated using the equations determined in Section 5.4 for the various gold mines. Although quarterly data points were originally used to estimate the cost equations, moving quarterly totals of the independent variables of the cost equations were computed at weekly intervals thus enabling weekly cost values to be estimated.

The value of k' was taken to be the average dividend over profit ratio for the past 4 years and actual share prices were used in the numerator of equation (6.1).

The annual yield was taken to be constant at 10% over the period. It should be noted that the expected yield would undoubtedly vary for a share according to economic conditions and changes in the risk of the share, however, a constant yield was used solely as a basis for visual comparison of the actual gold prices and implicit gold prices generated by the

Figures 6.1 to 6.7 show a comparison of the actual and implicit gold prices for the various gold mines using MODEL 1 at an expected yield of 10%.

On examination of Figures 6.1 to 6.7 the following points emerge:

(a) Over the period January 1979 to August 1980 the implicit gold price is significantly lower than the actual gold price and in January 1983 the implicit gold price is significantly higher than the actual gold price. One of two reasons is possible for this occurrence. Firstly, from the standpoint of assumed market efficiency the variation would be due either to different expected yields over these periods, or the general structure of the model used to generate the implicit gold price may not be appropriate. Secondly, if the yield and model assumptions are appropriate then the difference reflects inefficiency.

Of the two possible causes for the pronounced difference in actual and implied gold prices the first reason, that is, model misspecification is the most likely as it is extremely unlikely that either the market would be expecting such vastly different yields (assuming market efficiency), or that investors were ignorant to the fact that the shares were under/over-priced (assuming market inefficiency).

(b) Figures 6.2 and 6.7 for ERPM and Venterspost display trends vastly different from the other shares during June 1981 to December 1982, that is, the implicit gold prices over this

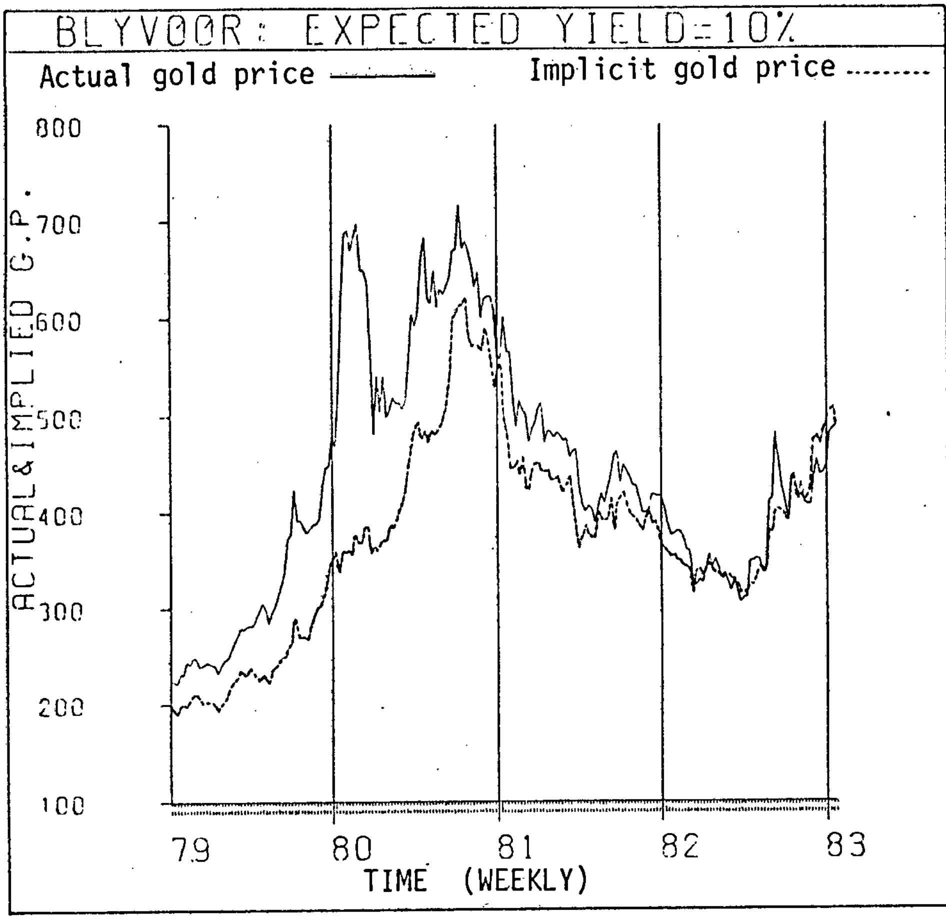


FIGURE 6.1

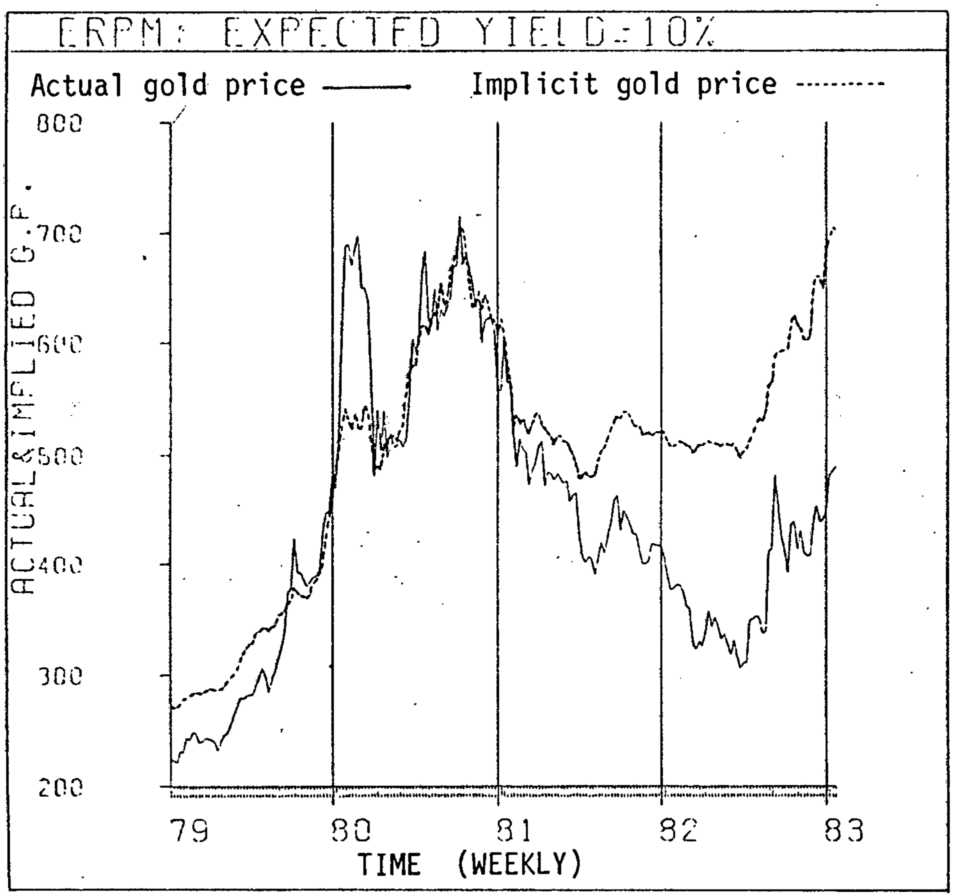


FIGURE 6.2

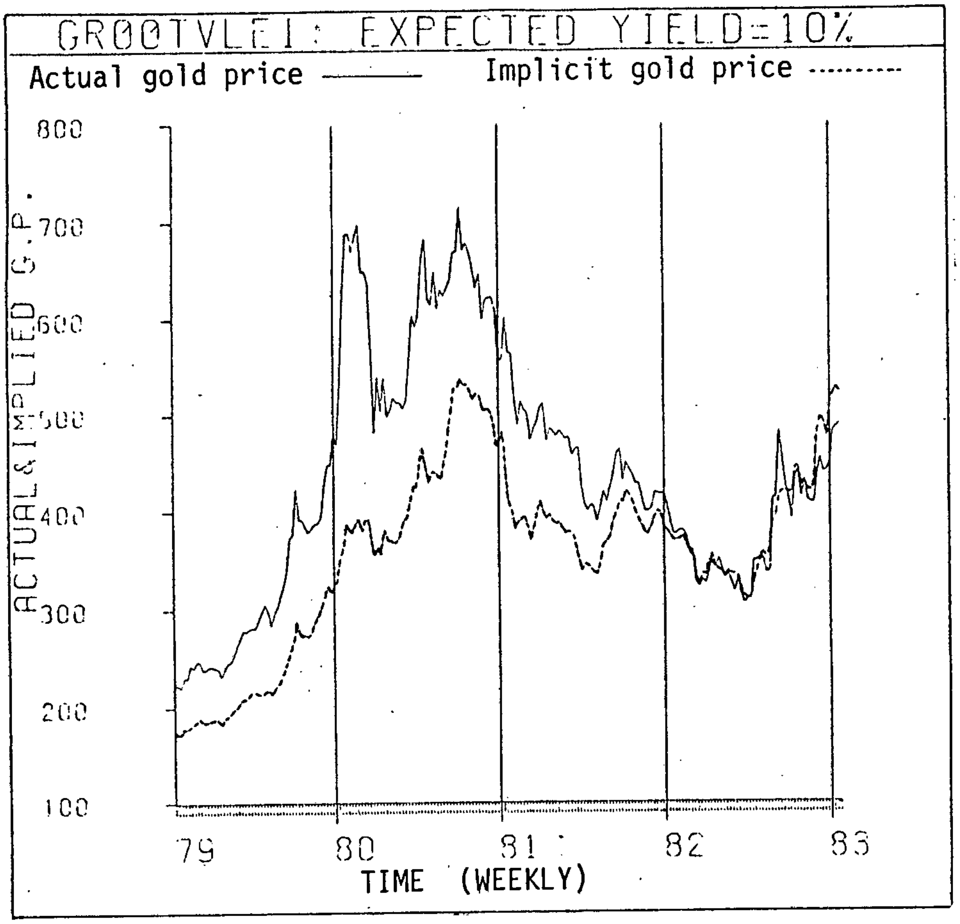


FIGURE 6.3

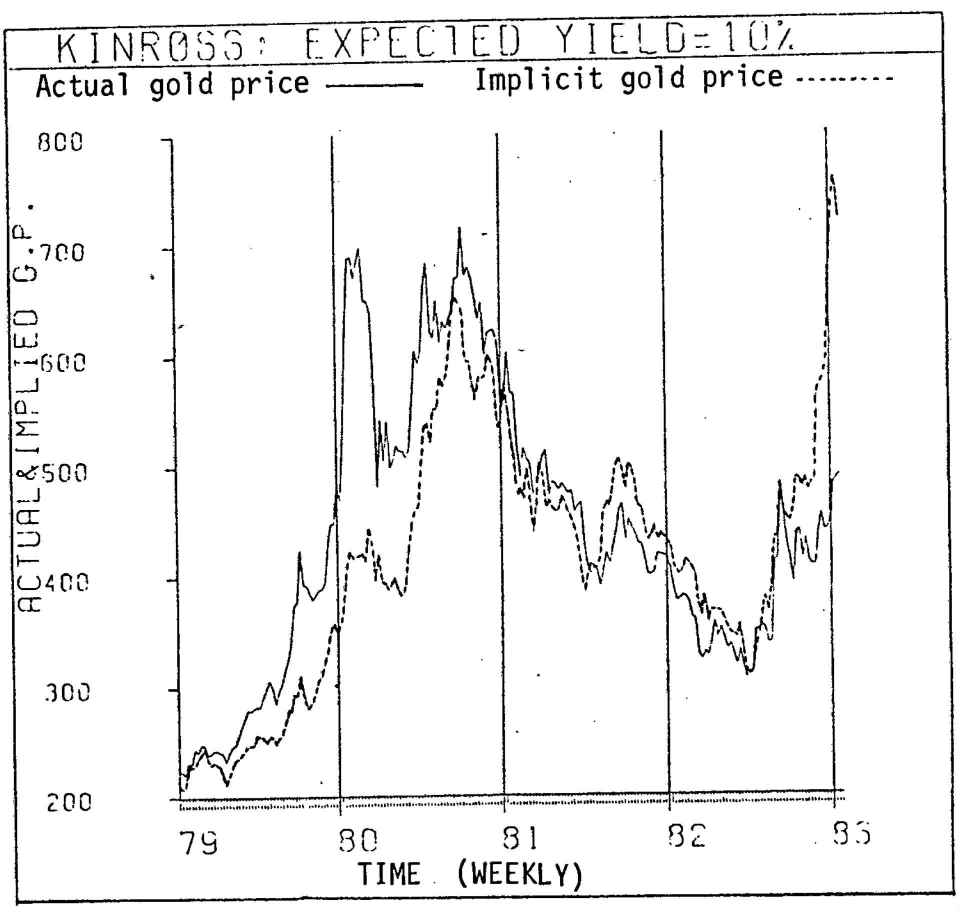


FIGURE 6.4

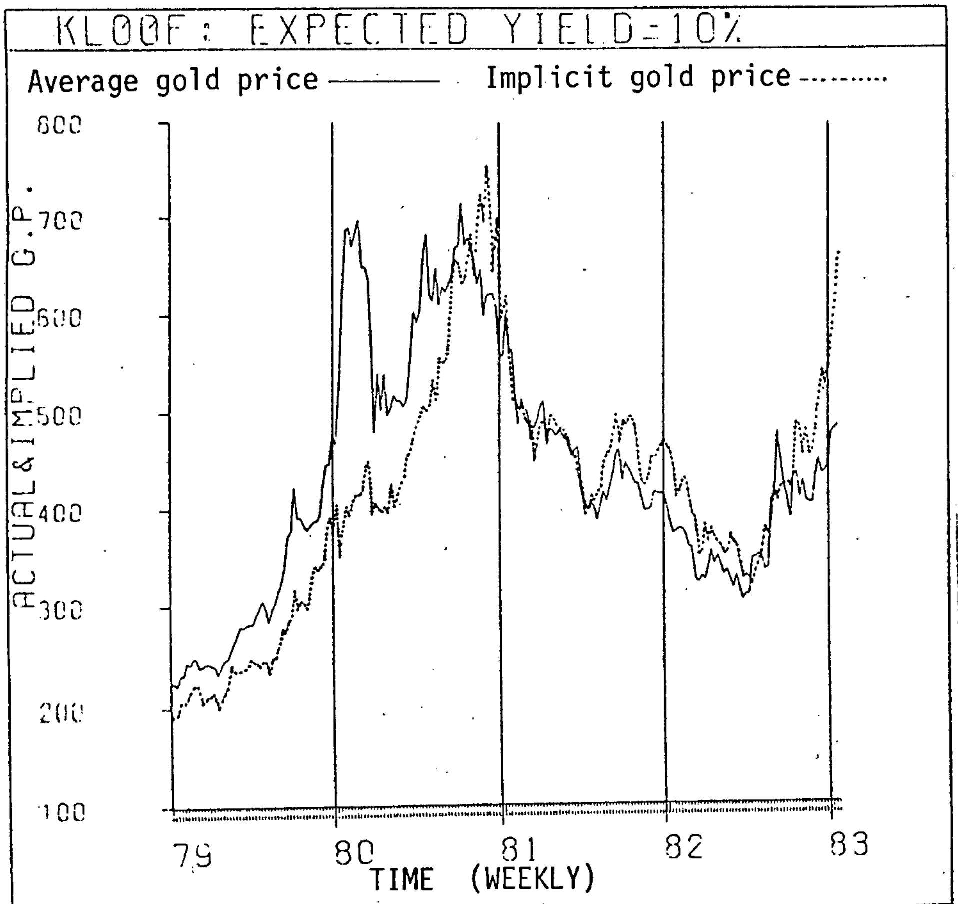


FIGURE 6.5

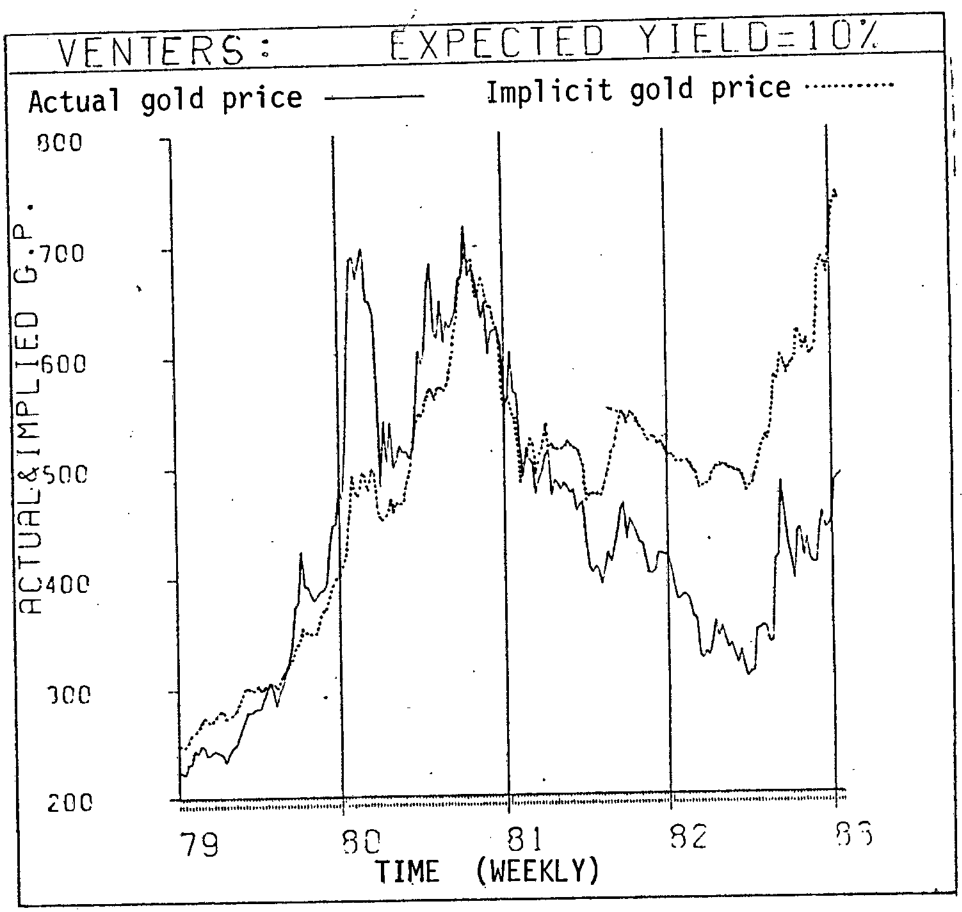


FIGURE 6.6

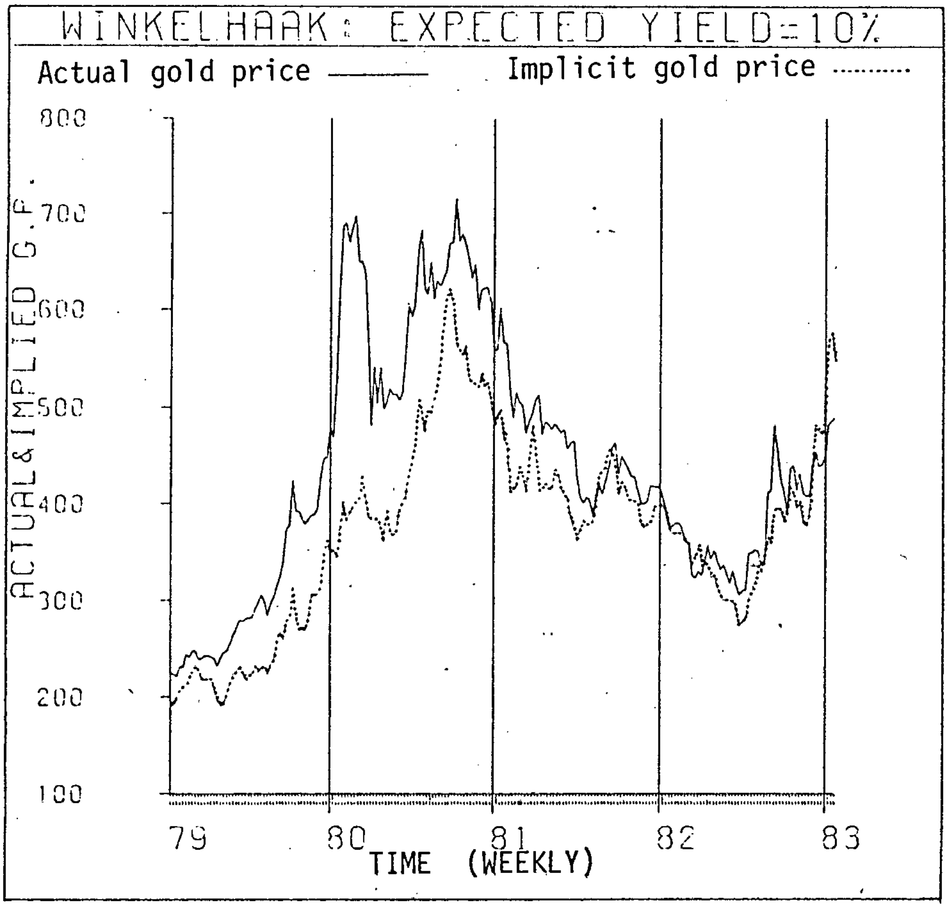


FIGURE 6.7

period are much higher than the actual gold prices. The reason for this is that these two mines were in fact making a loss over roughly this period. The share prices, however, although declined, still maintained a positive market value as investors were prepared to take the chance of an expected higher gold price and hence expected positive profits later.

(c) Fluctuations of the implicit gold price follow fluctuations of the actual gold price closely, indicating that changes in the gold price impact immediately on the share price and hence the implicit gold price.

(d) The sharp increase in the price of gold in January 1980 was not followed to the same extent by the implicit gold price. It could be argued that in this instance investors in the gold share market were correct in their pricing of the gold shares as the gold price declined sharply shortly afterwards. It is, however, interesting to note that the bullion market reacted completely differently to the gold share market on essentially the same information during this period. This could be attributed to different types of investors dominating the two markets, however, it appears that in this situation the gold share market reacted more rationally to the available information.

It is felt that assumption 1, which justifies the use of the cost estimates found in Section 5.4, is reasonable as the estimates computed over the required period were found to be sufficiently accurate. Assumptions 2 and 3, namely, that the relationship between dividend and profit remains constant and that tax rates remained constant are felt to be too strict to benefit from any further research using MODEL 1.

MODEL 2, however, discussed in Section 4.2 allows assumptions 2 and 3 to be relaxed. Since this model is more sophisticated in the sense that the relaxation of assumptions 2 and 3 might lessen the chance of model misspecification, it will be implemented below.

6.3 MODEL 2

Solving for the implicit gold price in equation (4.15) of MODEL 2 we have

$$\text{Implicit Gold price}(t) = \left\{\frac{\text{Yield}(t)\times\text{Number of shares in issue}(t)\times\text{share price}(t)}{k''}\right.$$

$$\left. - \text{Sundry revenue}(t) + \text{Tax}(t) + \text{Lease}(t) + \text{Capital expenditure}(t)\right\}$$

$$\times \frac{1}{\text{Annual production}(t)} + \text{Cost}(t) \qquad (6.2)$$

where $k'' = \dfrac{\text{dividend per share}}{\text{earnings per share}}$

Annual estimates of capital expenditure and production were estimated at weekly intervals using the equations determined in Sections 5.6 and 5.5 respectively, while weekly estimates of cost for MODEL 2 were the same as for MODEL 1. Weekly estimates of annual tax and lease payments were determined using the appropriate formulae discussed in Section 5.7, while weekly estimates of annual mining revenue and working profit used in these formulae for the various mines were computed using the following equations:

$$\text{Mining revenue}(t) = \text{Actual gold price}(t)\times\text{Annual production}(t) \qquad (6.3)$$

$$\text{Working profit}(t) = (\text{Actual gold price}(t)-\text{Cost}(t))\times\text{Annual production}(t) \qquad (6.4)$$

The value of k'' was taken to be the average dividend over earnings ratio over the past 3 years, while sundry revenue, which in general has little impact on the implicit gold price was also taken to be the average over the past 3 years.

The implicit gold prices for the various mines were computed at weekly intervals using equation (6.2), again for the sake of visual comparison only, the annual yield was assumed to be 10% over the entire period.

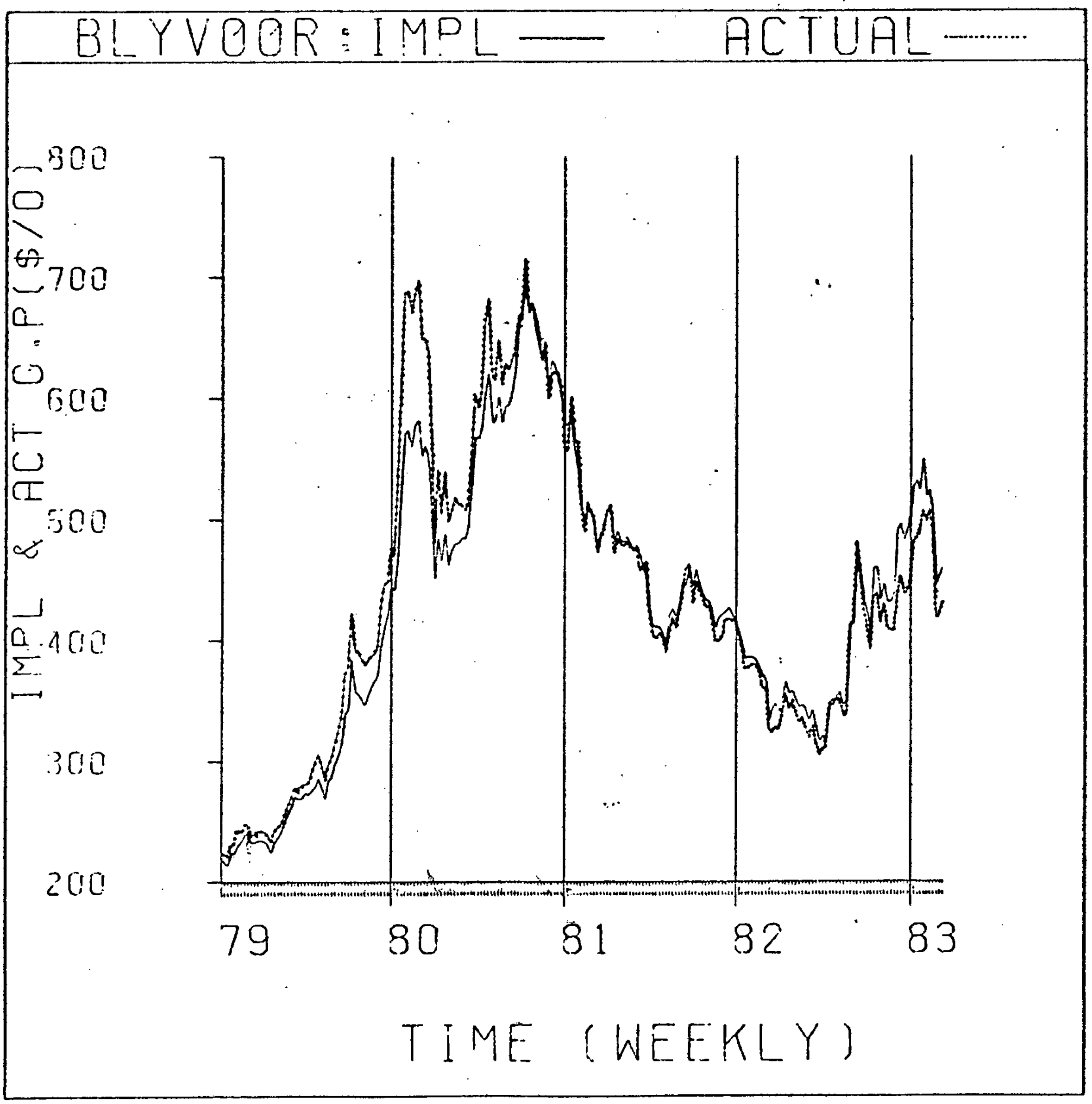
Figures 6.8 to 6.13 show a comparison of the actual and implied gold prices for the various gold mines using MODEL 2.

On inspection of Figures 6.8 to 6.13 the following notable features emerge:

(a) The implicit gold price computed using MODEL 2 follows the actual gold price much more closely than that obtained using MODEL 1, indicating that the larger differences found using MODEL 1 was due to model misspecification.

(b) It was still evident that the implicit gold price did not follow the actual gold price in January 1980 at a yield of 10%. Further, in January 1983 the implicit gold price was found to be generally higher than the actual gold price indicating that the shares were overpriced at a 10% yield.

(c) In general it is felt that except for short term flucutations the implicit gold price computed using MODEL 2 is very close to the actual gold price at a 10% yield. This indicates that the model's predictions has been extremely close to the market value of the gold shares over the past 4 years at a 10% yield. It should, however, be noted that the yields expected by investors change under different economic conditions, implying that difference in implicit and actual gold prices found in Figures 6.8 to 6.13 might be due to different yield expectations.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TIME (WEEKLY)

FIGURE 6.8

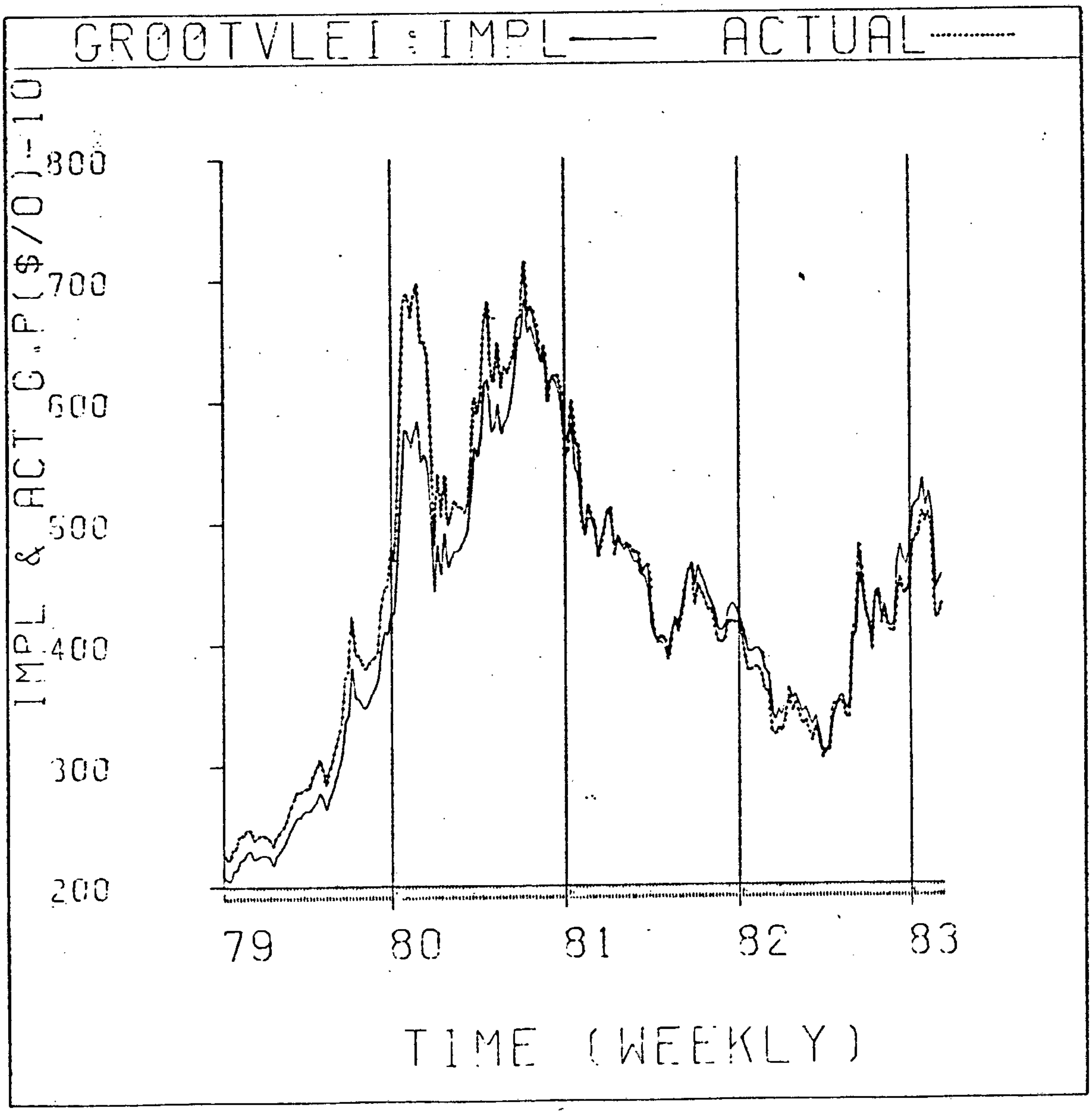

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FIGURE 6.9

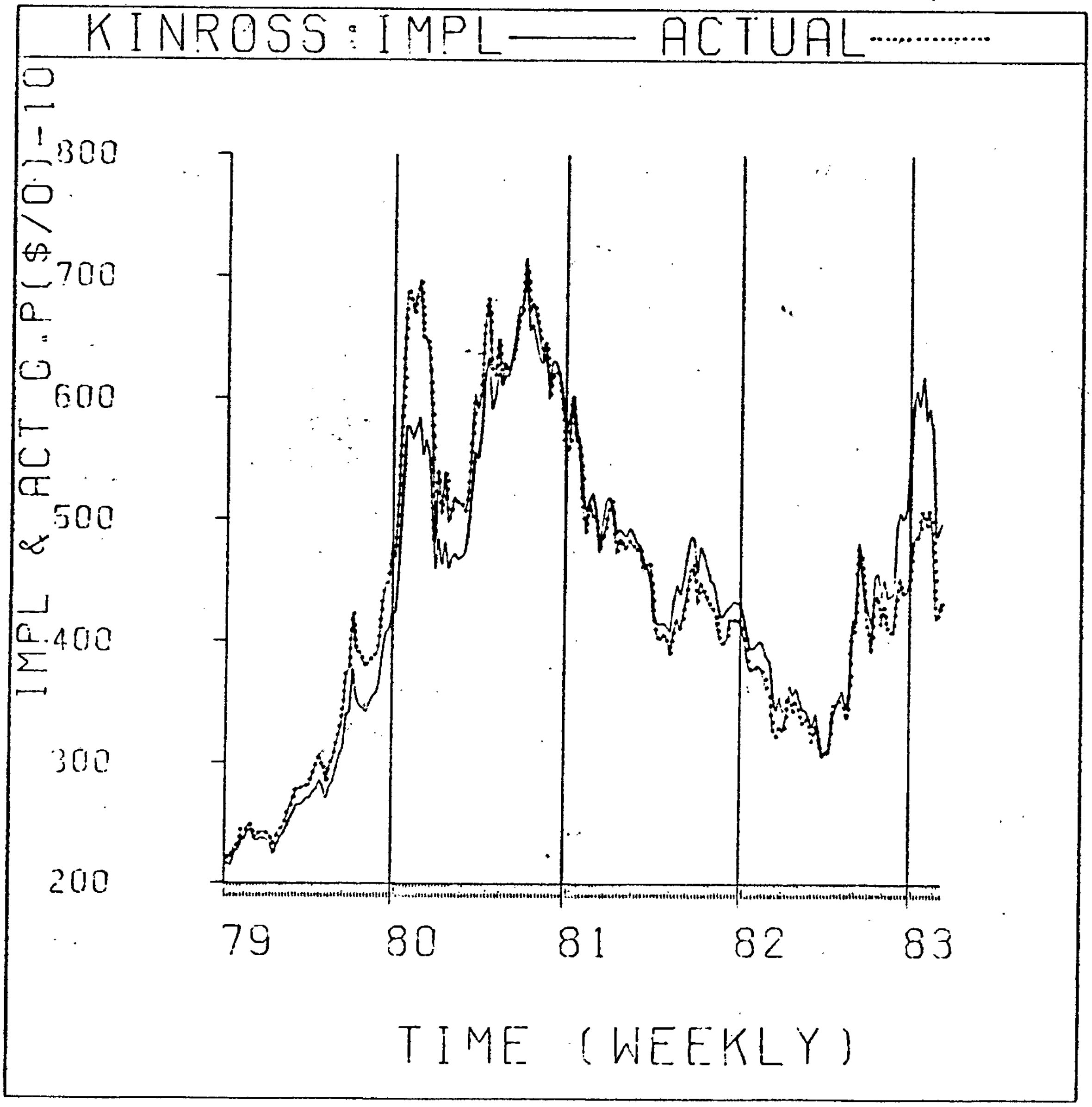
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FIGURE 6.10

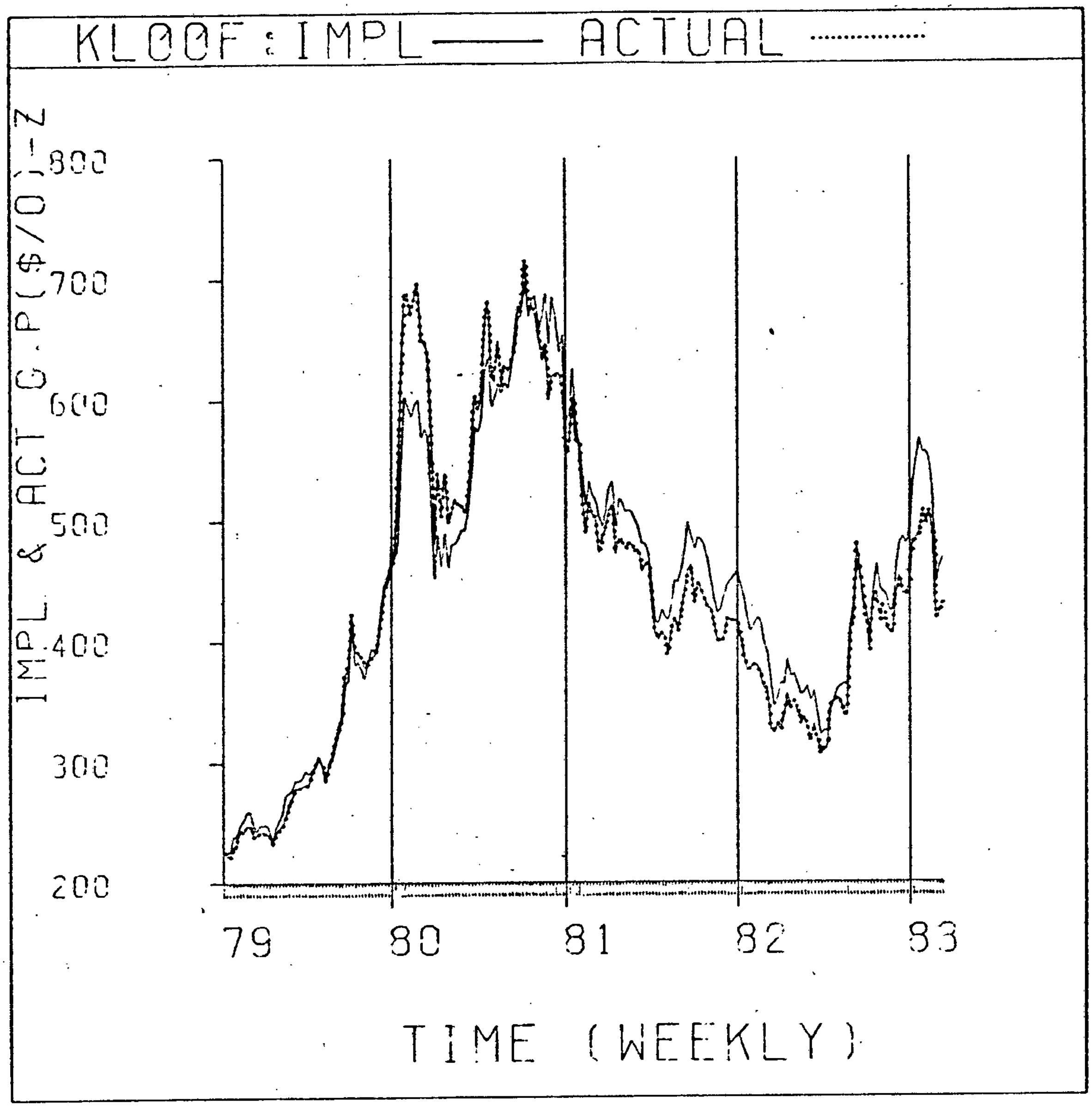
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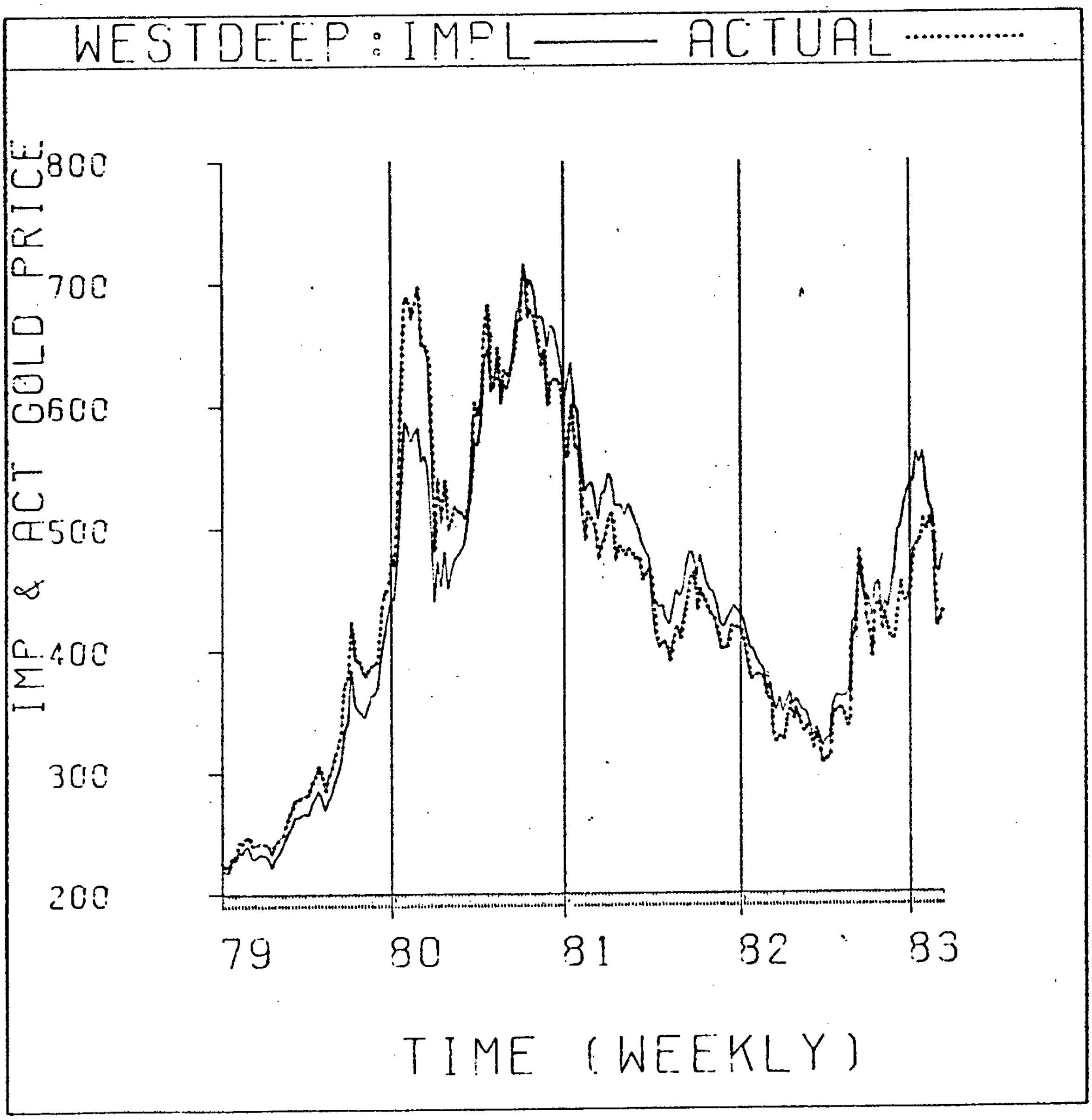
FIGURE 6.11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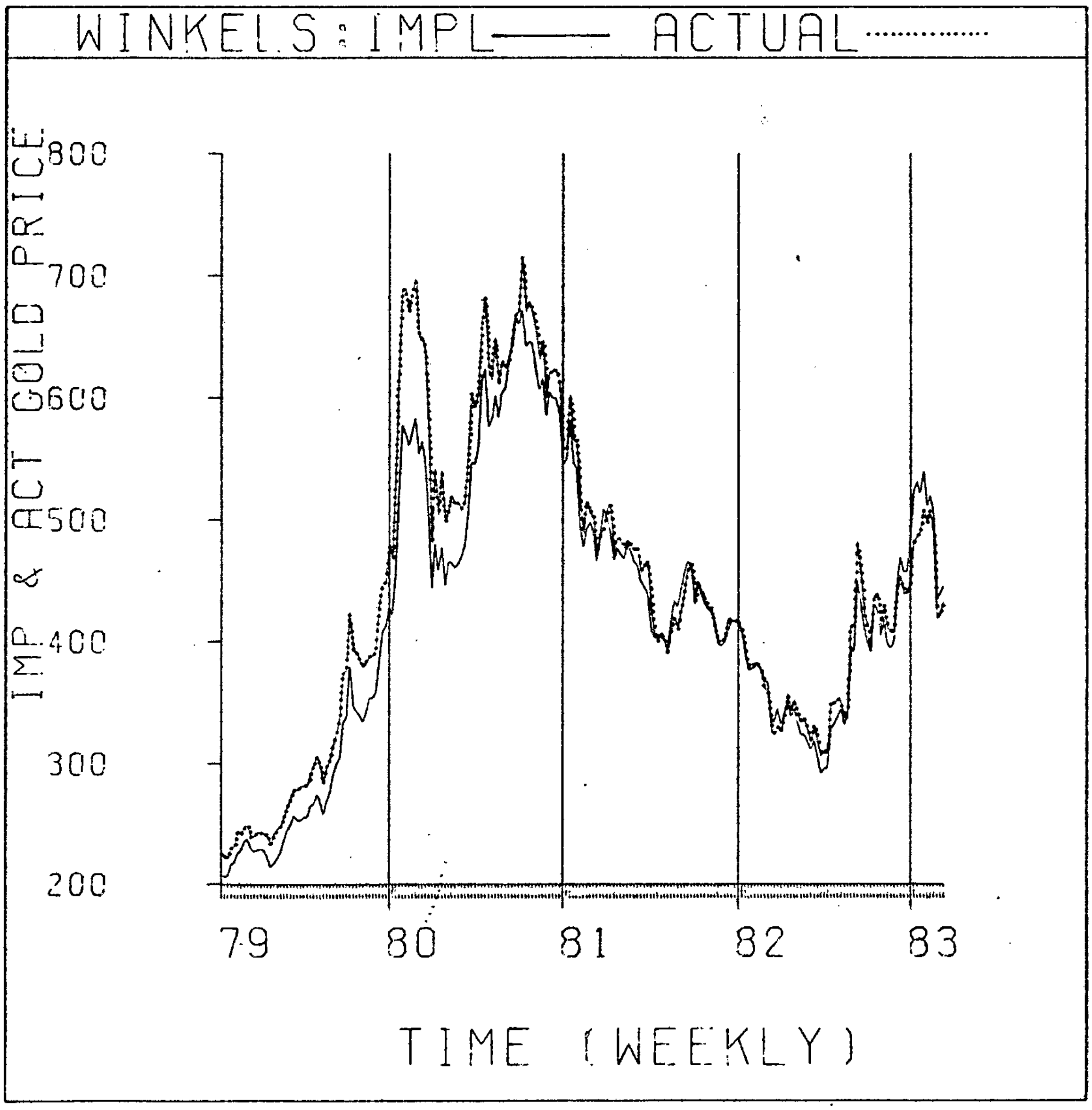
TIME (WEEKLY)

FIGURE 6.12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TIME (WEEKLY)

FIGURE 6.13

It is a well known concept that investors expect higher returns to be associated with higher risks, hence investors might expect higher yields for mines which are more marginal. To get an idea of the historic yields associated with the 6 mines researched here, different constant yields were substituted into MODEL 2 to find which yield gave the closest "fit" between the actual and implied gold prices over the period. Accordingly the following 2 statistics were computed for each constant yield.

$$\text{Cusum square} = \sum_{t=1}^{218} (\text{Actual gold price}(t) - \text{Implicit gold price}(t))^2 \quad (6.5)$$

$$\text{Absum} = \sum_{t=1}^{218} |\text{Actual gold price}(t) - \text{Implicit gold price}(t)|$$

where $t = 1$ represents the first week in January 1979. (6.6)

Tables 6.1 to 6.6 show the values of the above statistics for various constant yields for the six mines researched here. The minimum values of the above two statistics and the associated yields are marked with an asterisk in the tables below.

TABLE 6.1 : BLYVOOR

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	967348.52	13395.63
3.0	875903.48	12678.61
3.5	789853.80	11961.59
4.0	709199.59	11244.57
4.5	633940.78	10527.55
5.0	564077.51	9810.53
5.5	499609.61	9093.51
6.0	440537.11	8376.49
6.5	386660.02	7671.22
7.0	338578.39	6989.79
7.5	295692.21	6342.89
8.0	258201.52	5760.05
8.5	226106.17	5220.40
9.0	199406.28	4748.72
9.5	178101.82	4368.12
10.0	162192.79	4100.81
10.5	151679.22	3942.02
11.0*	146561.07*	3920.43*
11.5	146838.33	4002.58
12.0	152511.04	4167.24
12.5	163579.19	4398.42
13.0	180042.75	4664.11
13.5	201901.77	4977.77
14.0	229156.19	5363.94
14.5	261806.07	5798.99
15.0	299851.36	6273.39
15.5	343292.09	6789.24
16.0	392128.25	7329.15

TABLE 6.2 : GROOTVLEI

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	710089.80	11347.44
3.0	642686.78	10726.69
3.5	579507.30	10105.95
4.0	520551.36	9485.20
4.5	465818.91	8864.45
5.0	415310.00	8243.71
5.5	369024.68	7622.96
6.0	326962.89	7002.21
6.5	289124.66	6381.46
7.0	255510.05	5787.44
7.5	226118.92	5270.12
8.0	200951.34	4852.93
8.5	180007.31	4511.75
9.0	163266.84	4284.29
9.5	150789.90	4128.45
10.0*	142516.59	4066.90*
10.5*	138466.77*	4108.27
11.0	138640.50	4192.36
11.5	143037.79	4354.18
12.0	151658.62	4582.13
12.5	164503.02	4819.35
13.0	181570.95	5090.90
13.5	202862.44	5364.95
14.0	228377.46	5700.92
14.5	258116.06	6042.01
15.0	292078.20	6411.51
15.5	330263.89	6798.56
16.0	372673.14	7210.01

TABLE 6.3 : KINROSS

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	1008469.33	13698.77
3.0	890046.71	12760.73
3.5	781478.31	11822.68
4.0	682758.09	10884.64
4.5	593887.99	9948.60
5.0	514868.19	9078.28
5.5	445698.32	8279.81
6.0	386378.67	7585.75
6.5	336909.14	6920.89
7.0	297289.81	6281.45
7.5	267520.68	5694.57
8.0	247601.57	5270.20
8.5	237532.67	5039.88
9.0*	237313.88 *	4952.19*
9.5	246945.29	5015.49
10.0	266426.85	5216.20
10.5	295758.52	5531.90
11.0	334940.35	5928.24
11.5	383972.30	6414.51
12.0	442854.44	6944.73
12.5	511586.75	7524.74
13.0	590169.13	8143.58
13.5	678601.68	8794.38
14.0	776884.38	9473.86
14.5	885017.27	10184.31
15.0	1003000.26	10929.38
15.5	1130833.39	11694.17
16.0	1268516.67	12487.75

TABLE 6.4 : KLOOF

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	1565592.67	17586.79
3.0	1375605.30	16425.20
3.5	1199121.48	15263.61
4.0	1036141.23	14102.02
4.5	886664.50	12940.42
5.0	750691.25	11778.83
5.5	628221.77	10617.24
6.0	519255.80	9455.65
6.5	423793.30	8294.06
7.0	341834.41	7137.47
7.5	273379.15	6010.85
8.0	218427.42	4999.77
8.5	176979.21	4241.83
9.0	149034.58	3326.91
9.5 *	134593.56	3704.92 *
10.0 *	133636.37 *	3945.03
10.5	146222.15	4215.02
11.0	172291.30	4787.69
11.5	211365.01	5486.01
12.0	264941.31	6256.35
12.5	331522.18	7129.66
13.0	411606.05	8068.59
13.5	505193.54	9037.97
14.0	612254.58	10042.11
14.5	732879.20	11055.87
15.0	866977.31	12089.46
15.5	1014579.12	13132.72
16.0	1175684.39	14185.66

TABLE 6.5 : <u>WESTDEEP</u>

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	990484.98	13598.51
3.0	880823.85	12736.67
3.5	779192.23	11874.82
4.0	685590.34	11012.98
4.5	600018.02	10151.13
5.0	522475.38	9289.29
5.5	452962.22	8451.59
6.0	391478.66	7637.57
6.5	338024.69	6862.94
7.0	292600.35	6144.55
7.5	255205.71	5507.86
8.0	225840.55	4944.84
8.5	204504.98	4583.59
9.0*	191199.05	4454.85*
9.5*	185922.69*	4513.27
10.0	188675.96	4756.65
10.5	199458.84	5091.44
11.0	218271.29	5463.91
11.5	245113.35	5864.10
12.0	279925.00	6299.55
12.5	322866.28	6781.31
13.0	373817.13	7283.51
13.5	432777.58	7824.38
14.0	499767.63	8395.57
14.5	574787.26	8992.59
15.0	657236.53	9613.58
15.5	748915.36	10275.33
16.0	848023.83	10955.99

TABLE 6.6 : <u>WINKELHAAK</u>

YIELD	CUSUM SQUARE	ABSOLUTE DIFF SUM
2.5	1656206.27	18214.00
3.0	1492400.70	17262.71
3.5	1337930.52	16311.42
4.0	1192795.97	15360.13
4.5	1056976.73	14408.84
5.0	930532.68	13457.55
5.5	813404.53	12506.26
6.0	705611.65	11554.97
6.5	607154.30	10603.68
7.0	518032.34	9652.40
7.5	438245.75	8701.11
8.0	367794.64	7775.44
8.5	306679.00	6886.78
9.0	254698.87	6047.77
9.5	212454.11	5339.89
10.0	179344.79	4749.81
10.5	155570.95	4284.79
11.0	141132.59	4026.96
11.5*	136029.64*	3971.01*
12.0	140262.13	4066.28
12.5	153930.09	4340.99
13.0	176733.50	4726.54
13.5	208972.36	5190.57
14.0	250546.65	5713.60
14.5	301456.41	6306.45
15.0	361701.60	6957.31
15.5	431282.27	7650.22
16.0	510198.35	8382.18

From Tables 6.1 to 6.6 it is seen that the "average" yield obtained by MODEL 2 during the last 4 years is around 10%.

In order to determine what yields the gold share prices reflected over the past 4 years, equation (6.2) was rearranged so that the yield variable was made the subject of the formula, also the actual weekly gold price replaces the implied gold price. Thus equation (6.2) becomes

$$\text{Yield}(t) = \{[\text{Actual Gold Price}(t) - \text{Cost}(t)]\text{Annual Production}(t)$$
$$+ \text{Sundry Revenue}(t) - \text{Tax}(t) - \text{Lease}(t) - \text{Capital expenditure}(t)\}$$
$$\times \frac{k''}{\text{Number of shares in issue}(t)\times\text{Share price}(t)} \qquad (6.7)$$

where k'' is the same as for equation (6.2).

Figures 6.14 to 6.19 show the graphs of the weekly yields using equation (6.7) for the 6 mines.

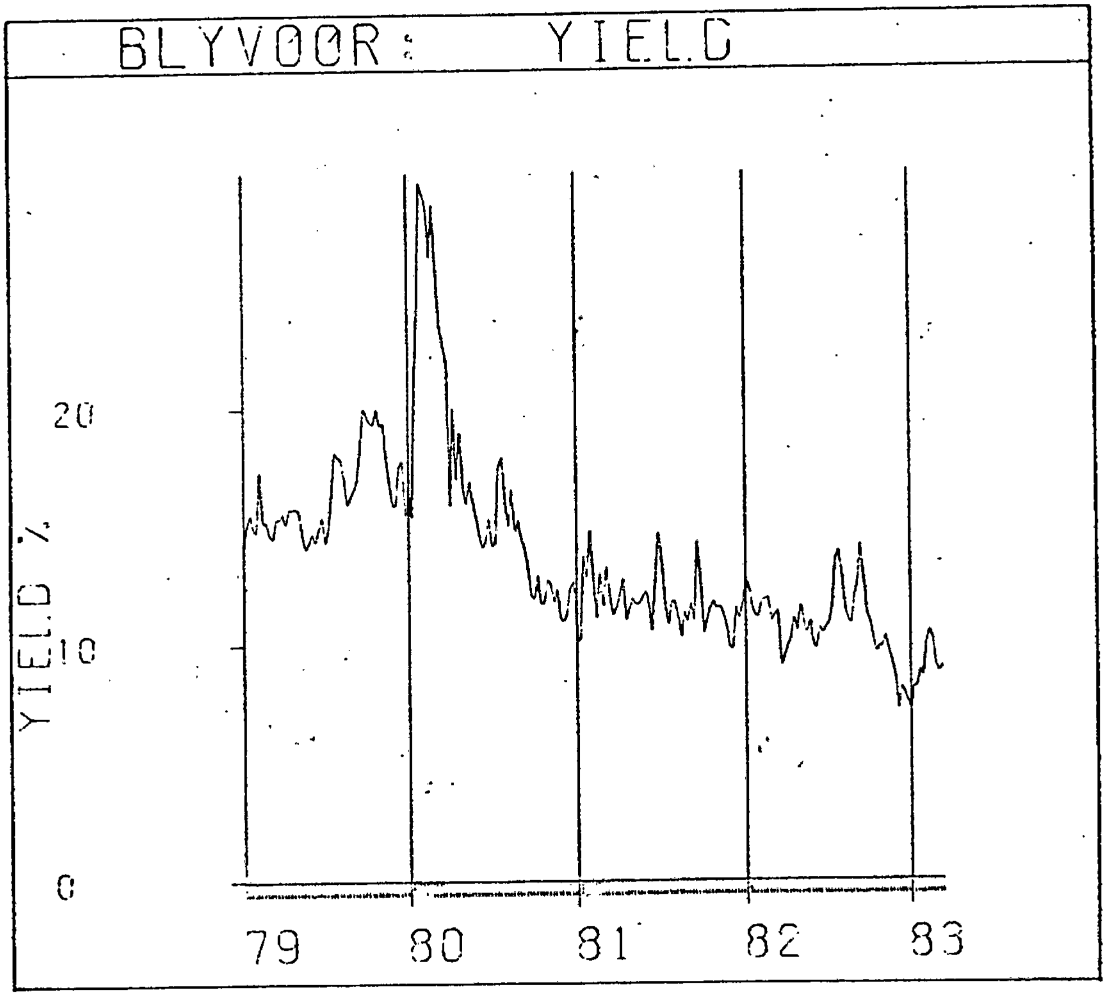
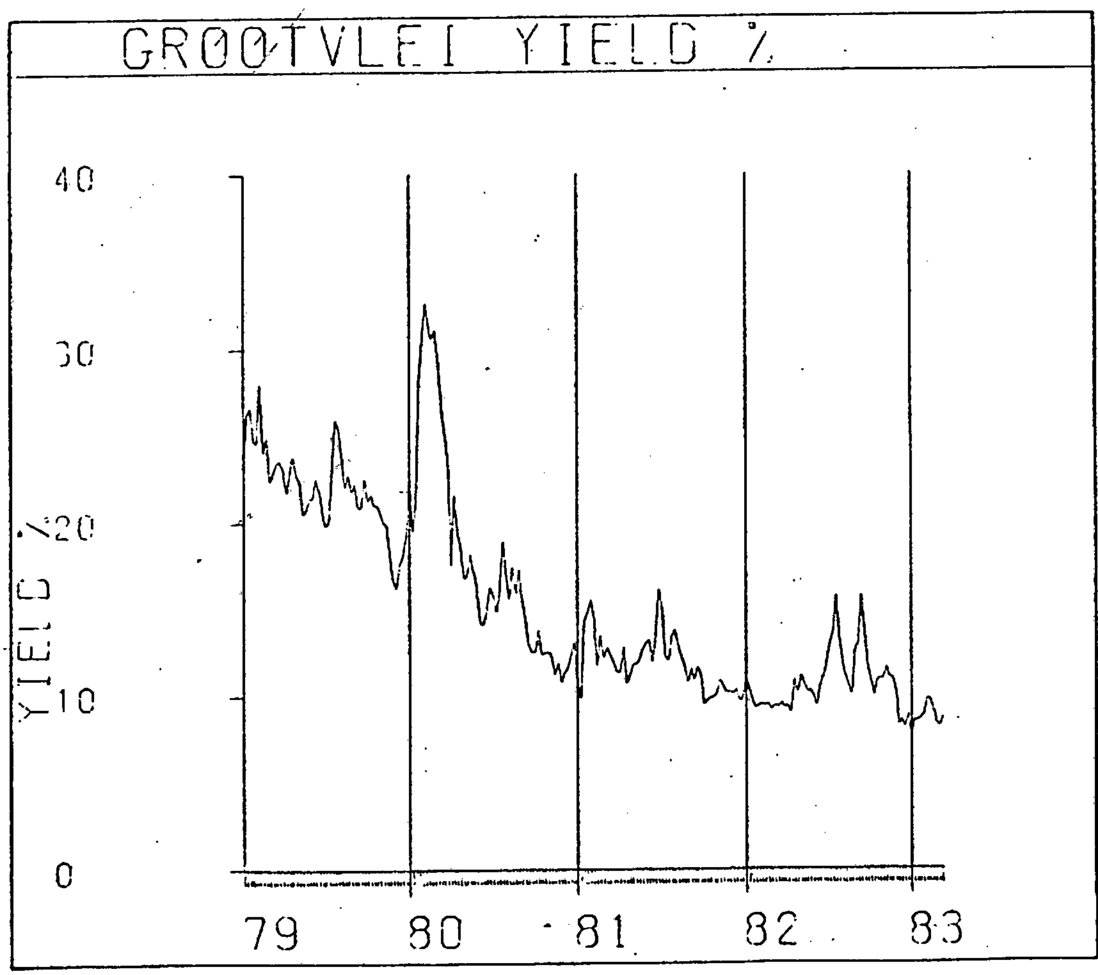

BLYVOOR: YIELD
YIELD %
20
10
0
79
80
81
82
83

FIGURE 6.14


GROOTVLEI YIELD %
YIELD %
40
30
20
10
0
79
80
81
82
83

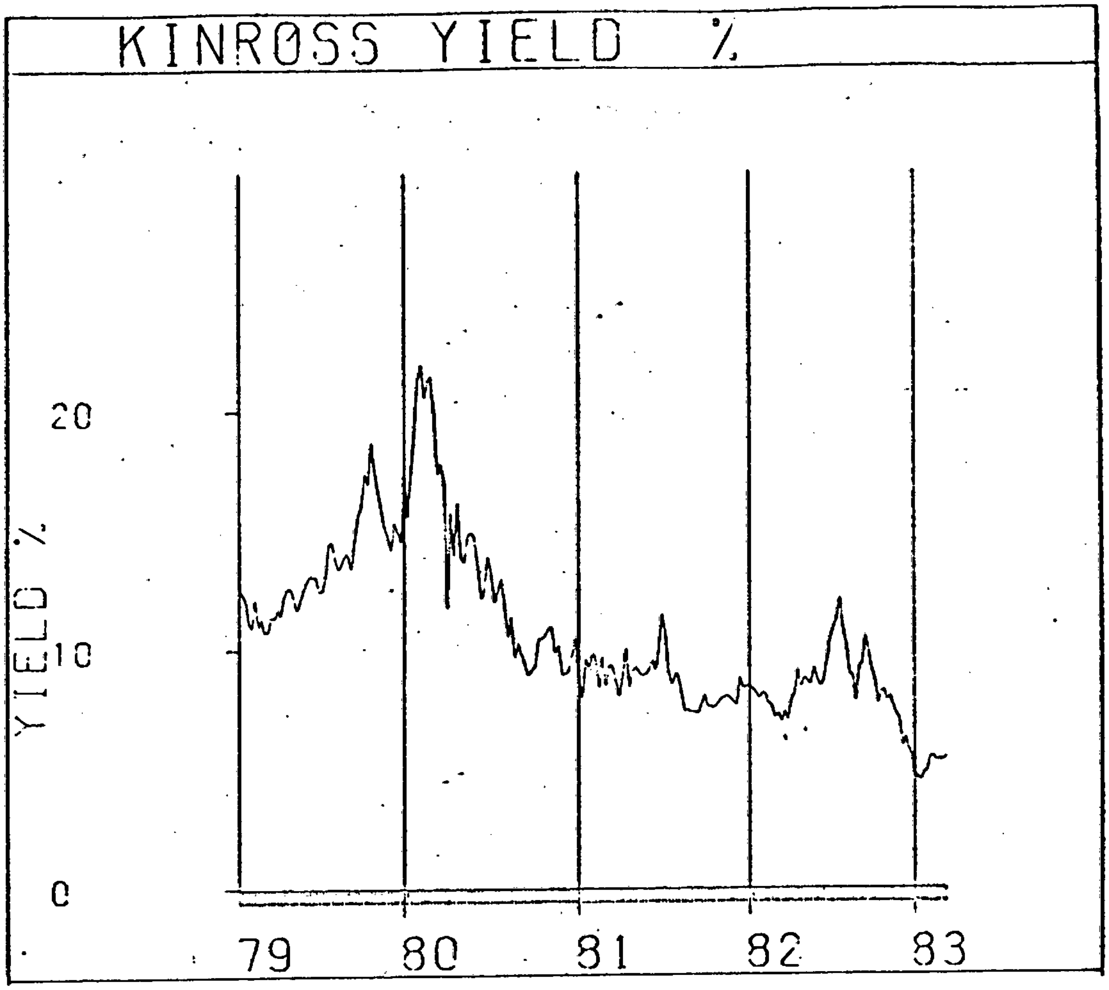
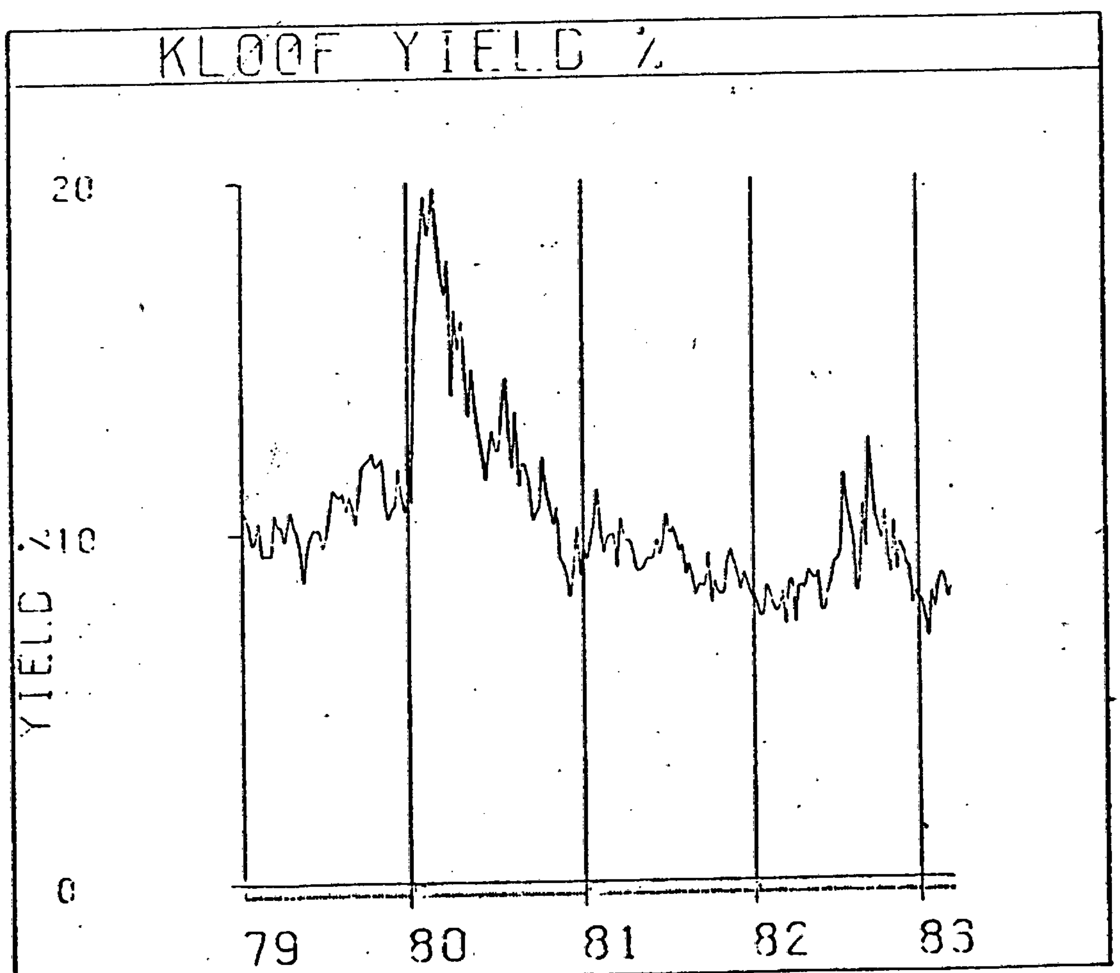

KINROSS YIELD %
YIELD %
20
10
0
79
80
81
82
83

FIGURE 6.16


KLOOF YIELD %
YIELD %
20
10
0
79
80
81
82
83

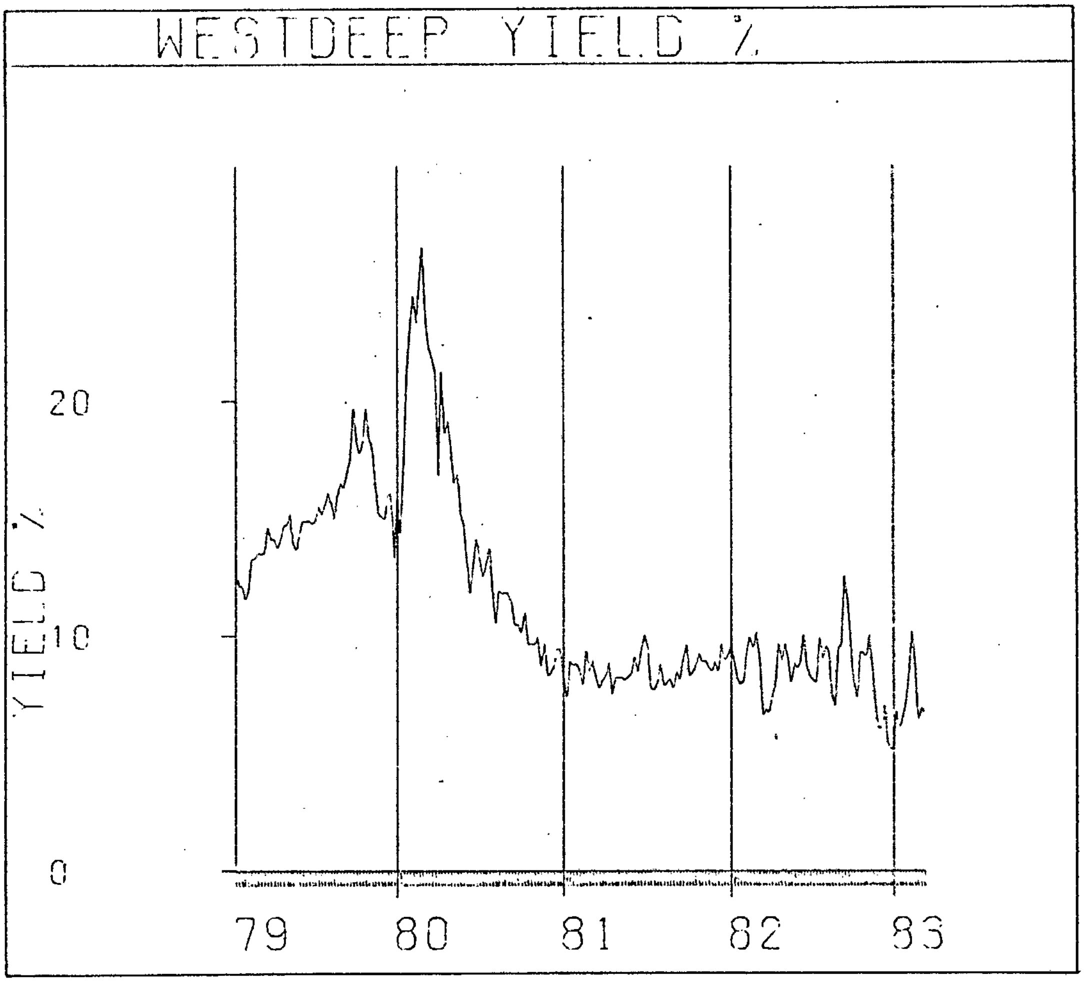
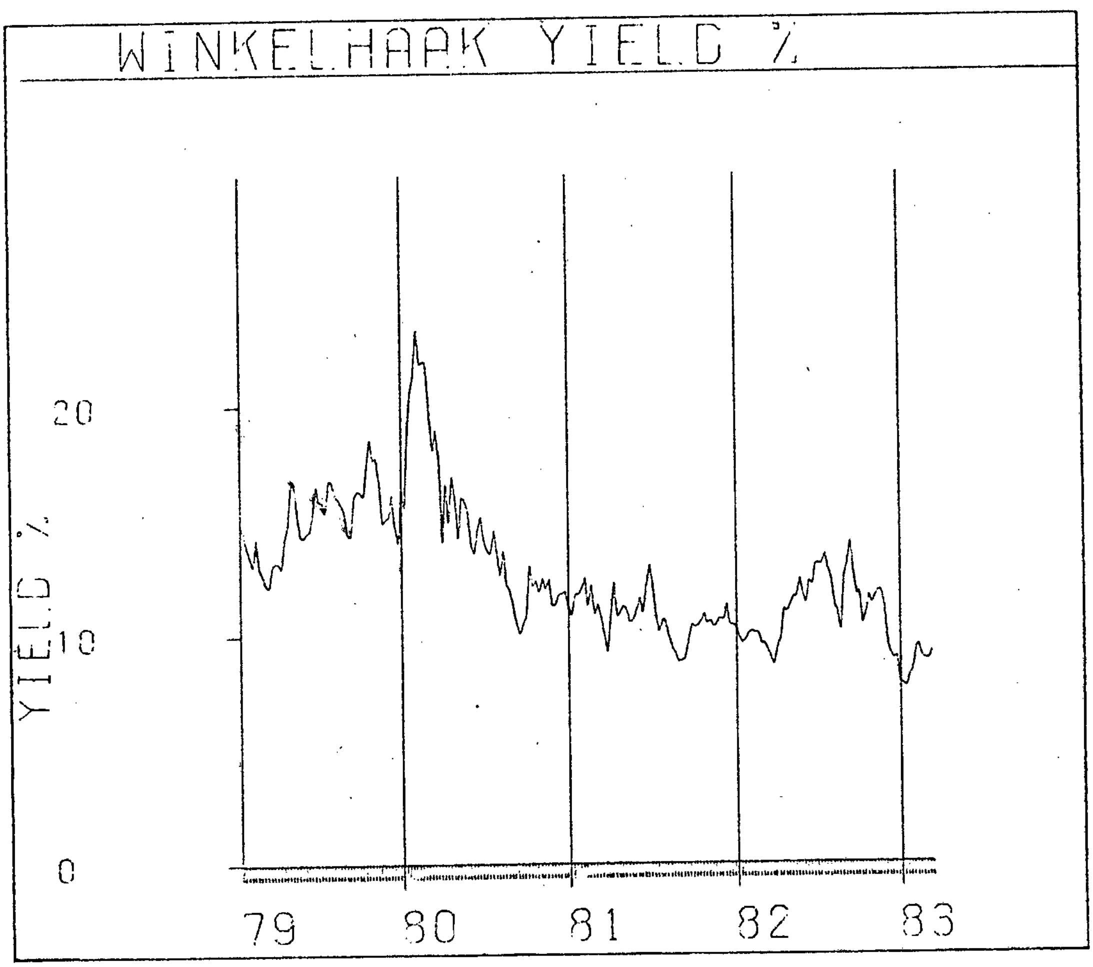

WESTDEEP YIELD %
YIELD %
20
10
0
79
80
81
82
83

FIGURE 6.18


WINKELHAAK YIELD %
YIELD %
20
10
0
79
80
81
82
83

The notable features of the yields shown in Figures 6.14 to 6.19 are:

(a) There are many short-term yield fluctuations of reasonably small magnitude present in all the graphs.

(b) In January 1980 a large upward fluctuation of the yields were present in all the graphs. It could be argued that this was due to the investors in the gold share market disbelieving that the high gold price of January 1980 would be sustained, hence the higher yield was justified in terms of the higher risk associated with the gold price at that time.

(c) It could be argued that there is a very slight indication of a decreasing trend in some of the graphs over the past 2 years, if this were ture, this may be an indication that investors are viewing gold shares relative to the gold price as being a less risky investment than it has been in the past, or simply that alternative investments are no longer as attractive.

6.4 A trading rule based on the yields obtained by MODEL 2

It is felt that the primary use of MODEL 2 is to determine the yield reflected by a gold share's price, thus enabling an investor to decide whether the computed yield suits his individual requirements to warrant investment in that share. This approach is the most logical approach to be used in efficient capital markets where the yield reflected in the price of a share already embodies all known information on both the expected economic conditions as well as the unique risk associated with the company at that time. It is, however, evident from Figures 6.14 to 6.19 that short term fluctuations in the yield of gold shares are present, indicating either that information is revealed so that investors change their view of the yields erratically in the short term (assuming market efficiency) or that there are very short term fluctuations which might be considered as exhibiting small deviations from efficiency. Although in the medium term the market is still considered to be efficient as the longer term trends in the yield are assumed to be gauged correctly by the market.

The existence of these short term fluctuations in the yields of gold shares motivated the research into a trading model in this section. Here an attempt will be made to formulate "buy and sell" signals on the basis of the yields computed using MODEL 2 and to compare the results of such a policy with a naive "buy and hold" policy.

In order to formulate "buy and sell" signals it is necessary to firstly discuss the major cause of short term increases and decreases in the yield obtained by MODEL 2. It is evident that an increase in the yield of a gold share found using equation (6.7) can be attributed mainly to two major causes, firstly, a situation where the gold price is rising but the price of the gold share is either not rising or rising at a slower rate than expected or, secondly, where the price of a gold share is declining and the gold price is either constant or declining at a slower rate than expected relative to the share price. In both cases one might consider the share a good prospect to purchase since relative to the gold price it is reflecting good value in terms of expected yields in the immediate past. Further, a decrease in the yield of a gold share found by using equation (6.7) can also be attributed to two major causes, firstly, a situation where the gold price could be declining but the share price is either constant or declining at a slower rate than expected relative to the gold price, or secondly, the share price is rising but the gold price is either constant or rising at a slower rate than expected relative to the share price. In the first instance where the gold price is declining one might consider the share a bad prospect to hold since relative to the gold price it is reflecting poor value in terms of expected yields in the immediate past. In the second instance where the share price is rising one might consider holding the share to appreciate the capital gain and only sell the share when the price starts to decline. In terms of the higher yields associated with the lower share price in the immediate past, however, one should not consider purchasing the share in this instance as the yield is decreasing. It should be noted that the above "buy" and "sell" situations can not be found by considering only the gold price and share price alone, but need to be considered in relation to the yield as well, since the yield, as determined by MODEL 2 takes into account all the components of profitability which are in turn affected by the gold price. Further, situations might arise where the share price might increase at a faster rate than the gold price yet the yield still increases. This situation might arise where a slight increase in the gold price might imply that a mine previously operating at a loss may be able to make a profit at the higher gold price, thus causing a much higher share price and possibly an increase in the yield. The reverse of the above situation could also occur causing a decrease in the yield.

In view of the above discussion "buy" and "sell" signals will be formulated for the trading model.

"Buy" Signals

Since it is felt that sudden increases in yield are considered to be a "buy" situation, a "buy" signal was formulated so that a share would be purchased when the yield rose through a 15 week moving average yield by more than 6%.

"Sell" Signals

According to the above discussion a "sell" signal should only be given when both the yield and the share price decreased, accordingly it was felt that a share should be sold when the yield dropped by more than 4% of a 15 week moving average yield and the share price dropped by more than 2% of a 15 week moving average share price. It should be noted that the percentage decrease for a sell signal was formulated to be less than a buy signal since the added share price constraint was included for the sell signal.

The trading policy was formulated for the 6 mines researched in this chapter, and was compared with a "buy and hold" policy over the period starting in January 1980 and ending in March 1983, that is, a total of 164 trading weeks. The trading policy assumed an initial sum of R10 000 available for investment in the following manner.

(a) For a buy signal as many shares as possible were purchased from the available funds. The running total of funds, including excesses are recorded in column 2 of Tables 6.7 to 6.12 for the six individual mines. Column 3 shows a record of the number of shares currently held.

(b) For a sell signal all shares that were held at the time are sold, also 1 share is sold short. For every sell signal encountered thereafter a further 1 share is sold short. The running total column allows funds accrued from short selling to be reflected immediately. If a buy signal is encountered during a negative holding of shares then all outstanding shares are purchased immediately, showing a zero for the holding in column 3 and a "buy" signal in column 4.

All current brokerage and tax rates were included in each transaction. Further any shares held or outstanding are sold or bought, whichever is the case, at the prevailing share price on the last week of the period. Column 5, headed "WEEK NO" gives the number of the WEEK when each signal is encountered. (Note that week 1 is the first week in January 1980.) Tables 6.7 to 6.12 show the details of the trading policy including the total sum accrued from this policy, as well as the sum accrued from a "buy and hold" policy.

TABLE 6.7 : BLYVOOR

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	WEEK NO
	10000.00			
1250.00	1034.63	7.	BUY	1
2350.00	17391.30	0.	SELL	51
2350.00	19720.82	-1.	SELL	51
2375.00	22075.14	-2.	SELL	52
1950.00	18103.99	0.	BUY	53
1950.00	224.81	9.	BUY	53
1775.00	16059.52	0.	SELL	57
1775.00	17818.94	-1.	SEEL	57
1700.00	16087.99	0.	BUY	58
1700.00	500.44	9.	BUY	58
1825.00	16781.32	0.	SELL	59
1825.00	18590.31	-1.	SELL	59
1625.00	16935.75	0.	BUY	60
1625.00	380.12	10.	BUY	60
1775.00	17974.25	0.	SELL	62
1775.00	19733.66	-1.	SELL	62
1775.00	21493.07	-2.	SELL	63
1775.00	23252.49	-3.	SELL	66
1400.00	18976.29	0.	BUY	76
1400.00	433.09	13.	BUY	76
1450.00	19116.36	0.	SELL	78
1450.00	20553.54	-1.	SELL	78
1575.00	22114.65	-2.	SELL	79
1500.00	23601.40	-3.	SELL	80
1475.00	25063.36	-4.	SELL	82
1425.00	19259.91	0.	BUY	88
1425.00	385.70	13.	BUY	88
1510.00	19842.34	0.	SELL	96
1510.00	21339.01	-1.	SELL	96
1460.00	22786.10	-2.	SELL	97
1520.00	24292.68	-3.	SELL	101
1275.00	20398.41	0.	BUY	103
1275.00	912.10	15.	BUY	103
1100.00	17264.35	0.	SELL	111
1100.00	18354.50	-1.	SELL	111
1150.00	19494.23	-2.	SELL	114
1160.00	20643.87	-3.	SELL	115
1100.00	21734.02	-4.	SELL	116
1050.00	17458.32	0.	BUY	120
1050.00	339.52	16.	BUY	120
1020.00	16512.80	0.	SELL	122
1020.00	17523.63	-1.	SELL	122
1065.00	18579.07	-2.	SELL	124
1030.00	19599.82	-3.	SELL	125
900.00	16851.37	0.	BUY	130
900.00	342.67	18.	BUY	130
1685.00				165

TOTAL R10000 INVESTMENT AT END OF PERIOD = 30405.36

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 11010.34

TABLE 6.8 : GROOTVLEI

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	WEEK NO
	10000.00			
835.00	639.58	11.	BUY	2
1300.00	14812.53	0.	SELL	52
1300.00	16100.98	-1.	SELL	52
1390.00	17478.66	-2.	SELL	53
1070.00	15300.07	0.	BUY	54
1070.00	35.94	14.	BUY	54
910.00	12660.65	0.	SELL	58
910.00	13562.42	-1.	SELL	58
900.00	12646.27	0.	BUY	59
900.00	723.32	13.	BUY	59
950.00	12961.84	0.	SELL	60
950.00	13903.27	-1.	SELL	60
890.00	14785.20	-2.	SELL	63
970.00	15746.46	-3.	SELL	64
900.00	12998.01	0.	BUY	73
900.00	157.91	14.	BUY	73
815.00	11463.92	0.	SELL	79
815.00	12271.49	-1.	SELL	79
840.00	13103.85	-2.	SELL	80
790.00	11495.62	0.	BUY	81
790.00	224.01	14.	BUY	81
1040.00	14653.25	0.	SELL	98
1040.00	15683.91	-1.	SELL	98
1030.00	16704.66	-2.	SELL	99
1085.00	17779.94	-3.	SELL	100
1000.00	18779.94	-4.	SELL	106
995.00	19747.06	-5.	SELL	107
990.00	20728.15	-6.	SELL	108
1000.00	21719.15	-7.	SELL	109
1010.00	22720.06	-8.	SELL	110
960.00	23671.40	-9.	SELL	111
900.00	24563.25	-10.	SELL	112
880.00	25435.27	-11.	SELL	113
740.00	26168.48	-12.	SELL	114
810.00	26971.10	-13.	SELL	116
800.00	27763.80	-14.	SELL	117
910.00	28665.56	-15.	SELL	118
850.00	15687.19	0.	BUY	119
850.00	95.14	18.	BUY	119
775.00	13917.56	0.	SELL	126
775.00	14685.48	-1.	SELL	126
780.00	13891.55	0.	BUY	127
780.00	377.74	17.	BUY	127
1550.00	26495.26	0.	SELL	164
1550.00	28031.59	-1.	SELL	164
1600.00	29617.49	-2.	SELL	165
1575.00				166

TOTAL R10000 INVESTMENT AT END OF PERIOD = 26495.26

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 19328.41

TABLE 6.9 : KINROSS

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	SEQUENCE NO
	10000.00			
1120.00	870.24	8.	BUY	2
1170.00	10146.68	0.	SELL	14
1170.00	11306.23	-1.	SELL	14
1125.00	12421.17	-2.	SELL	16
1175.00	13585.68	-3.	SELL	17
1200.00	14774.93	-4.	SELL	18
1125.00	15889.92	-5.	SELL	19
1090.00	16970.16	-6.	SELL	20
1095.00	18055.35	-7.	SELL	21
1160.00	19204.99	-8.	SELL	22
1875.00	21063.55	-9.	SELL	45
1890.00	22936.99	-10.	SELL	47
1650.00	6136.74	0.	BUY	51
1650.00	1093.66	3.	BUY	51
1725.00	6223.17	0.	SELL	52
1725.00	7933.01	-1.	SELL	52
1875.00	9791.57	-2.	SELL	53
1625.00	11402.26	-3.	SELL	55
1475.00	12864.22	-4.	SELL	58
1575.00	14425.34	-5.	SELL	60
1450.00	15862.51	-6.	SELL	63
1425.00	7157.34	0.	BUY	66
1425.00	1349.89	4.	BUY	66
1500.00	7296.89	0.	SELL	67
1500.00	8783.64	-1.	SELL	67
1360.00	7398.98	0.	BUY	76
1360.00	470.68	5.	BUY	76
1310.00	6962.50	0.	SELL	79
1310.00	8260.87	-1.	SELL	79
1390.00	9638.55	-2.	SELL	80
1375.00	11001.36	-3.	SELL	81
1525.00	6343.23	0.	BUY	101
1525.00	128.38	4.	BUY	101
1400.00	5678.78	0.	SELL	110
1400.00	7066.38	-1.	SELL	110
1375.00	8429.19	-2.	SELL	111
1350.00	9767.21	-3.	SELL	112
1315.00	11070.54	-4.	SELL	113
1200.00	12259.84	-5.	SELL	114
1150.00	13399.56	-6.	SELL	115
1275.00	14663.22	-7.	SELL	116
1170.00	6325.21	0.	BUY	119
1170.00	364.48	5.	BUY	119
2350.00	12012.11	0.	SELL	164
2350.00	14341.63	-1.	SELL	164
2400.00				166

TOTAL R10000 INVESTMENT AT END OF PERIOD = 11962.53

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 21516.58

TABLE 6.10 : KLOOF

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	WEEK NO
	10000.00			
2500.00	2359.75	3.	BUY	2
2900.00	10984.30	0.	SELL	15
2900.00	13359.15	-1.	SELL	15
2950.00	16783.57	-2.	SELL	16
2875.00	19633.64	-3.	SELL	17
2875.00	22483.70	-4.	SELL	19
3675.00	7513.75	0.	BUY	29
3675.00	26.77	2.	BUY	29
4400.00	8753.97	0.	SELL	52
4400.00	13113.07	-1.	SELL	52
4500.00	17574.32	-2.	SELL	53
3650.00	10140.27	0.	BUY	56
3650.00	2704.22	2.	BUY	56
3625.00	9391.63	0.	SELL	58
3625.00	13485.29	-1.	SELL	58
3600.00	17054.19	-2.	SELL	62
3175.00	10527.71	0.	BUY	63
3175.00	335.70	3.	BUY	63
3450.00	11145.52	0.	SELL	67
3450.00	14565.70	-1.	SELL	67
3350.00	11154.22	0.	BUY	77
3350.00	916.20	3.	BUY	77
3425.00	11102.95	0.	SELL	83
3425.00	14498.35	-1.	SELL	83
3400.00	17968.95	-2.	SELL	84
3725.00	10282.12	0.	BUY	96
3725.00	2693.30	2.	BUY	96
3830.00	10326.85	0.	SELL	100
3830.00	14143.62	-1.	SELL	103
3650.00	17762.10	-2.	SELL	107
3550.00	21281.42	-3.	SELL	110
3550.00	24300.75	-4.	SELL	111
3275.00	28047.41	-5.	SELL	112
3100.00	31120.56	-6.	SELL	114
2650.00	14729.41	0.	BUY	115
2650.00	1431.79	5.	BUY	115
3150.00	17345.41	0.	SELL	117
3150.00	20169.14	-1.	SELL	117
2825.00	17291.37	0.	BUY	121
2825.00	24.80	6.	BUY	121
2900.00	17273.90	0.	SELL	126
2900.00	20143.75	-1.	SELL	126
2500.00	17600.00	0.	BUY	129
2500.00	2322.60	6.	BUY	129
4930.00	31767.00	0.	SELL	165
4930.00	36574.47	-1.	SELL	165
4930.00				166

TOTAL R10000 INVESTMENT AT END OF PERIOD = 31516.52

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 15100.00

TABLE 6.11 : WESTDEEP

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	SEQUENCE NO
	10000.00			
3830.40	2196.48	2.	BUY	3
3635.20	9404.08	0.	SELL	13
3635.20	13007.89	-1.	SELL	13
3491.20	16468.90	-2.	SELL	15
3683.20	20120.29	-3.	SELL	16
3443.20	23523.73	-4.	SELL	17
3683.20	27185.12	-5.	SELL	19
6950.00	33976.40	-6.	SELL	51
6950.00	40866.82	-7.	SELL	52
7400.00	48203.42	-8.	SELL	53
6775.00	54920.33	-9.	SELL	54
6200.00	61067.13	-10.	SELL	55
5600.00	66619.03	-11.	SELL	57
5450.00	72922.21	-12.	SELL	58
5130.00	9329.35	0.	BUY	59
5130.00	4103.94	1.	BUY	59
5400.00	9457.54	0.	SELL	60
5400.00	14811.14	-1.	SELL	60
4950.00	19718.57	-2.	SELL	62
5400.00	25072.17	-3.	SELL	63
5300.00	30326.62	-4.	SELL	64
5600.00	35878.52	-5.	SELL	65
5462.00	41293.59	-6.	SELL	67
5300.00	46548.04	-7.	SELL	69
5000.00	10904.04	0.	BUY	74
5000.00	718.04	2.	BUY	74
4750.00	10136.29	0.	SELL	79
4750.00	14845.41	-1.	SELL	79
4825.00	19628.90	-2.	SELL	80
4850.00	24437.18	-3.	SELL	81
4600.00	28997.58	-4.	SELL	83
4700.00	33657.13	-5.	SELL	84
5050.00	7942.50	0.	BUY	89
5050.00	2798.58	1.	BUY	89
3975.00	6739.29	0.	SELL	106
3975.00	10689.00	-1.	SELL	106
3900.00	14447.20	-2.	SELL	107
3775.00	18189.61	-3.	SELL	108
3300.00	8107.96	0.	BUY	109
3300.00	1384.86	2.	BUY	109
3300.00	7927.76	0.	SELL	114
3300.00	11199.21	-1.	SELL	114
3200.00	14371.51	-2.	SELL	115
3450.00	17791.69	-3.	SELL	116
3075.00	20840.05	-4.	SELL	117
3125.00	23937.99	-5.	SELL	118
2900.00	9172.24	0.	BUY	119
2900.00	309.79	3.	BUY	119
2800.00	8636.89	0.	SELL	123
2800.00	11412.59	-1.	SELL	123
2375.00	8994.15	0.	BUY	127
2375.00	1735.84	3.	BUY	127
5850.00	19135.16	0.	SELL	164
5850.00	24934.94	-1.	SELL	164
5850.00				166

TOTAL R10000 INVESTMENT AT END OF PERIOD = 19135.16

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 13700.25

TABLE 6.12 : WINKELHAAK

SHARE PRICE	RUNNING TOTAL	HOLDING	ACTION	WEEK NO
	10000.00			
2550.00	2206.98	3.	BUY	1
2800.00	10534.08	0.	SELL	15
2800.00	13309.78	-1.	SELL	15
2650.00	15936.75	-2.	SELL	16
2700.00	18613.30	-3.	SELL	18
2650.00	21240.27	-4.	SELL	19
2700.00	23916.82	-5.	SELL	20
3950.00	27832.75	-6.	SELL	46
4100.00	31897.40	-7.	SELL	47
3575.00	35441.51	-8.	SELL	51
3675.00	39084.77	-9.	SELL	52
3000.00	42058.77	-10.	SELL	57
3300.00	45330.22	-11.	SELL	59
3225.00	48527.31	-12.	SELL	60
3025.00	51526.10	-13.	SELL	61
3400.00	54896.70	-14.	SELL	62
3100.00	10700.80	0.	BUY	65
3100.00	1227.25	3.	BUY	65
3175.00	10669.78	0.	SELL	66
3175.00	13817.30	-1.	SELL	66
3260.00	10497.49	0.	BUY	73
3260.00	535.06	3.	BUY	73
3050.00	9605.78	0.	SELL	78
3050.00	12629.36	-1.	SELL	78
3525.00	9039.64	0.	BUY	93
3525.00	1858.22	2.	BUY	93
3387.00	8573.64	0.	SELL	103
3387.00	11931.35	-1.	SELL	103
3325.00	15227.59	-2.	SELL	105
3125.00	18325.53	-3.	SELL	106
3100.00	21398.68	-4.	SELL	107
3100.00	24471.83	-5.	SELL	108
3125.00	27569.76	-6.	SELL	109
3050.00	30593.34	-7.	SELL	110
3000.00	33567.34	-8.	SELL	111
3000.00	36541.34	-9.	SELL	112
2775.00	39292.25	-10.	SELL	113
2925.00	42191.89	-11.	SELL	114
2850.00	45017.16	-12.	SELL	116
2800.00	10801.56	0.	BUY	118
2800.00	2244.66	3.	BUY	118
2100.00	105.31	4.	BUY	128
4300.00	17157.11	0.	SELL	163
4300.00	21420.06	-1.	SELL	163
4350.00	25732.59	-2.	SELL	164
4325.00				165

TOTAL R10000 INVESTMENT AT END OF PERIOD = 17157.11

BUY AND HOLD INVESTMENT OF R10000 AT PERIOD END = 14614.86

With reference to Tables 6.7 to 6.12 it is seen that the trading policy suggested here substantially beats a "buy and hold" policy over the given period in all cases, except for the case of Kinross. It should, however, be noted that it is possible that over some different period the results may differ, this still requires further substantiation. Further, different combinations of "buy" and "sell" filters for the yield and share price as well as different moving average lengths may show better results and should thus also be researched.

CHAPTER 7

FUTURE PREDICTIONS USING MODEL 2

7.1 Introduction

In this chapter MODEL 2 will be used to predict the earnings and share prices of various gold mines for 30 June 1984, using high, medium and low future gold price scenarios, an inflation assumption as well as an additional expected yield assumption for predicting share prices. It would not, however, be realistic to use the same equations found in Chapter 5 for the estimates of the components of MODEL 2 for 30 June 1984, since a time variable was used in most of these equations. Although these equations were suitable for the "in-period" study performed in Chapter 6 where weekly estimates were required, it is felt that it would be unrealistic to assume that inflation would continue to increase at the same rate with time in the future. The equations generating the estimates of the components of the model will thus be re-estimated here replacing the time variable by the Wholesale Manufacturing Price Index for Basic Metals and Products to proxy inflation.

It should be noted that the treatment of prediction of earnings differs for the prediction of share prices as the predicted share price would embody the expected earnings further into the future than the earnings predicted for the

12 months preceding 30 June 1984.

7.2 Estimation of the Components

As before, cost, capital expenditure and production equations were estimated using ordinary least squares regression. In all these equations the time variable was replaced by quarterly data observations of the Wholesale Manufacturing Price Index for Basic Metals and Products (henceforth referred to as the Price Index) extracted from the South African Reserve Bank Quarterly Bulletins. It should be noted that the Price Index was adjusted so that the year 1970 was taken to be the base year. A graph of the Price Index is shown in Figure 7.1 below.

7.2.1 Cost

The Price Index, as can be seen from Figure 7.1, has an exponential trend, thus it is felt that this variable would replace the exponential time variable determined in Section 5.4.

The general form of the cost equation estimated in rands per ounce now becomes

$$\text{Cost}(t) = \alpha_1 + \alpha_2 \text{ Price Index}(t) + \alpha_3 \sum_{k=t-4}^{t-1} \text{Gold price}(k)/4 \tag{7.1}$$

The coefficients of equation (7.1) obtained for the six mines which will be analyzed in this chapter are shown in Table 7.1 below.

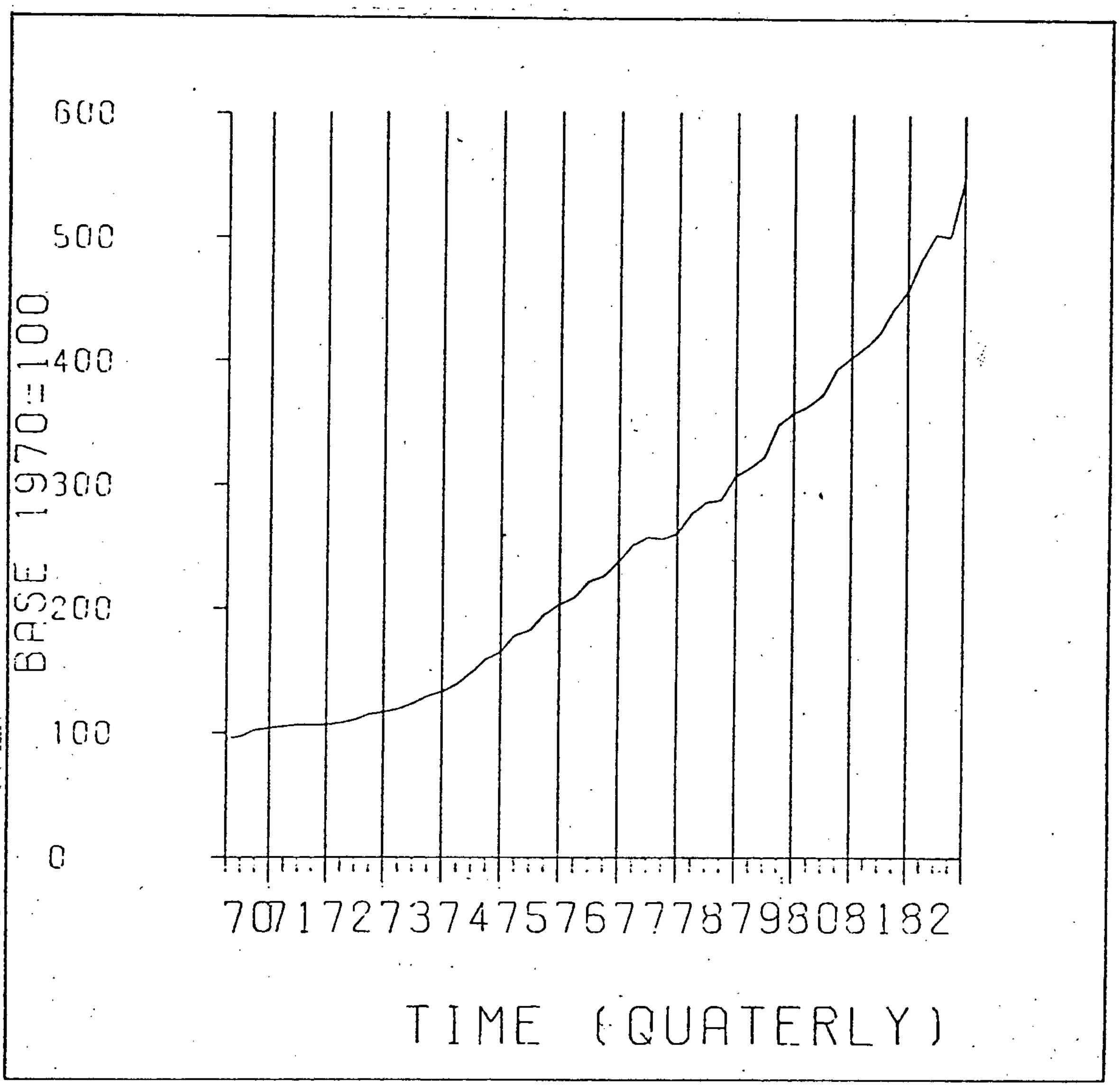


FIGURE 7.1

TABLE 7.1

Mine	α_1	α_2	α_3	F Ratio
Blyvoor	-34,34	0,38131	0,09193	1393,05
Grootvlei	-8,79	0,31402	0,22038	1513,73
Kinross	-32,81	0,36266	0,10691	909,31
Kloof	-1,01	0,27146	-0,02023	168,37
Westdeep	-22,12	0,2589	0,08047	367,74
Winkelhaak	-14,69	0,24700	0,07568	578,77

The graphs of the comparison of the actual and predicted costs using equation (7.1) are shown in Appendix E. These figures as well as the high associated F ratios compared to the critical F value of 3,25 at the 5% significance level indicate that the independent variables account for changes in cost reasonably well.

7.2.2 Production

The general form of the production equation, where production is estimated in thousands of ounces per annum is given by

$$\text{Production}(t) = \alpha_1 + \alpha_2 \sum_{k=1}^{4} (5-k).\text{Gold price}(t-k)/10 + \alpha_3 \text{ Gold price}(t) + \alpha_4 \text{ Price Index}(t) + \alpha_5(t) \qquad (7.2)$$

where the first quarter of 1970 is taken to be $t = 1$.

It should be noted that the time variable was not removed from the production equation as it is expected that due to the limited gold resources, production will decrease with time. The Price Index variable, however, is assumed to represent the effect of increasing mining costs on production.

Table 7.2 shows the coefficients obtained using equation (7.2) for the six mines.

The critical value for the F ratio test at the 5% level is 2,64 here, indicating that a significant linear relationship between dependent and independent variables was found to exist for all six mines.

TABLE 7.2

Mine	α_1	α_2	α_3	α_4	α_5	F Ratio
Blyvoor	1288,89	0,1520	0,0507	3,1176	-46,0365	422,703
Grootvlei	185,93	-0,1284	0,1084	0,4192	-3,2715	5,311
Kinross	441,41	-0,1371	-0,0924	0,7007	-7,5997	34,562
Kloof	810,29	-0,3408	1,4495	2,21309	-27,6449	6,778
Westdeep	2064,69	-0,4419	1,2823	0,8259	-30,4984	37,515
Winkelhaak	557,72	-0,1892	0,0658	0,1163	-2,3407	16,543

7.2.3 Capital Expenditure

The capital expenditure equation which yields annual estimates in units of thousands of rands has the following form

$$\text{Capital Expenditure}(t) = \alpha_1+\alpha_2\sum_{k=1}^{4}(5-k)\text{Gold Price}(t-k)/10 + \alpha_3 \text{ Gold Price}(t) + \alpha_4 \text{ Price Index}(t) \quad (7.3)$$

It is expected that capital expenditure increases in relation to mining costs, therefore the time variable of equation (5.23) has been replaced by the Price Index variable.

The coefficients of equation (7.3) for the six mines are shown in Table 7.3 below.

The critical F value at the 5% level is 2,87 here indicating a significant linear relationship between independent and dependent variables for the six mines.

TABLE 7.3

Mine	α_1	α_2	α_3	α_4	F Ratio
Blyvoor	-4200,65	3,6349	-17,1934	58,7887	75,651
Grootvlei	-1614,68	11,1830	-7,6300	7,5682	19,213
Kinross	-254,10	11,4899	-22,4991	23,9272	3,021
Kloof	-3400,73	31,6707	-39,7341	73,3549	42,054
Westdeep	-31941,73	106,7816	-7,6043	200,3330	81,889
Winkelhaak	-1702,04	15,5521	-4,5507	5,9302	19,503

7.3 Prediction of Earnings as at 30 June 1984

In order to compute annual earnings at 30 June 1984, the components of gold mine earnings had to be considered for the 12 months prior to 30 June 1984. Since the components of gold mine earnings are dependent on the rand price of gold received, an assumption about the future gold price and exchange rates up to 30 June 1984 had to be made. Consequently three different gold price scenarios were considered and are listed together with the associated exchange rate assumptions in Table 7.4 below.

Further an assumption about the inflation rate as impacted on the Price Index had to be made. It was assumed that this increase would be 12% per annum up to 30 June 1984.

The following component of MODEL 2 was used to compute the predicted annual earnings per share as at 30 June 1984.

TABLE 7.4

Scenarios		1983 III	1983 IV	1984 I	1984 II	Annual % Increase
Scenario 1	$/ounce	405	390	375	365	-14%
LOW GOLD	exchange rate	0,89	0,88	0,87	0,86	
PRICE	R/ounce	455	443	431	424	
Scenario 2	$/ounce	435	450	465	480	14%
MEDIUM GOLD	exchange rate	0,93	0,94	0,95	0,965	
PRICE	R/ounce	468	478	490	500	
Scenario 3	$/ounce	452	488	525	550	31%
HIGH GOLD	exchange rate	0,935	0,96	0,98	1,00	
PRICE	R/ounce	483	508	536	550	

$$\text{Earnings per share} = [(\text{Average annual gold price} - \text{Average annual cost}) \times \text{Annual Production} - \text{Annual capital expenditure} - \text{tax} - \text{lease} + \text{Sundry Revenue}] \times \frac{1}{\text{No. of shares in issue}} \qquad (7.4)$$

where estimates of production and capital expenditure for the 12 months prior to 30 June 1984 were computed using the equations shown in Sections 7.2.2 and 7.2.3 respectively for the six gold mines. The average costs for the 4 quarters prior to 30 June 1984 were computed using the equations shown in Section 7.2.1 and the tax and lease payments were estimated using the formulae discussed in Section 5.7.

The earnings and components of earnings for each of the six mines are tabulated below.

Since the Blyvooruitzicht Gold Mining Company also accrues revenue from uranium production, this revenue must also be considered in the predicted earnings figure. Strong (1982) assumes that the net mining revenue accrued from uranium sales is 6% of the net mining revenue accrued from gold sales. The same assumption will be made here.

TABLE 7.5 Blyvooruitzicht Gold Mining Company

Components of Earnings	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	245,6024	246,8320	247,8777
Production(oz)	917 758	925 656	932 064
Capital Expenditure(R)	28 065 368	27 412 170	26 916 604
% Lease payment	9,3107	10,7984	11,3282
% Tax payment	49,0907	51,2663	52,0589
Lease payment(R)	13 638 134	24 075 303	31 059 651
Tax payment(R)	67 960 213	106 001 230	131 471 108
Mining Revenue(R)	399 542 532	477 732 604	530 544 972
Working profit(R)	173 549 408	248 407 352	298 493 252
Total earnings(R)	65 045 694	92 078 650	110 205 892
Earnings per share(C)	271,02	383,66	459,19

TABLE 7.6 Grootvlei Proprietary Mines Limited

Components of Earnings	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	288,4267	291,3743	293,8811
Production (oz)	279 700	274 227	275 743
Capital Expenditure(R)	5 018 634	4 849 170	4 807 633
% Lease payment	5,5000	8,7403	10,5185
% Tax payment	47,3488	49,0763	49,9415
Lease payment(R)	1 970 941	4 233 040	6 091 494
Tax payment(R)	16 783 379	22 539 768	26 872 096
Mining Revenue(R)	118 634 697	132 725 907	143 179 926
Working profit(R)	40 557 299	52 823 175	62 144 045
Total earnings(R)	16 987 344	21 404 196	24 575 821
Earnings per share(C)	148,51	187,12	214,85

TABLE 7.7 Kinross Mines Limited

Components of Earnings	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	242,4153	243,8452	245,0613
Production (oz)	386 342	374 288	365 501
Capital Expenditure(R)	10 838 079	9 549 827	8 774 165
% Lease payment	10,5410	10,8088	10,9434
% Tax payment	49,4793	50,8885	51,6001
Lease payment(R)	6 884 661	8 761 746	10 103 755
Tax payment(R)	30 099 959	38 244 996	44 069 222
Mining Revenue(R)	169 314 762	181 155 826	189 786 424
Working profit(R)	75 659 340	89 887 267	100 216 253
Total Earnings(R)	29 107 420	34 601 477	38 539 891
Earnings per share(C)	161,71	192,23	214,11

TABLE 7.8 Kloof Gold Mining Company Limited

Components of Earnings	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	158,8012	158,5306	158,3005
Production (oz)	1 218 858	1 316 513	1 378 627
Capital Expenditure(R)	41 430 078	39 572 601	38 548 685
% Lease payment	13,3931	13,5254	13,5966
% Tax payment	52,5688	53,1691	53,4926
Lease payment(R)	40 407 225	53 102 449	63 043 592
Tax payment(R)	142 834 446	187 474 200	222 435 086
Mining Revenue(R)	534 164 700	637 192 312	715 852 448
Working profit(R)	340 608 528	428 484 688	497 614 992
Total Earnings(R)	126 131 248	158 529 908	183 782 100
Earnings per share(C)	417,10	524,24	607,745

It is felt that the estimate of the number of ounces produced is too high yielding unrealistically high estimates or earnings per share for Kloof.

An additional assumption is required for Western Deep Levels as it is also a uranium producer. The same assumption used by Strong (1982) will be used here, that is, the net mining revenue accrued from uranium sales is 1% of the net mining revenue accrued from gold sales.

TABLE 7.9 Western Deep Levels

Components of Earnings	Gold Price Scenarios Low	Medium	High
Cost(R/oz)	183,9897	194,1660	195,0814
Production (oz)	1 320 612	1 363 059	1 394 826
Capital Expenditure(R)	142 152 906	145 723 894	148 702 002
% Lease payment	2,9333	6,0689	7,0838
% Tax payment	40,5284	44,5958	45,9694
Lease payment(R)	4 802 948	16 657 963	24 887 079
Tax payment(R)	68 528 730	121 117 537	157 551 756
Mining Revenue(R)	871 011 728	1106 778 784	1271 155 296
Working profit(R)	307 992 320	421 038 640	500 000 548
Total Earnings(R)	93 667 736	138 699 248	170 019 712
Earnings per share(C)	366,61	542,85	665,44

TABLE 7.10 Winkelhaak Mines Limited

Components of Earnings	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	174,0809	175,0931	175,9540
Production (oz)	450 988	449 045	446 583
Capital Expenditure(R)	7 107 431	7 332 340	7 577 588
% Lease payment	13,4122	13,5112	13,5679
% Tax payment	52,6529	53,1026	53,3611
Lease payment(R)	15 185 485	17 943 896	19 989 908
Tax payment(R)	53 540 894	63 249 951	70 452 687
Mining Revenue(R)	197 645 696	217 338 084	231 888 716
Working profit(R)	119 137 206	138 713 270	153 310 482
Total Earnings(R)	45 913 782	52 797 470	57 900 686
Earnings per share(C)	376,96	433,48	475,3751

With reference to Tables 7.5 to 7.10 it should be noted that in many cases the serial correlation coefficients for lags of 1 quarter computed using the actual data for cost, production and capital expenditure (see Table E.1 of Appendix E) were found to be excessive, therefore in some cases more meaningful estimates of the components might be obtained from a management source.

7.4 Prediction of Share Prices as at 30 June 1984

The price of gold shares in the future will not depend only on the earnings over the 12 months prior to a given date, but will largely depend on the gold price on that date. This is evidenced in the manner in which gold shares react immediately to changes in the gold price. This immediate reaction is simply due to the fact that increased gold prices imply increased expected earnings, thus it is the expected earnings and not the actual earnings that influence the share price.

The same 3 gold price scenarios shown in Table 7.4 will be used to predict share prices for 30 June 1984 here. Accordingly the following component of MODEL 2 will be used for this prediction:

$$\text{Share price}(t) = \{[\text{Gold price}(t) - \text{Cost}(t)].\text{Annual production}(t) + \text{Sundry revenue}(t) - \text{Tax}(t) - \text{Lease}(t) - \text{Capital expenditure}(t)\} \times \frac{k''}{\text{Yield}(t) \times \text{Number of shares in issue}(t)} \qquad (7.5)$$

where k'' is the same as previously defined.

A further assumption concerning the expected yield for 30 June 1984 is required in equation (7.5). Since the expected yield will depend on the economic conditions prevailing at the time, 2 different expected yield scenarios will be considered here. Firstly the yields discussed in Section 6.3 and marked with an asterisk in Tables 6.1 to 6.6 will be considered for the six individual mines. Secondly the last available yields computed using MODEL 2 will be considered, these yields are also discussed in Section 6.3 and can be read off Figures 6.14 to 6.19. The two yield scenarios will be referred to as the average yield and the last yield respectively.

The predicted share prices under the various gold price and yield scenarios are tabulated below for each of the individual mines.

TABLE 7.11 Blyvooruitzicht Gold Mining Company

Components of Share Price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	254,6061	257,0653	259,1567
% Lease payment(R)	8,8581	10,5519	11,1333
% Tax payment	48,4429	50,9006	51,7661
Mining revenue(R)	398 702 880	477 548 300	530 762 664
Distributable earnings(R)	59 874 208	85 807 533	103 108 000
Share price(C) (ave. yield)	2 268	3 250	3 906
(last yield)	2 578	3 694	4 439

TABLE 7.12 Grootvlei Proprietary Mines Limited

Components of Share Price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	294,0512	299,9464	304,9600
% Lease payment(R)	5,5000	8,9049	11,05130
% Tax payment	46,0344	49,1549	50,2074
Mining revenue(R)	114 777 209	137 113 540	151 659 046
Distributable earnings(R)	13 254 720	20 473 937	24 470 208
Share price(C) (ave. yield) (last yield)	 1 158 1 343	 1 789 2 073	 2 139 2 478

TABLE 7.13 Kinross Proprietary Mines Limited

Components of Share Price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	250,7376	253,5984	256,7518
% Lease payment(R)	10,3101	10,8023	10,9720
% Tax payment	48,2707	50,8541	51,7518
Mining revenue(R)	163 809 376	187 144 448	201 025 582
Distributable earnings(R)	24 145 832	32 978 748	38 289 143
Share price(C) (ave. yield) (last yield)	 1 490 1 554	 2 035 2 123	 2 364 2 465

TABLE 7.14 Kloof Gold Mining Company Limited

Components of Share Price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	166,2713	165,7301	165,2699
% Lease payment(R)	13,2944	13,5208	13,6126
% Tax payment	52,1219	53,1477	53,5653
Mining revenue(R)	516 795 968	658 256 520	758 245 248
Distributable earnings(R)	115 936 000	161 402 000	193 857 000
Share price(C) (ave. yield) (last yield)	 3 834 4 625	 5 337 6 432	 6 346 7 656

TABLE 7.15 Western Deep Levels Limited

Components of Share Price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	199,6974	201,8500	203,6807
% Lease payment(R)	6,9222	9,7038	10,5351
% Tax payment	45,7645	49,6706	50,8850
Mining revenue(R)	552 191 840	691 788 168	788 841 656
Distributable earnings(R)	72 963 712	115 352 000	144 791 000
Share price(C) (ave. yield) (last yield)	 3 006 4 139	 4 752 6 543	 5 965 8 213

TABLE 7.16 Winkelhaak Mines Limited

Components of Share price	Gold Price Scenarios		
	Low	Medium	High
Cost(R/oz)	179,7136	181,7380	183,4598
% Lease payment(R)	13,3302	13,5096	13,5839
% Tax payment	52,2809	53,0955	53,4342
Mining revenue (R)	191 219 110	224 522 814	245 621 174
Distributable earnings(R)	40 080 962	50 912 874	57 754 731
Share price(C) (ave. yield) (last yield)	2 861 3 582	3 635 4 550	4 123 5 161

With reference to Tables 7.11 to 7.16 it should again be noted that no attempt to place confidence intervals around the estimates has been made, since the serial correlation coefficients for lags of 1 quarter (see Appendix E) were found to be excessive in many cases. It is thus suggested that contemporaneous expected earnings and expected share prices should be computed by implementing MODEL 2 interactively. Further it should be noted that vastly different share prices were obtained using the two different yield scenarios. The reason for this is that the gold shares were priced at relatively low yields during March 1983, possibly due to the fact that the market was anticipating a higher gold price in the short term. These low yield values tend to overinflate the predicted share prices for 30 June 1984, although if the market has the same yield expectations at 30 June 1984 then the predicted share prices may be realistic.

DIRECTIONS OF FUTURE RESEARCH

In view of the limited fundamental research relating specifically to gold shares that has appeared in the literature as well as some of the interesting findings in this thesis, it is felt further research into this field is warranted. Further, it is felt that the wealth of literature in the fields of Finance and Economics can be implemented extensively in the gold share market using computer-based and statistical techniques.

With reference to this thesis it is felt that MODEL 2 should be programmed to operate interactively. This would imply that all current information would be used to re-estimate not only the estimates of the components of MODEL 2, but would also re-estimate the regression coefficients used to estimate these components. Further this model should be set up for the entire universe of gold shares quoted on the JSE so that it could be viewed as an information service for investors. The informative output should be presented in the form of the expected yields reflected by gold shares so that investors could choose whichever share suited their personal yield preferences. It should be noted that in this regard further research into a method of factoring out the current unique risk reflected in a share's expected yield could be researched.

APPENDIX A

TABLE A.1 : Securities used in Efficiency Study of Chapter 2

1. The Afrikander Lease Ltd.
2. Blyvooruitzicht Gold Mining Co. Ltd.
3. Bracken Mines Ltd
4. Buffelsfontein Gold Mining Co. Ltd.
5. Durban Roodepoort Deep Ltd.
6. Doornfontein Gold Mining Co. Ltd.
7. East Rand Proprietary Mines Ltd.
8. Eastern Transvaal Consolidated Mines Ltd.
9. Drienfontein Consolidated Ltd.
10. Elsburg Gold Mining Company Ltd.
11. Free State Geduld Mines Ltd.
12. The Grootvlei Proprietary Mines Ltd.
13. Harmony Gold Mining Co. Ltd.
14. Hartebeesfontein Gold Mining Co. Ltd.
15. Kinross Mines Ltd.
16. Kloof Gold Mining Co. Ltd.
17. Leslie Gold Mines Ltd.
18. Libanon Gold Mining Co. Ltd.
19. Loraine Gold Mines Ltd.
20. Marievale Consolidated Mines Ltd.
21. President Brand Cold Mining Co. Ltd.
22. The Randfontein Estates Gold Mining Co. Witwatersrand Ltd.
23. The South African Land and Exploration Co. Ltd.
24. Southvaal Holdings Ltd.
25. St Helean Gold Mining Company Ltd.
26. Stlifontein Gold Mining Co. Ltd.
27. Vaal Reefs Exploration and Mining Co. Ltd.
28. Venterspost Gold Mining Co. Ltd.
29. Village Main Reef Gold Mining Company (1934)
30. Vlakfontein Gold Mining Co. Ltd.
31. West Rand Consolidated Mines Ltd.
32. Welkom Gold Mining Co. Ltd.
33. Western Areas Gold Mining Co. Ltd.
34. Western Holdings Ltd.
35. Winkelhaak Mines Ltd.
36. Western Deep Levels Ltd.
37. Zandpan Gold Mining Co. Ltd.

B.1

APPENDIX B

TABLE B.1 : Case 1 (Zero)

		A_1	A_2	t_{A2}	B_1	B_2	t_{B2}	R^2_{adj}	F Ratio	SIMM F Ratio	F test increase in R^2
1.	Amic	.00374	-0.0014	-0.2709	1.0659	-.2182	-1.0349	.3291	51.146	101.960	.5500
2.	ATI	.0031	-.0119	-1.6322	.8760	.5314	1.8286	.2128	28.532	53.227	3.2554*
3.	Barlows	-.0013	-.0004	-.6690	1.2402	.2532	1.0124	.4703	75.248	150.322	.4951
4.	Calan	-.0009	.0008	.1012	1.1746	.4193	1.2953	.3120	47.336	93.908	.8343
5.	Fed. Volks	.0092	-.0119	-1.6193	1.5940	-.2036	-.6946	.3327	51.983	102.253	1.4746
6.	Ind Com	.0052	.0030	.4069	3422	-.3538	-1.2096	.0110	1.889	2.922**	.8493
7.	Malbak.	.0116	-.0028	-.2422	.8720	-.5863	-1.2978	.0328	4.234	7.621	.8690
8.	W & A	.0097	-.0135	-1.1353	1.6106	-.0358	-.0756	.1727	22.201	43.834	.6443
9.	S.A. Brews	-.0053	.0050	.9666	1.1762	.3577	1.7376	.5440	123.320	243.759	1.8430
10.	Boumat.	-.0013	.0147	1.5118	.9566	-.2891	-.7461	.1544	19.504	37.398	1.5029
11.	Everite	.0002	.0059	1.1876	.1691	-.1162	-.5808	.0234	3.207	5.483	.9236
12.	Grinaker	-.0045	.0112	1.3719	.6889	.0969	.3039	.1613	20.505	40.056	.9532
13.	L.T.A.	-.0033	-.0013	-.1230	.9687	.4020	.9701	.1550	19.591	38.789	.4652
14.	M & R	-.0064	.0026	.3236	.9122	.5387	1.7105	.2679	38.354	75.050	1.5121
15.	Plate Gl.	.0031	-.0011	-.1715	1.0530	-.1531	-.6112	.2658	37.951	76.006	.1955
16.	P.P. Cemnt.	-.0049	.0084	1.4013	.5252	.1143	.4818	.1605	23.389	45.714	1.0506
17.	AECI	.0042	-.0109	-2.1986*	.9055	.1845	.9358	.3062	46.106	88.306	3.0139*
18.	Chemkold.	.0001	.0105	1.1910	.3134	-.6349	-1.2664	.0066	1.434	1.228**	1.6509
19.	Sentrchem	-.0056	.0014	.2106	.4490	.6929	2.6594*	.1962	25.830	47.536	3.5451
20.	Rex True	.0070	-.0005	-.0537	.6444	-.3502	-1.0502	.0432	5.388	10.247	.5571
21.	Rex True A	.0026	.0073	.8210	.6124	-.2801	-.7911	.0619	7.535	14.386	.6993
22.	Afcol	.0002	.0042	.4794	1.4082	-.3017	-.8620	.2622	37.261	74.174	.5279
23.	Russels	.0007	-.0006	-.0625	1.5901	.2317	.6560	.3609	58.773	117.771	.2245
24.	Aberdare	-.00157	.0021	.3614	.1570	.1107	.4703	.0196	2.803	5.464*	.1463
25.	Af Cable	.0049	-.0002	-.0426	.3100	-.2641	-1.523	.0251	3.393	5.619*	1.1565
26.	Afrox	.0028	-.0067	-.9739	.9935	-.0216	-.0794	.2040	27.079	53.821	.4893
27.	Asea	.0036	-.0092	-1.1120	.7973	.1605	.4882	.1066	13.013	25.268	.7801
28.	Claude NE	.0080	.0103	.9565	1.1966	-1.1521	-2.7067*	.09413	11.427	18.213	4.3221*
29.	Cullinan	.0052	-.0036	-.4845	.4380	-.2182	-.7355	.0156	2.383	4.417*	0.3540
30.	Dorbyl	.0025	-.0017	-.2882	.6833	-.1882	-.7922	.1199	14.752	29.258	.3494
31.	Dunswart	.0010	.0043	.5972	.6297	-.2189	-.7695	.0935	11.351	22.242	.4975
32.	Natal Trdg.	.0169	-.0118	-1.6739	.9003	-.1436	-2.6581*	.0543	6.652	8.533	4.6171**
33.	Rennert L	.0133	-.0127	-1.9854*	.9099	-.4112	-1.6217	.1003	12.204	21.138	3.0533*
34.	Rennert A	.01681	-.0176	-2.3627*	.7908	-.4499	-1.5165	.03535	4.515	5.274*	3.6764*
35.	Scot Cabl	.0032	.0085	1.4395	.4336	-.4489	-1.9143	.0603	7.342	11.468	3.0757*
36.	Steelmetl	.0069	.0024	.2691	.7943	-.4250	-1.1840	.0683	8.280	15.811	.7701
37.	Stew Lloyd	.0028	-.0068	-.8429	.7666	.4079	1.2693	.1486	18.689	36.084	1.2521
38.	Unisteel	-.0096	.0108	1.4512	.3642	.4651	1.5728	.1411	17.636	32.964	2.1242
39.	Asseng.	.0039	-.0116	-1.5884	.4605	.1593	.5494	.0361	4.597	7.688	1.4886
40.	Curries	-.0004	.0026	.3485	.5375	-.0484	-.1608	.07239	8.769	17.539	.0884
41.	Dunlop	-.0000	.0068	.8135	.8751	-.3764	-1.1291	.1245	15.358	29.665	1.0536
42.	Gen Tire	.0022	.0003	.0342	.6897	-.1297	-.4394	.09695	11.781	23.568	.0908
43.	Gen Tire B	.0027	-.0005	-.0667	.7209	-.1356	-.4601	.1023	12.461	24.924	.1142
44.	McCarthy	.0042	-.0013	-.1650	1.0853	.0591	.18786	.2269	30.909	62.078	.0530
45.	Toyota	.0036	-.0042	-.4910	1.3079	.0024	.0072	.2462	34.308	68.789	.1359
46.	Kohler	.0054	-.0026	-.3576	.2970	-.1734	-.6110	.0033	1.092	1.956**	.2262
47.	Metal Box	.0043	-.0053	-.7978	.6698	.0241	.0907	.1078	13.172	26.099	.3447
48.	Sappi	-.0047	.0071	1.0017	.6348	.1673	.5933	.1727	22.200	43.843	

* Exceeds the critical value at a 5% significance level.

** Exceeds the critical value at a 1% significance level.

TABLE B.2 : Case 2 (S.D.)

		A_1	A_2	tA_2	B_1	B_2	tB_2	R^2 adj	F Ratio	F-test increase in R^2
1.	Amic	.0091	-.0063	-.5819	1.2135	-.3913	-1.1529	.3962	40.770	.8853
2.	ATI	.0023	-.0209	-1.4947	.8548	.82300	1.8595	.2877	25.394	2.6268
3.	Barlows	.0028	-.0029	-.2425	1.3473	.1024	.2701	.5205	66.977	.0507
4.	Calan	.0117	-.0130	-.7799	1.4837	.1669	.3171	.3675	36.193	.3457
5.	Fed. Volks	.0047	-.0130	-.9185	1.4636	.0895	.1999	.4254	45.902	.4228
6.	Ind & Com	.0126	.0016	.1044	.5238	-.7040	-1.4955	.0143	1.638	1.1217
7.	Malbak.	-.0032	.0167	.8606	.5277	-.3723	-.6092	.0666	5.099	.5076
8.	W & A	-.0063	-.0128	-.5467	1.2432	.7308	.9881	.2333	19.315	.6022
9.	S.A. Brews	-.0082	.0029	.2961	1.1035	.5897	1.8531	.6332	106.034	1.8217
10.	Boumat.	.0102	-.0045	-.2632	1.2344	-.3644	-.6697	.2186	17.812	.2798
11.	Everite	-.0069	.0125	1.2804	-.0223	.0903	.2938	.0293	2.588	.9011
12.	Grinaker	-.0159	.0408	2.7047**	.4017	-.1739	-.3657	.2436	20.393	3.6622*
13.	L.T.A.	-.0136	.0139	.6664	.7149	.4947	.7522	.2017	16 165	.5479
14.	M & R	-.0070	.0123	.7848	.8944	.2961	.5971	.3346	31.417	.5112
15.	Plate Gl.	-.0004	.0194	1.5168	.9499	-.6376	-1.3310	.3330	31.198	1.8761
16.	P.P. Cemnt.	-.0058	.0123	1.0338	.5057	.0520	.1386	.2276	18.721	.5663
17.	A E C I	.0060	-.0215	-2.2664*	1.0108	.2817	.9421	.4091	42.979	2.8371
18.	Chemhold.	-.0075	.0359	2.4564*	.1323	-.8260	-1.7917	.0456	3.667	4.2641*
19.	Sentrchem	-.0124	-.0027	-.2186	.2601	1.1742	2.9824	.2638	22.618	4.4231*
20.	Rex True	.0207	-.0140	-.8337	.9947	-.7138	-1.3487	.0601	4.654	1.3573
21.	Rex True A	.0077	-.0011	-.0635	.7575	-.3492	-.6432	.0797	6.039	.2112
22.	Afcol	-.0120	.0203	1.2334	1.0904	-.1342	-.2592	.3534	34.096	.7704
23.	Russels	.0076	-.0046	-.2548	1.7495	-.0075	-.0133	.4278	46.365	.0425
24.	Aberdare	-.0183	.0287	2.7528**	-.2499	.2149	.6539	.0689	5.267	4.1627*
25.	Af-Cable	.0032	.0072	.7504	.2652	-.3815	-1.2592	.02778	2.492	.9997
26.	Afrox	.0013	-.0106	-.8446	.9505	.1325	.3348	.2860	25.187	.3914
27.	Asea	-.0004	-.0056	-.3368	.7166	.2925	.5610	.1526	11.735	.2007
28.	Claude NE	.0036	.0241	1.1874	1.0845	-1.3359	-2.0885*	.1244	9.419	2.6919
29.	Cullinan	-.0068	.0173	1.1667	.1425	-.1846	-.3959	.0280	2.510	.7250
30.	Dorbyl	-.0024	.0200	1.6371	.5662	-.5571	-1.4467	.1696	13.207	2.1946
31.	Dunswart	-.0017	.0051	.3938	.5547	-.1307	-.3189	.1322	10.039	.1112
32.	Natal Trdg.	.0159	-.0069	-.5949	.8748	-.8679	-2.372*	.0912	6.869	3.1146*
33.	Rennert L	.0039	-.0031	-.2676	.6654	-.1507	-.4168	.1587	12.255	.1299
34.	Rennert A	.0099	-.0226	-1.6509	.6199	.0670	.1554	.0479	3.819	1.3526
35.	Scot Cabl	-.0090	.0296	3.1458**	.1220	-.3862	-1.3036	.1357	10.329	5.4826**
36.	Steelmetl	.0108	-.0204	-1.2722	.9066	-.0000	-.0001	.1096	8.256	.8050
37.	Stew Lloyd	.0100	-.0153	-.9950	.9491	.2358	.4865	.2026	16.250	.5789
38.	Unisteel	-.0275	.0229	1.6979	-.0825	1.0606	2.4953	.2245	18.405	4.9191**
39.	Asseng.	-.0051	.0045	.3234	.2294	.20307	.4585	.0527	4.140	.1667
40.	Curries	-.0007	-.0082	-.6059	.5307	.2626	.6187	.11487	8.667	.3569
41.	Dunlop	.0069	-.0203	-1.3024	1.0573	.0156	.0317	.1746	13.654	.8538
42.	Gen Tire	-.0044	.0002	.0153	.5304	.2227	.5119	.1483	11.374	.1284
43.	Gen Tire B	-.0091	.0143	1.0087	.4274	.0674	.1506	.1523	11.712	.5303
44.	McCarthy	.00845	-.0112	-.7057	1.19496	.0752	.1499	.2765	24.072	.2519
45.	Toyota	.0015	-.01195	-.7312	1.2678	.3295	.63966	.3343	31.378	.4380
46.	Kohler	-.0027	.0139	1.0289	.0969	-.2058	-.4820	.0107	1.410	.6140
47.	Metal Box	-.0020	.0089	.7179	.5262	-.0656	-.1672	.1704	13.2819	.2636
48.	Sappi	-.0114	.0118	.8704	.4722	.3920	.9177	.2393	19.940	.0933

TABLE B.3 : Case 3 (VIS)

		A_1	A_2	tA_2	B_1	B_2	tB_2	R^2 adj	F Ratio	F test increase in R^2
1.	Amic	.0007	-.0006	-1.4464	.9308	.0805	.4512	.3116	39.792	.1249
2.	ATI	.0032	-.0027	-.5176	.9263	.1520	.6528	.2101	23.689	.3049
3.	Barlows	.0007	-.0004	-.0821	1.2757	.2619	1.2694	.4077	60.108	.8130
4.	Calan	.0032	.0017	.2783	1.3383	.0061	.0226	.2811	34.479	.0479
5.	Fed. Volks	.0015	-.0016	-.2981	1.3089	.1394	.5776	.3301	43.258	.2054
6.	Ind & Com	-.0012	.0107	2.1367*	.2207	-.2616	-1.1819	.0199	2.502	2.6323
7.	Malbak	.0003	.0195	2.296 *	.7409	-1.0838	-2.8941*	.0560	5.8667	5.8849**
8.	W & A	.0006	.0011	.1320	1.3966	-.0662	-.1702	.1646	17.744	.0206
9.	S A Brews	.0014	-.0004	-.1148	1.3728	.1219	.7219	.5273	96.944	.2547
10.	Boumat	.0017	.0088	1.2239	1.1268	-.3896	-1.2181	.1516	16.161	1.2772
11.	Everite	.0011	.0008	.2232	.1224	.1166	.7361	.0095	1.574	.3299
12.	Grinaker	.0003	.0076	1.2578	.8929	-.0844	-.3158	.1553	16.609	.7942
13.	L.T.A.	-.0033	.0031	.4079	.9427	.2812	.8428	.1312	13.780	.5148
14.	M & R	-.0019	.0068	1.1403	1.1916	-.3139	-1.1904	.2316	26.743	1.1639
15.	Plate Gl.	-.0023	.0083	1.7778	.8892	.1480	.7144	.2657	31.954	2.1081
16.	P.P. Cemnt.	-.0016	.0048	1.1349	.6255	-.0736	-.3771	.1544	16.503	.6917
17.	A E C I	.0036	-.0063	-1.7361	.8908	-.2318	-1.4564	.2927	36.442	3.0394*
18.	Chemhold.	.0018	.0001	.0059	.1487	.1891	.4419	.0045	.3611	.1027
19.	Sentrchem	.0023	.0001	.0352	.7694	-.1742	-.8289	.1542	16.479	.3661
20.	Rex True	-.0031	.0134	2.1800*	.4528	.2667	.9862	.0819	8.4426	3.2972*
21.	Rex True A	-.0039	.0145	2.1631	.4449	.6191	2.0991*	.1007	10.404	5.4124**
22.	Afcol	-.0011	.0044	.6950	1.3769	-.2414	-.8578	.2641	31.708	.5142
23.	Russels	-.0033	.0138	2.1534*	1.5775	-.0984	-.3492	.3516	47.529	2.3080
24.	Aberdare	-.0012	.0026	.5983	.1549	.1274	.6562	.0118	1.779	.4699
25.	Af Cable	.0013	.0023	.6348	.1740	.0816	.5599	.0265	3.098	.4771
26.	Afrox	.0006	-.0059	-1.1869	.8224	.0232	.1051	.1722	18.696	.7064
27.	Asea	.0006	-.0031	-.5140	.7312	.1069	.4082	.1102	11.431	.1739
28.	Claude NE	.0011	.0012	.1508	.7699	.3237	.9418	.0886	9.136	.4907
29.	Cullinan	.0007	.0012	.2267	.3039	-.1269	-.5231	.01288	1.875	.1568
30.	Dorbyl	-.0021	.0015	.3590	.5316	-.0181	-.0976	.1117	11.5995	.0775
31.	Dunswart	.0011	.0034	.6574	.6878	-.3377	-1.4774	.1027	10.617	1.1884
32.	Natal Trdg.	.0057	.0004	.0745	.5905	-.6208	-2.6548*	.0607	6.324	3.5891*
33.	Rennert L	-.0015	.0092	1.9513	.5219	-.2519	-1.2113	.0895	9.2326	2.3048
34.	Rennert A	-.0022	.0114	2.1268*	.3083	-.2117	-.8928	.0317	3.5766	2.4159
35.	Scot Cabl.	.0033	.0012	.2759	.3223	.1234	.6411	.0482	5.1204	.2891
36.	Steelmetl	.0051	-.0029	-.4588	.6084	-.2451	-.8828	.0502	5.3131	.5795
37.	Stew Lloyd	.0037	.0057	.3816	.1286	.2531	1.7369	.1678	18.1523	1.7155
38.	Uristeel	.0019	-.0044	-.8509	.7224	-.0805	-.3451	.1157	12.0310	.4862
39.	Asseng.	-.0028	.0022	.4146	.3279	-.3166	-1.3751	.0159	2.1521	.9614
40.	Curries	-.0048	.0081	1.6823	.3614	.3725	1.7508	.0940	9.701	3.5121*
41.	Dunlop	-.0015	.0015	.2493	.8128	-.0089	-.0344	.1334	14.0284	.0198
42.	Gen Tire	-.0050	.0125	2.3578*	.6114	-.3542	-1.5104	.0989	10.2133	3.4165*
43.	Gen Tire B	-.0046	.0099	1.8976	.5786	-.0747	-.3251	.1037	10.7291	1.8038
44.	McCarthy	.0013	.0081	1.4527	1.0262	-.2293	-.9310	.2119	23.9475	1.2877
45.	Toyota	.0022	.0009	.1427	1.3332	-.2238	-.8130	.2550	30.2731	.3232
46.	Kohler	-.0014	.0057	1.1058	.0288	.2662	1.1752	.0058	1.2524	1.5396
47.	Metal Box	.0006	.0025	.5168	.5656	.0394	.1875	.1071	11.0984	.1734
48.	Sappi	.0009	-.0003	-.0648	.7876	-.0122	-.0530	.1528	16.3060	.0203

TABLE B.4 : Case 4 (RISK - F)

		A_1	A_2	tA_2	B_1	B_2	tB_2	R^2	F Ratio	F test increase in R^2
1.	Amic	.0019	.0135	.6642	.9277	- .1996	- .6567	.5502	27.525	.3067
2.	ATI	.0095	.0174	.5998	.8938	- .4325	- .9968	.3195	10.565	.51661
3.	Barlows	- .0037	.0214	.7588	1.3509	- .0552	- .1308	.6125	35.567	.2986
4.	Calan	.0195	- .0229	- .5948	1.4013	.1987	.3461	.4293	16.923	.1871
5.	Fed. Volks	.0147	.0101	.3549	1.6209	- .6729	-1.5818	.5903	32.418	1.2708
6.	Ind & Com	.0089	.0371	1.0549	.3849	- .4465	- .8493	.0645	2.079**	.6659
7.	Malbak	.0297	- .0077	- .2241	1.0724	- .4193	- .8101	.2681	8.2435	.4864
8.	W & A	.0368	- .0026	- .0534	1.8509	-1.0813	-1.4668	.3264	10.903	1.2816
9.	S A Brews	- .0046	.0031	.1372	1.1673	.2713	.7967	.6642	44.497	.4373
10.	Boumat	- .0085	.0676	1.8280	.8986	- .2897	- .5244	.3837	14.010	1.6679
11.	Everite	- .0006	.0064	.2518	.0992	.3084	.8104	.0733	1.779**	.5090
12.	Grinaker	- .0174	.0571	1.6528	.6449	.0341	.0661	.3434	11.769	1.6266
13.	L.T.A.	- .0063	- .0046	- .1274	.9763	.1907	.3512	.3267	10.917	.0595
14.	M & R	- .0033	.0114	.3506	1.2333	- .0664	- .1366	.4768	20.50	.0681
15.	Plate Gl	.0038	.0220	.8953	1.3342	- .3334	- .9075	.6323	38.698	.5809
16.	P.P. Cement	- .0049	.0201	.6878	.7408	- .0664	- .1526	.3271	10.935	.2447
17.	A.E.C.I.	.0086	- .0189	- .9941	.7882	- .0574	- .2023	.4216	16.3976	.6847
18.	Chemhold	.0058	- .0355	-1.1657	.6109	.5154	1.1341	.2201	6.348	.9471
19.	Sentrchem	.0095	- .0204	- .7913	.8049	.2719	.7076	.3749	13.499	.4058
20.	Rex True	.0352	.0124	.2629	1.1079	- .9222	-1.3093	.1533	4.075	.8777
21.	Rex True A	.0063	.0317	.7365	.8643	- .1431	- .2227	.2412	7.151	.2697
22.	Afcol	- .0106	.0118	.2977	1.1913	.0802	.1350	.3884	14.290	.0800
23.	Russels	.0140	- .0290	- .7810	1.6730	.3610	.6508	.5482	27.299	.3742
24.	Aberdare	- .0186	.0222	.7098	.0500	.4375	.9383	.0973	2.425**	1.0944
25.	Af. Cable	.0199	- .0222	-1.0919	.4635	.0203	.0669	.1583	4.233	.6609
26.	Afrox	- .0097	- .0448	-1.7192	.7158	.9473	2.4363*	.4294	16.931	3.2989*
27.	Asea	.0022	.0055	.1313	.7528	- .1434	- .2275	.1494	3.9522	.0262
28.	Claude NE	- .0031	.0744	2.0221*	.9249	- .9973	-1.8151	.2990	9.598	2.6535
29.	Cullinan	.0326	- .0539	-1.5470	.6536	- .1661	- .3192	.0693	1.674**	1.6639
30.	Dorbyl	.0031	.0452	1.5443	.8979	- .9029	-2.0658*	.3140	10.299	2.4391
31.	Dunswart	- .0187	.0205	.6109	.8148	.5788	1.1506	.4354	17.348	1.2926
32.	Natal Trdg.	.0151	.0370	1.3838	.7364	- .7245	-1.8144	.2724	8.426	1.9021
33.	Rennert L	.0307	- .0085	- .2688	.9965	- .6162	-1.2999	.2305	6.738	1.1739
34.	Rennert A	.0266	.0113	.3397	.7965	- .8000	-1.6062	.1451	3.820	1.3169
35.	Scot Cabl.	.0136	.0500	1.8669	.5609	- .7813	-1.9514	.2124	6.067	2.6159
36.	Steelmetl	.0337	- .0374	- .8803	.8399	.0297	.0468	.1273	3.283	.42833
37.	Stew Lloyd	.0170	- .0527	-1.5431	.9496	.7399	1.4507	.3436	11.774	1.6065
38.	Unisteel	- .0135	.0002	.0080	.6537	.5937	1.4309	.4036	15.224	1.1938
39.	Asseng	- .0163	.0905	2.3379*	.2165	-1.1161	-1.9315	.0894	2.208	3.3279*
40.	Curries	- .0101	.0413	1.4088	.6533	- .3001	- .6862	.2966	9.488	.99325
41.	Dunlop	- .0125	.0131	.4083	.7913	.0603	.1254	.3165	10.4189	.13021
42.	Gen. Tyre	.0005	.0608	1.8994	.8879	- .9645	-2.0180*	.3085	10.039	2.7478
43.	Gen Tyre B	.0031	.0682	2.0307*	.9818	-1.1738	-2.3423	.3180	10.492	3.4647*
44.	McCarthy	.0303	.0058	.2039	1.5334	- .5656	-1.3256	.5645	29.169	.9196
45.	Toyota	- .0025	.0148	.3804	1.0402	- .0327	- .0561	.3265	10.905	.0793
46.	Kohler	.0230	.0266	.7719	.7326	- .9403	-1.8272	.1299	3.361	1.6519
47.	Metal Box	.0124	- .0135	- .4453	.8216	.0491	.1079	.2761	8.579	.1045
48.	Sappi	- .0066	.0525	1.7983	.6059	- .6236	-1.4295	.2441	7.2649	1.9191

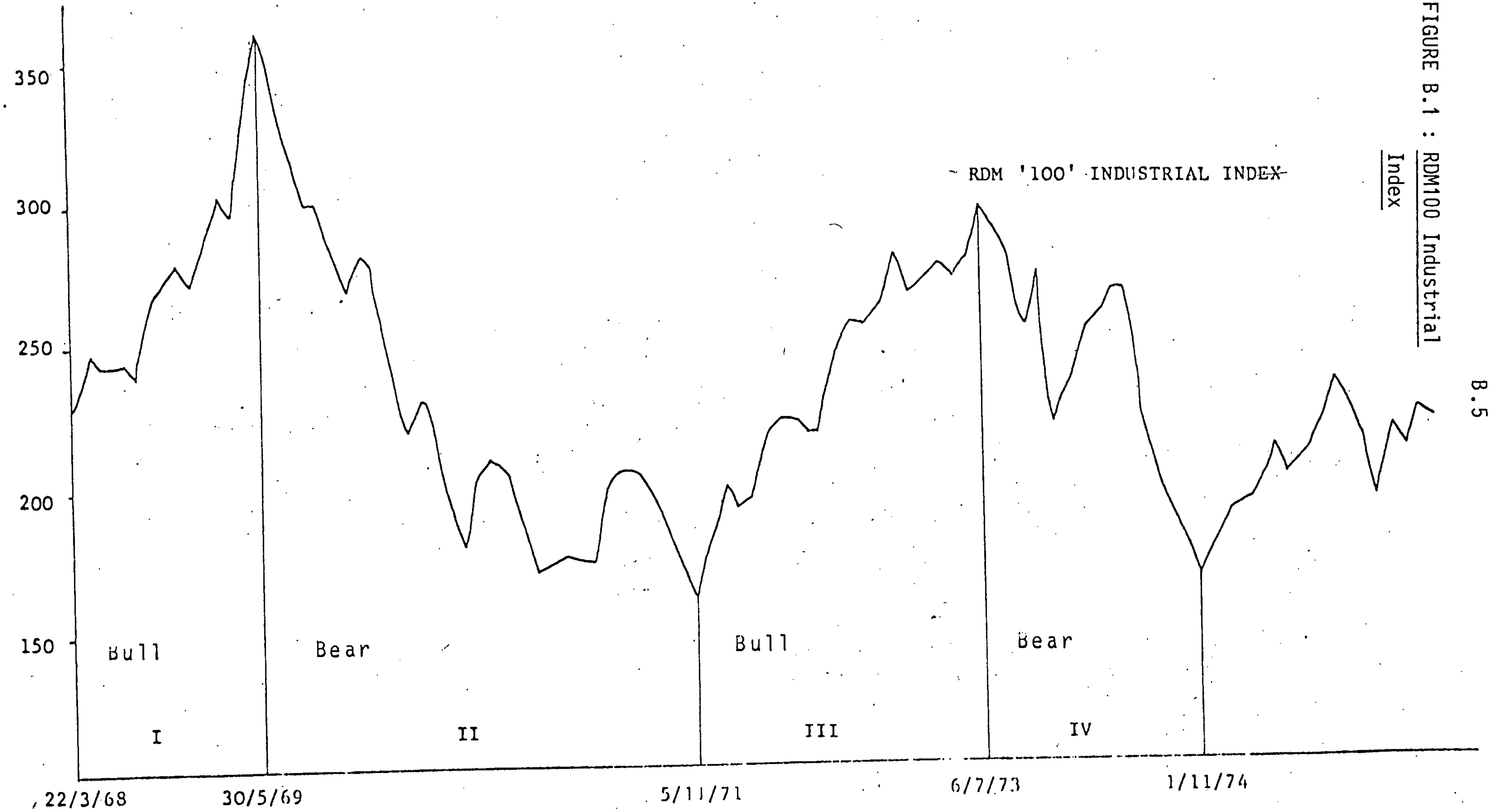


FIGURE B.1 : RDM100 Industrial Index

APPENDIX C

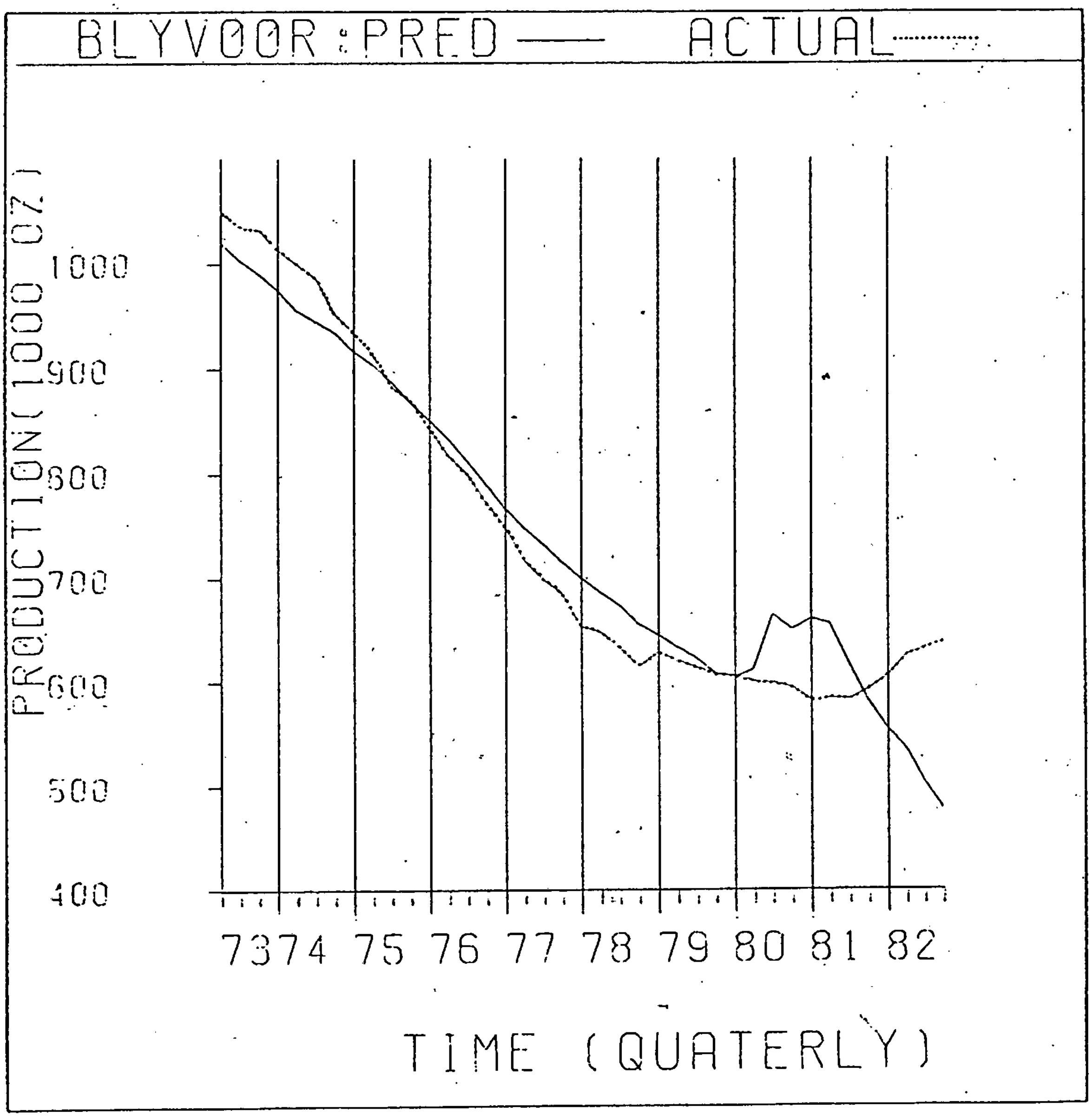


FIGURE C.1

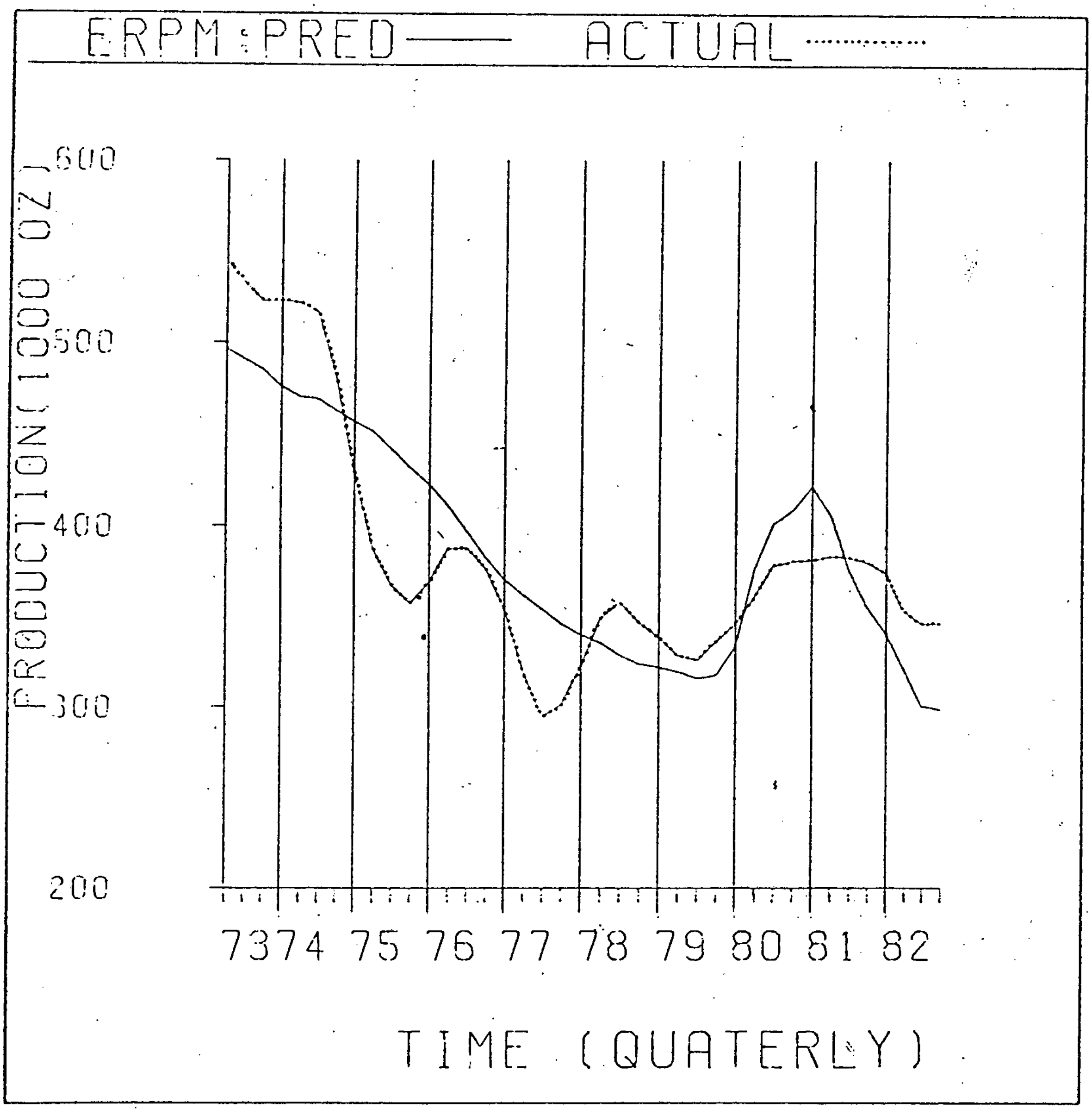

ERPM : PRED
ACTUAL
PRODUCTION(1000 OZ)
600
500
400
300
200
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE C.2

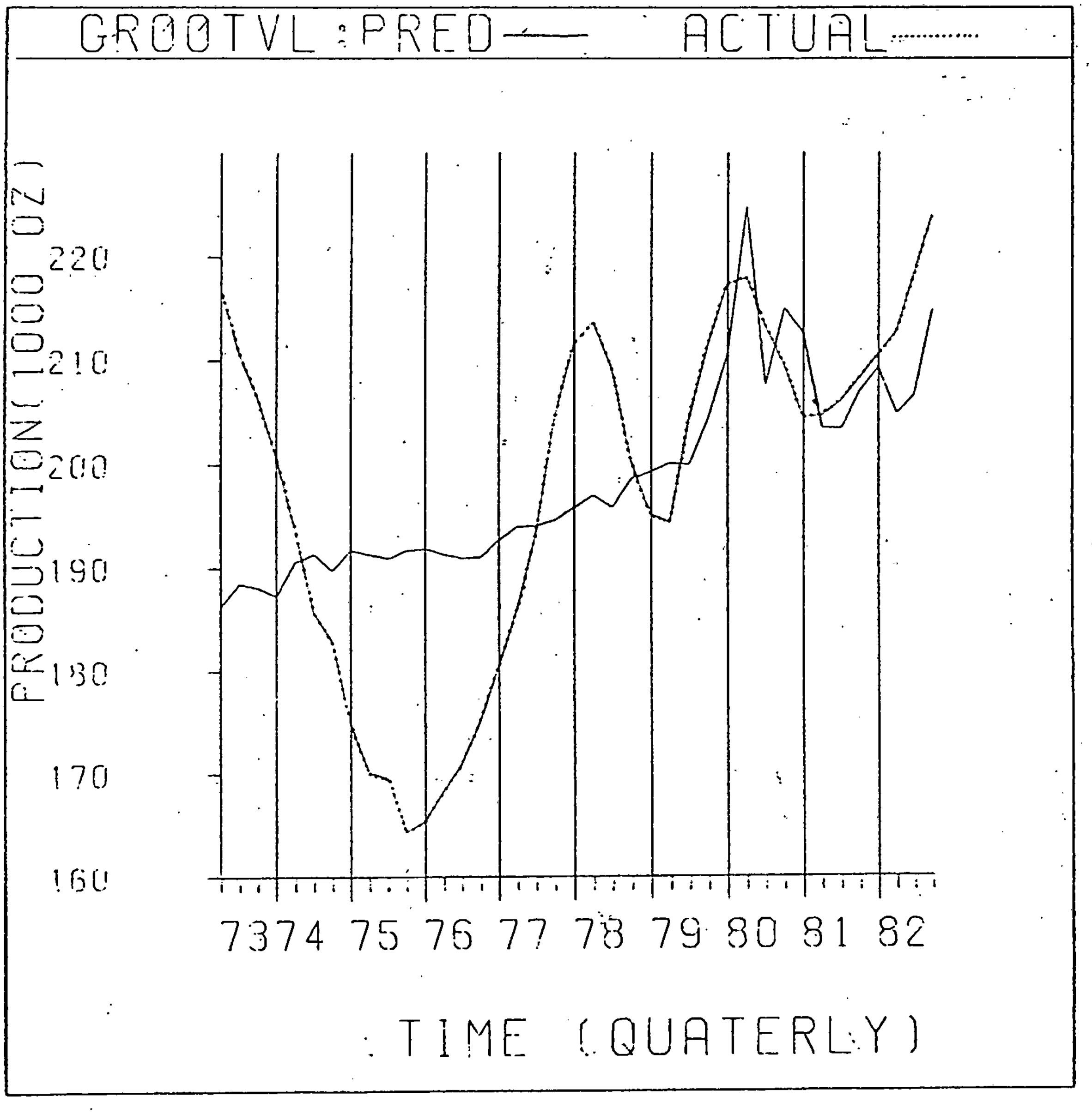

GROOTVL : PRED
ACTUAL
PRODUCTION (1000 OZ)
220
210
200
190
180
170
160
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE C.3

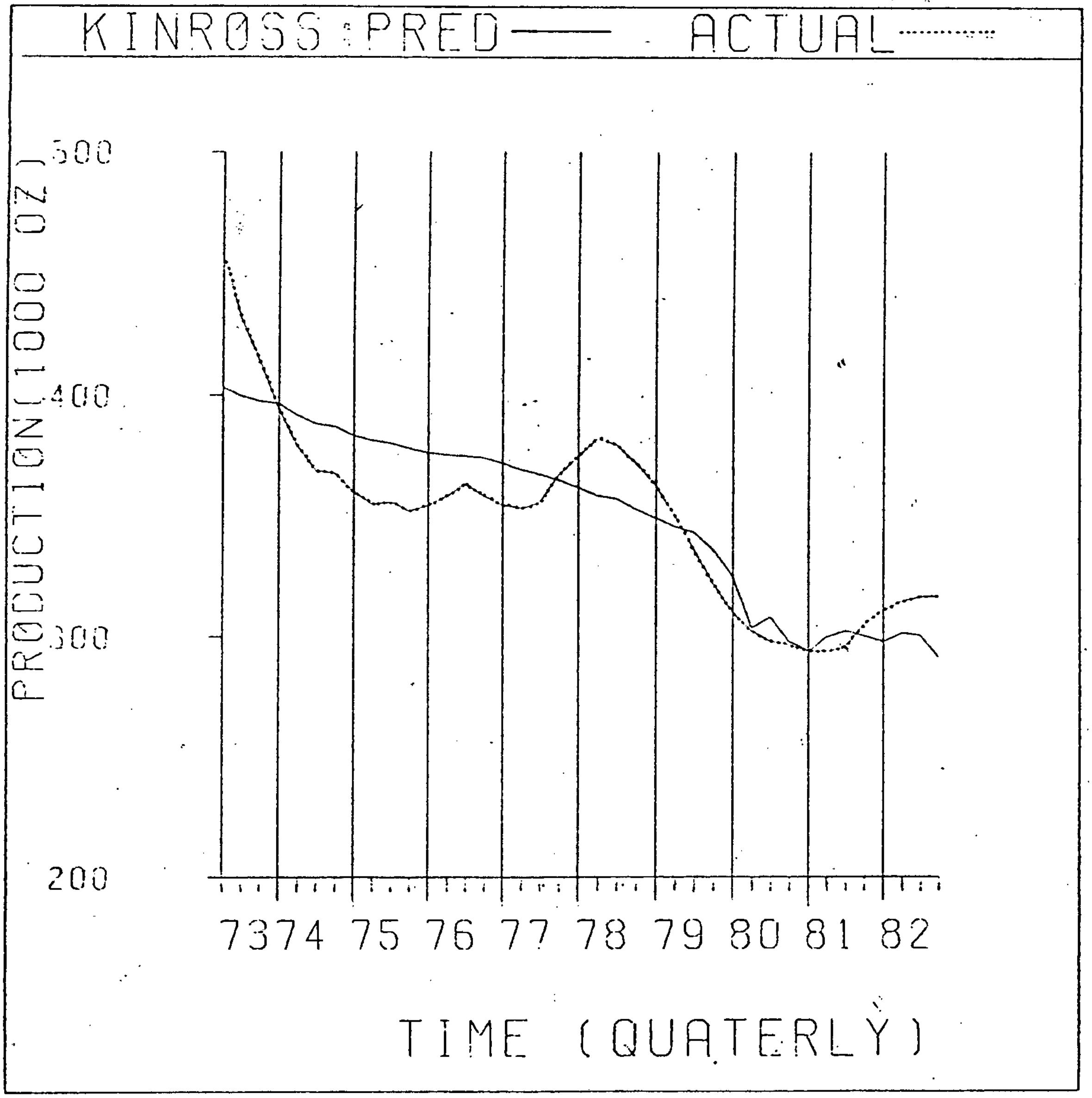

KINROSS:PRED—— ACTUAL········
PRODUCTION(1000 OZ)
500
400
300
200
7374 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE C.4

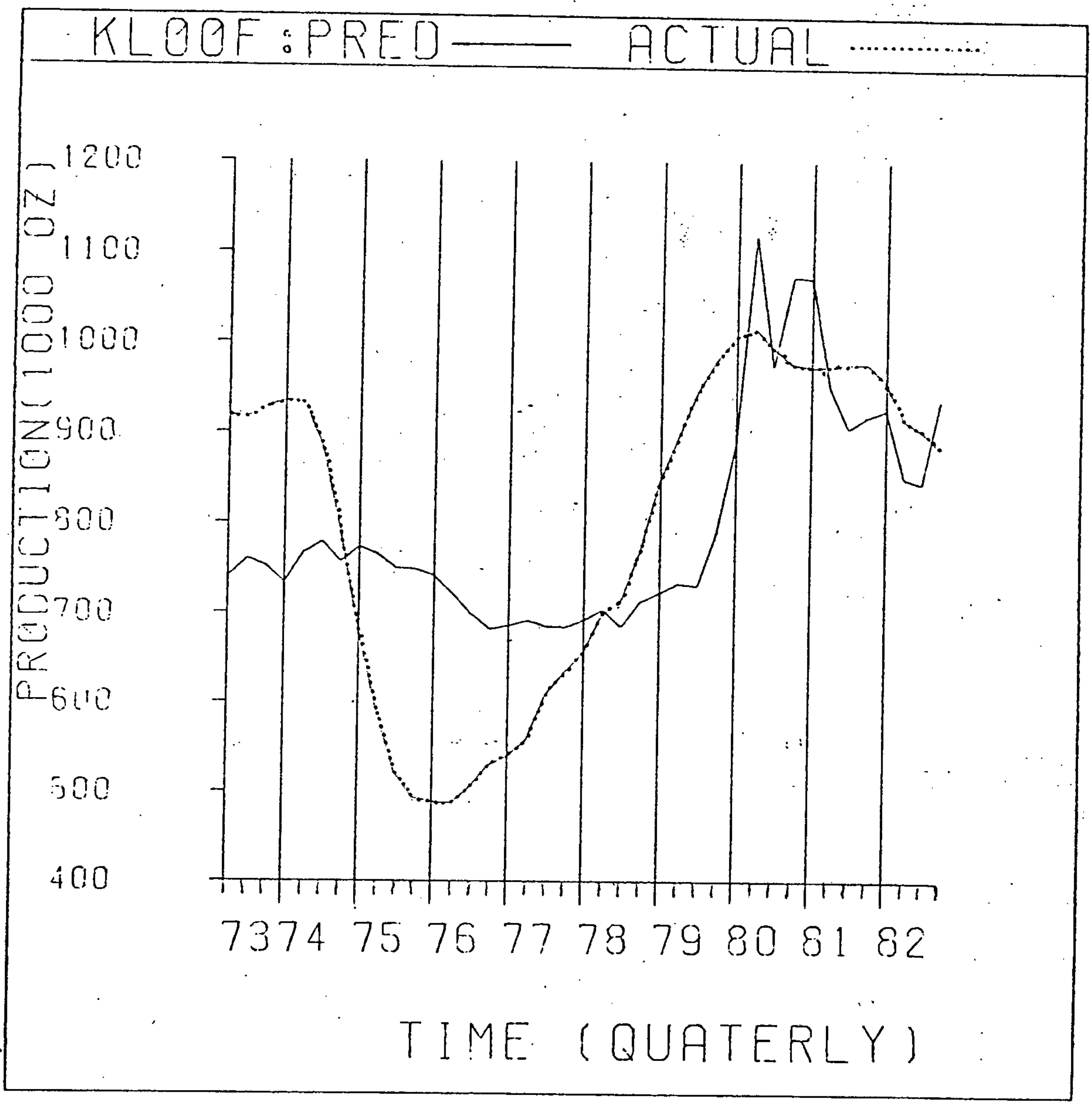

KLOOF : PRED —— ACTUAL ....
PRODUCTION(1000 OZ)
1200
1100
1000
900
800
700
600
500
400
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE C.5

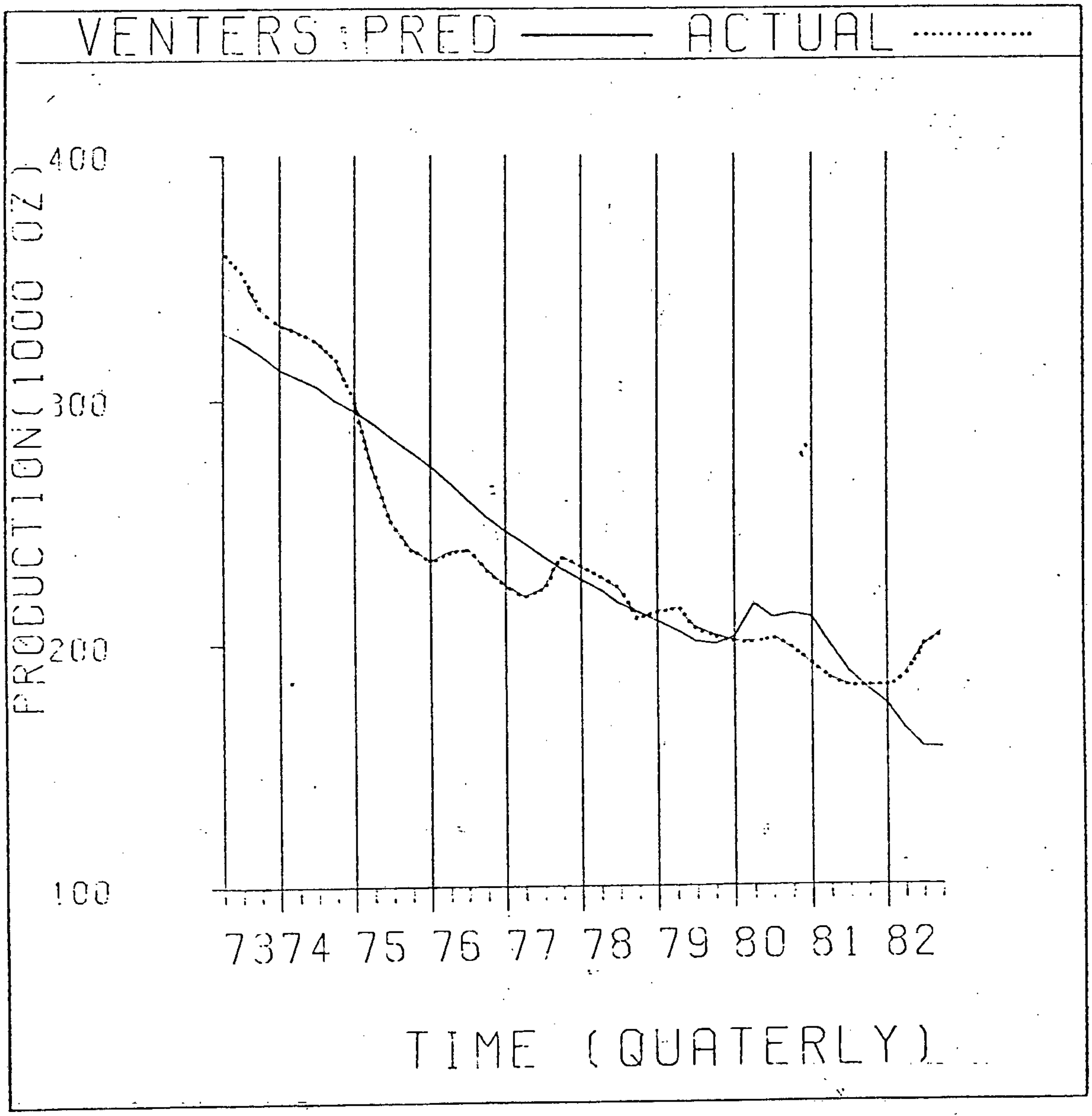

VENTERS:PRED ——— ACTUAL ....
PRODUCTION(1000 OZ)
400
300
200
100
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE C.6

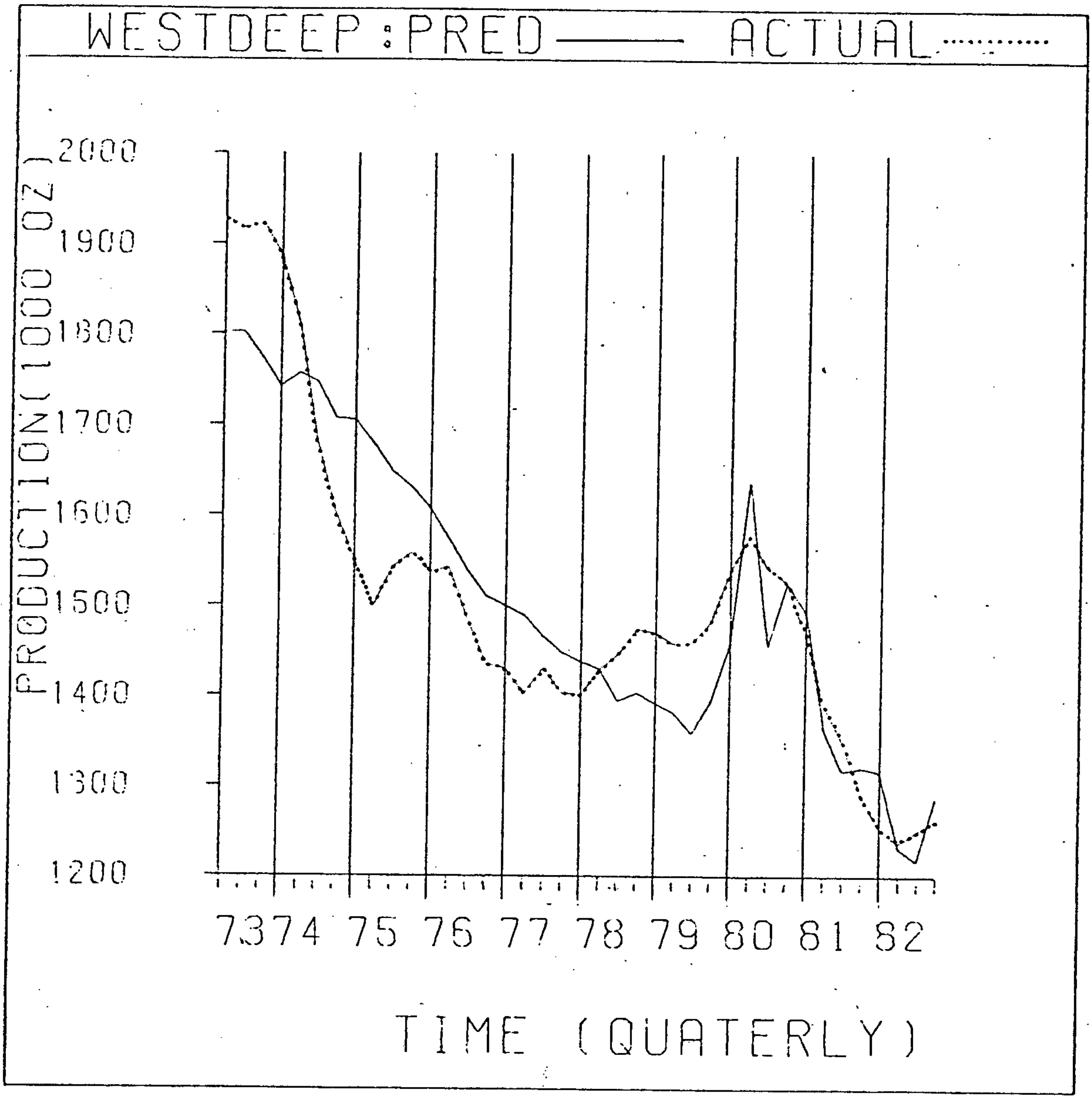

WESTDEEP:PRED —— ACTUAL ········
PRODUCTION(1000 OZ)
2000
1900
1800
1700
1600
1500
1400
1300
1200
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE C.7

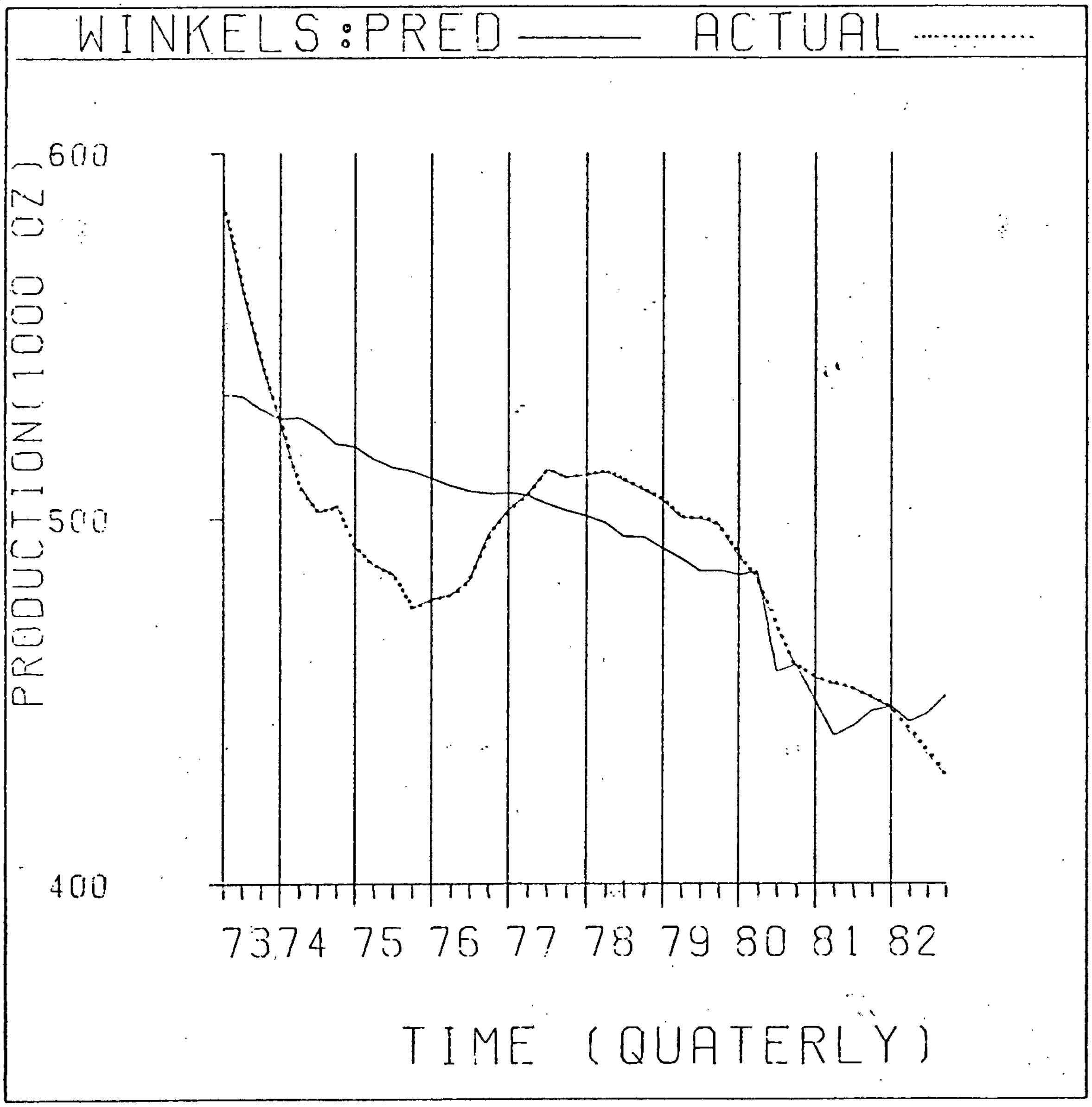

WINKELS:PRED ——— ACTUAL ....
PRODUCTION(1000 OZ)
600
500
400
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE C.8

APPENDIX D.1

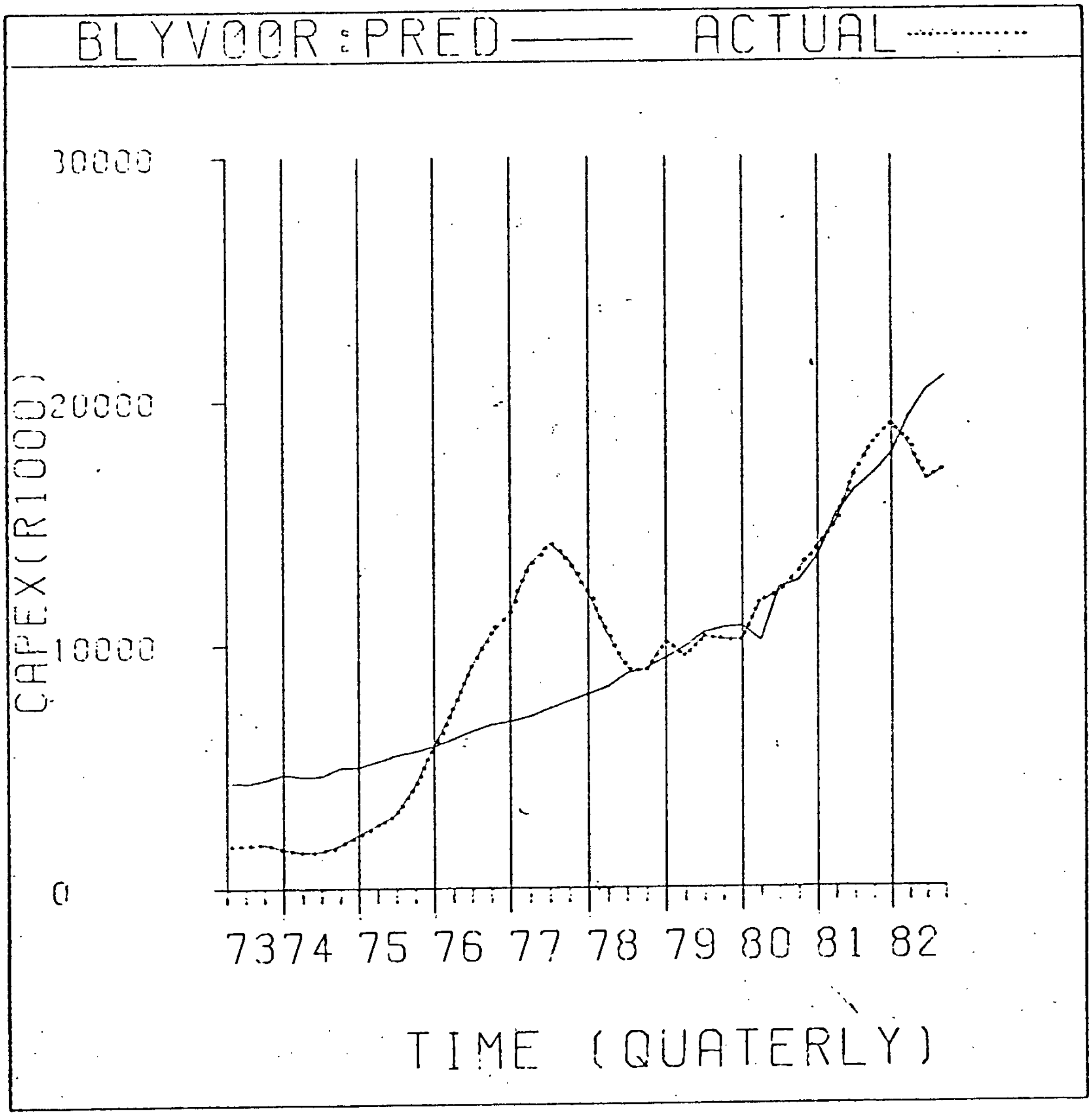
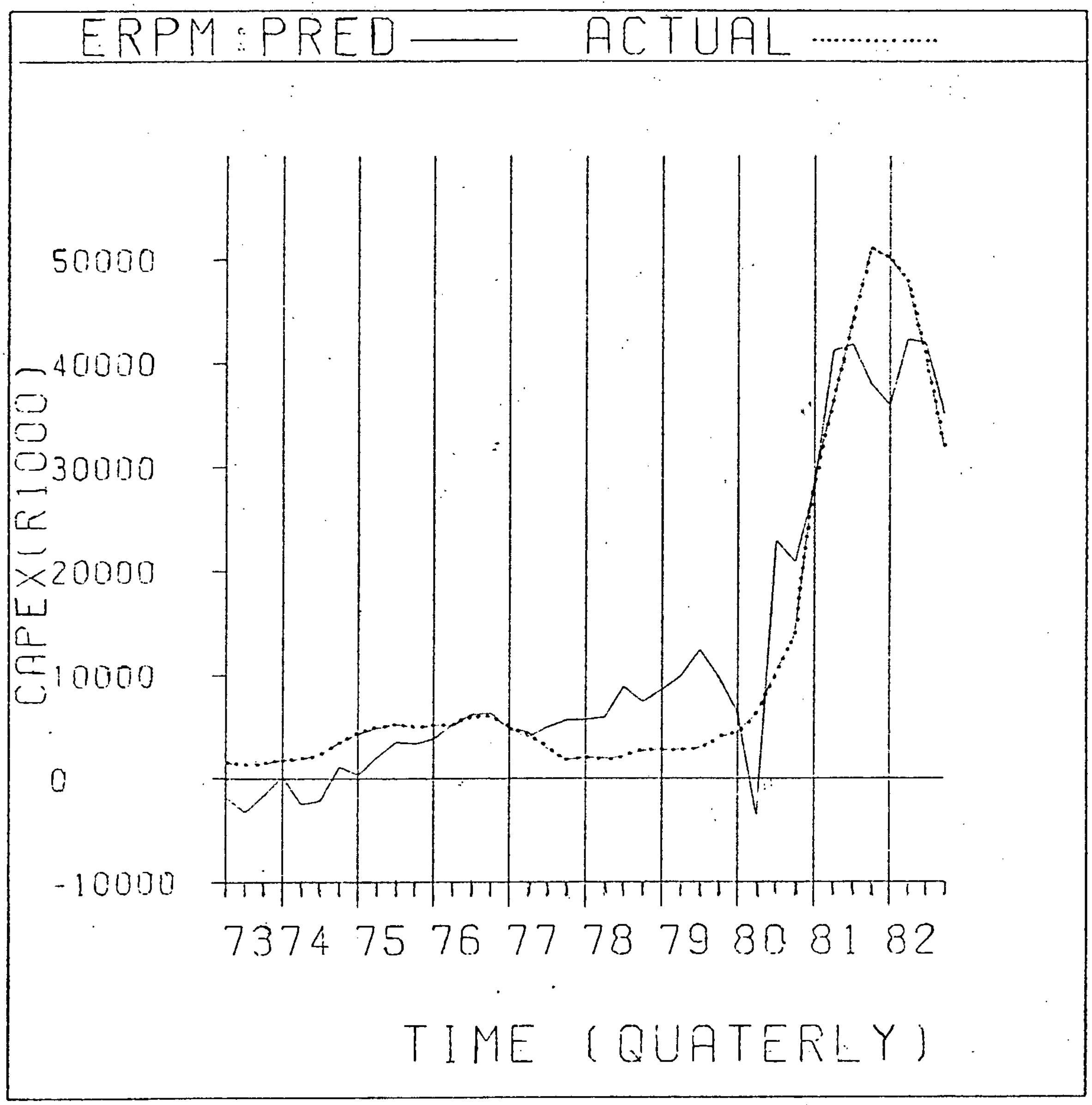


FIGURE D.1



ERPM : PRED —— ACTUAL ....
50000
40000
30000
20000
10000
0
-10000
CAPEX(R1000)
7374 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE D.2

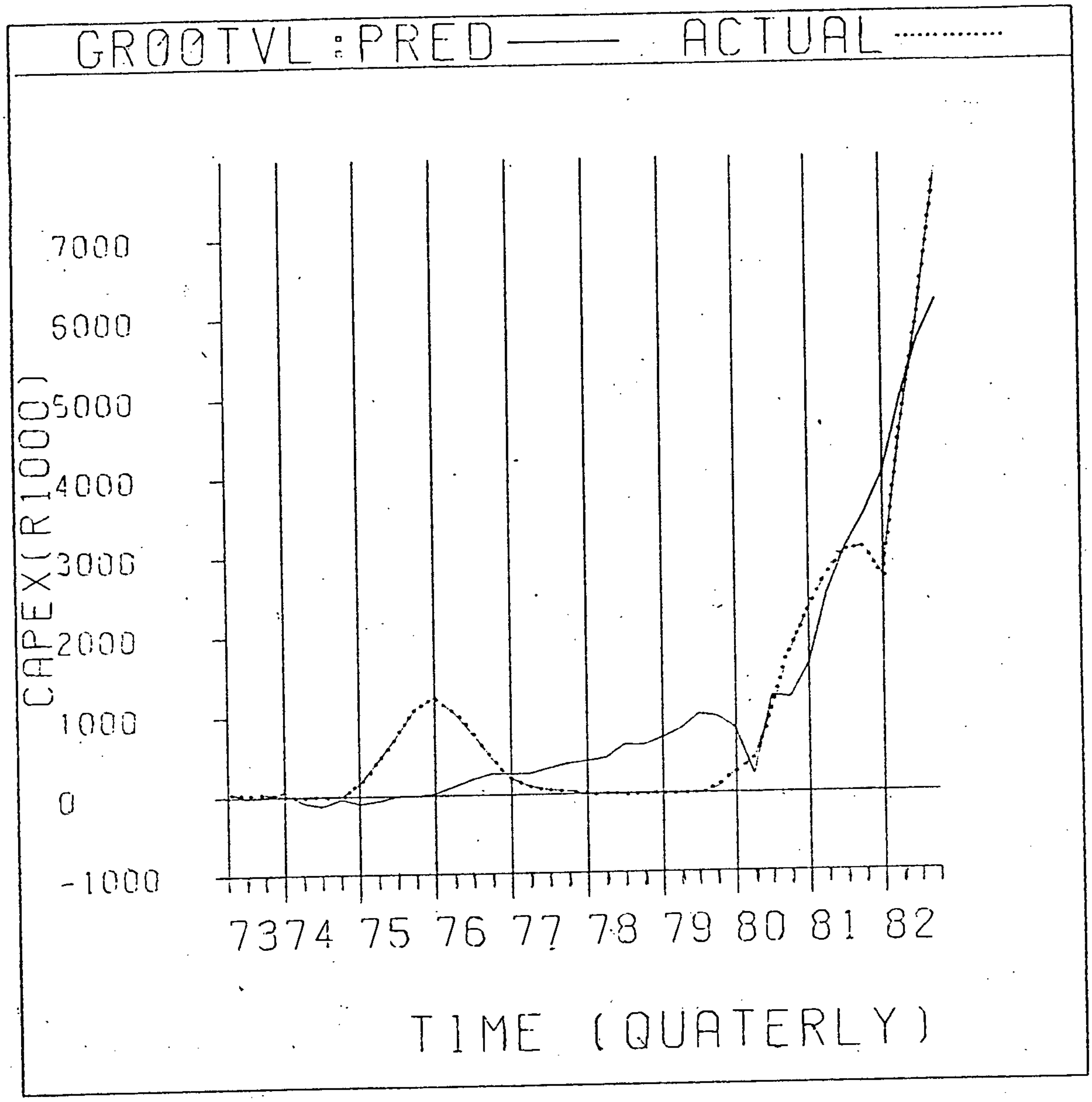

GROOTVL : PRED
ACTUAL
CAPEX(R1000)
7000
6000
5000
4000
3000
2000
1000
0
-1000
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE D.3

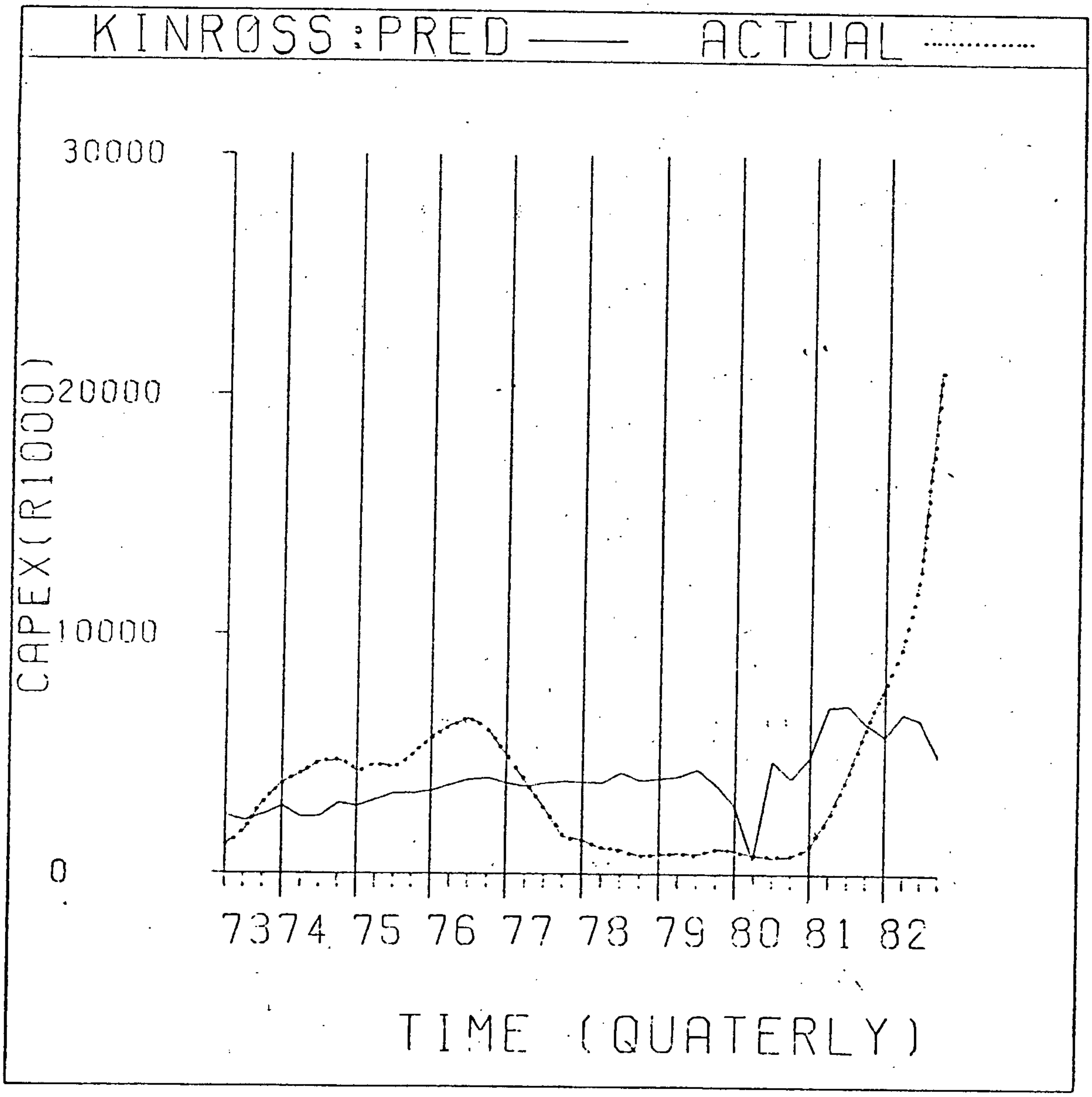

KINRØSS:PRED —— ACTUAL ....
30000
20000
10000
0
CAPEX(R1000)
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE D.4

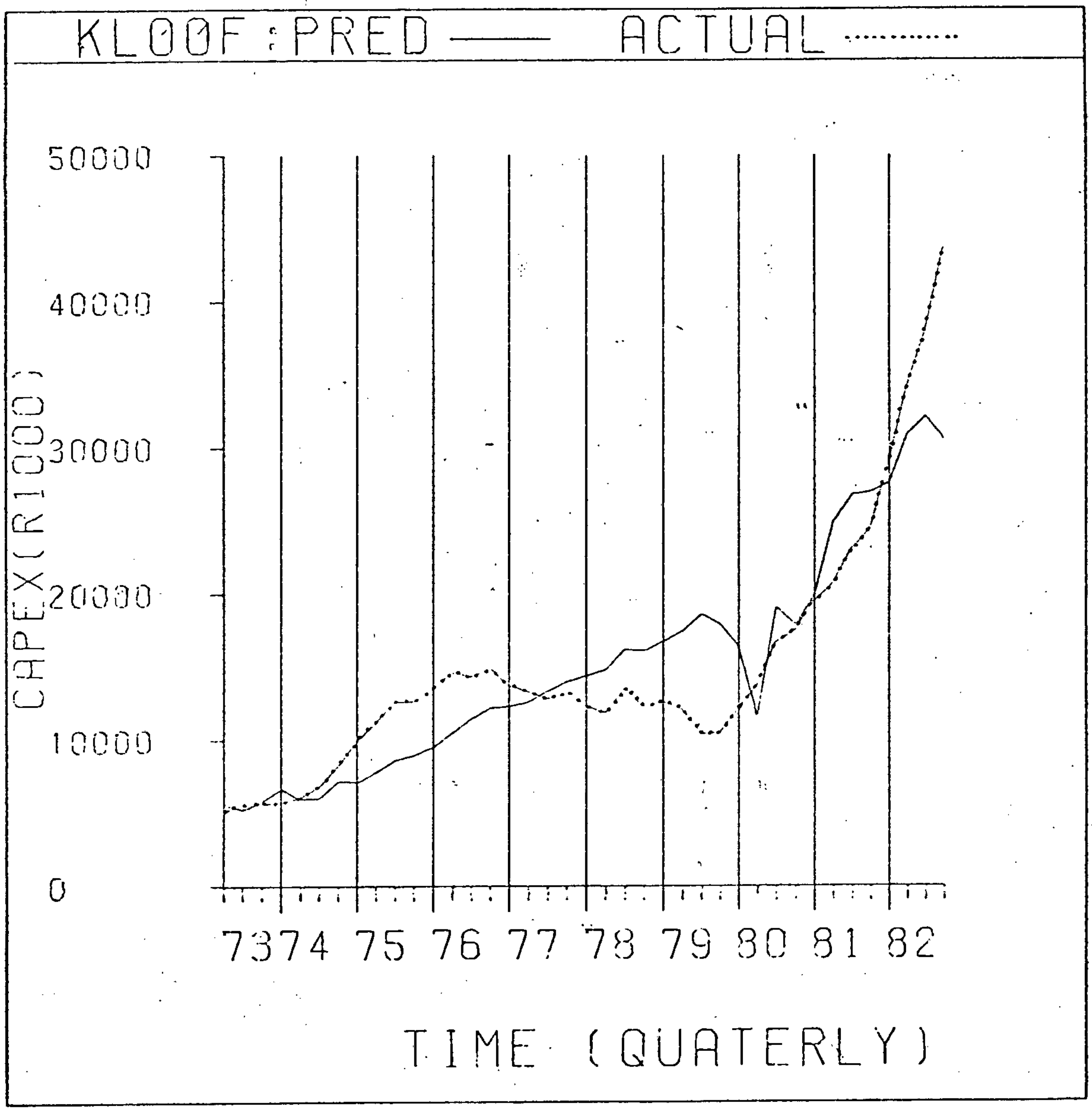

KLOOF : PRED —— ACTUAL ....
50000
40000
30000
20000
10000
0
CAPEX(R1000)
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE D.5

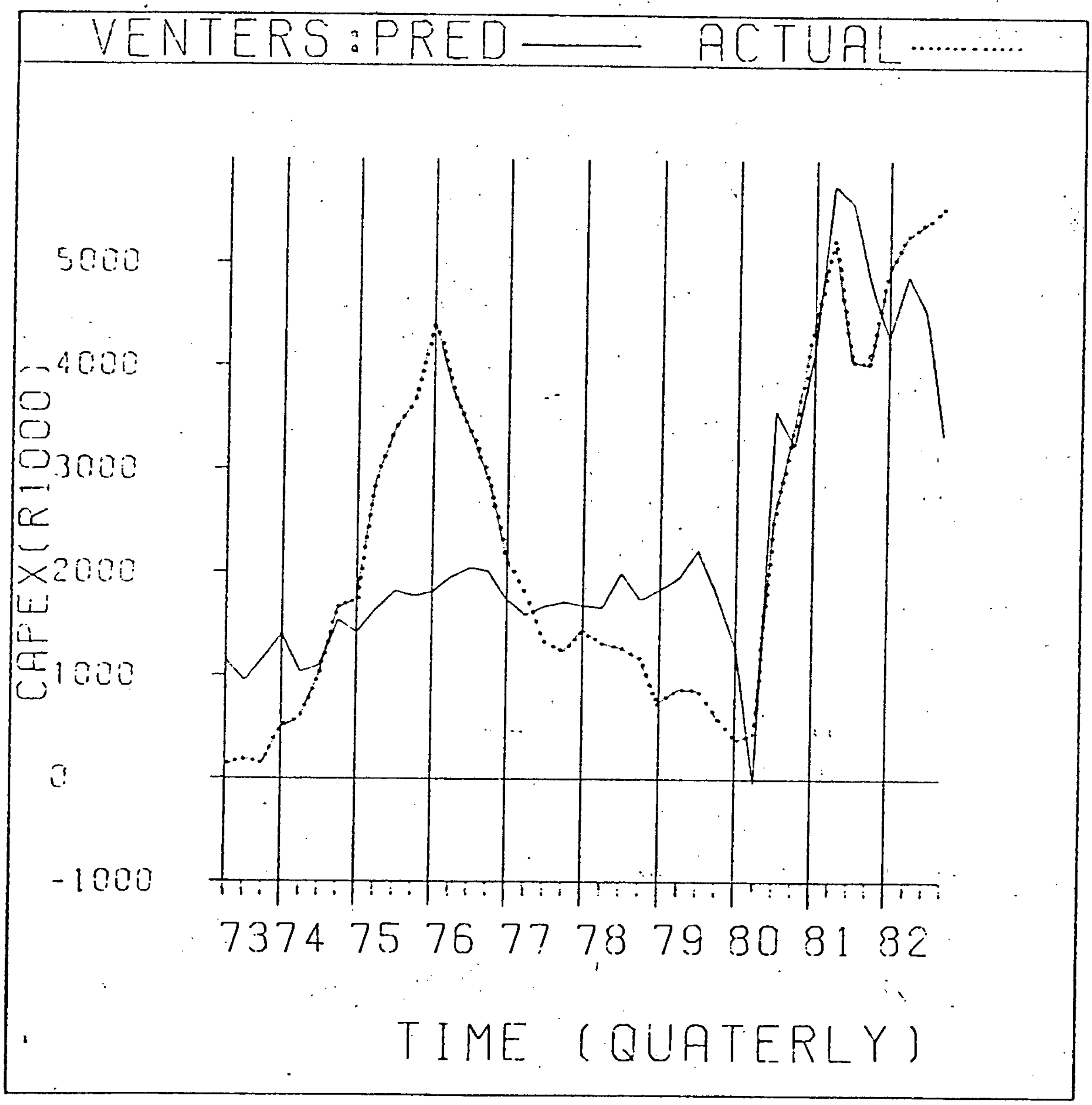

VENTERS:PRED ——— ACTUAL ....
5000
4000
3000
2000
1000
0
-1000
CAPEX(R1000)
7374 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE D.6

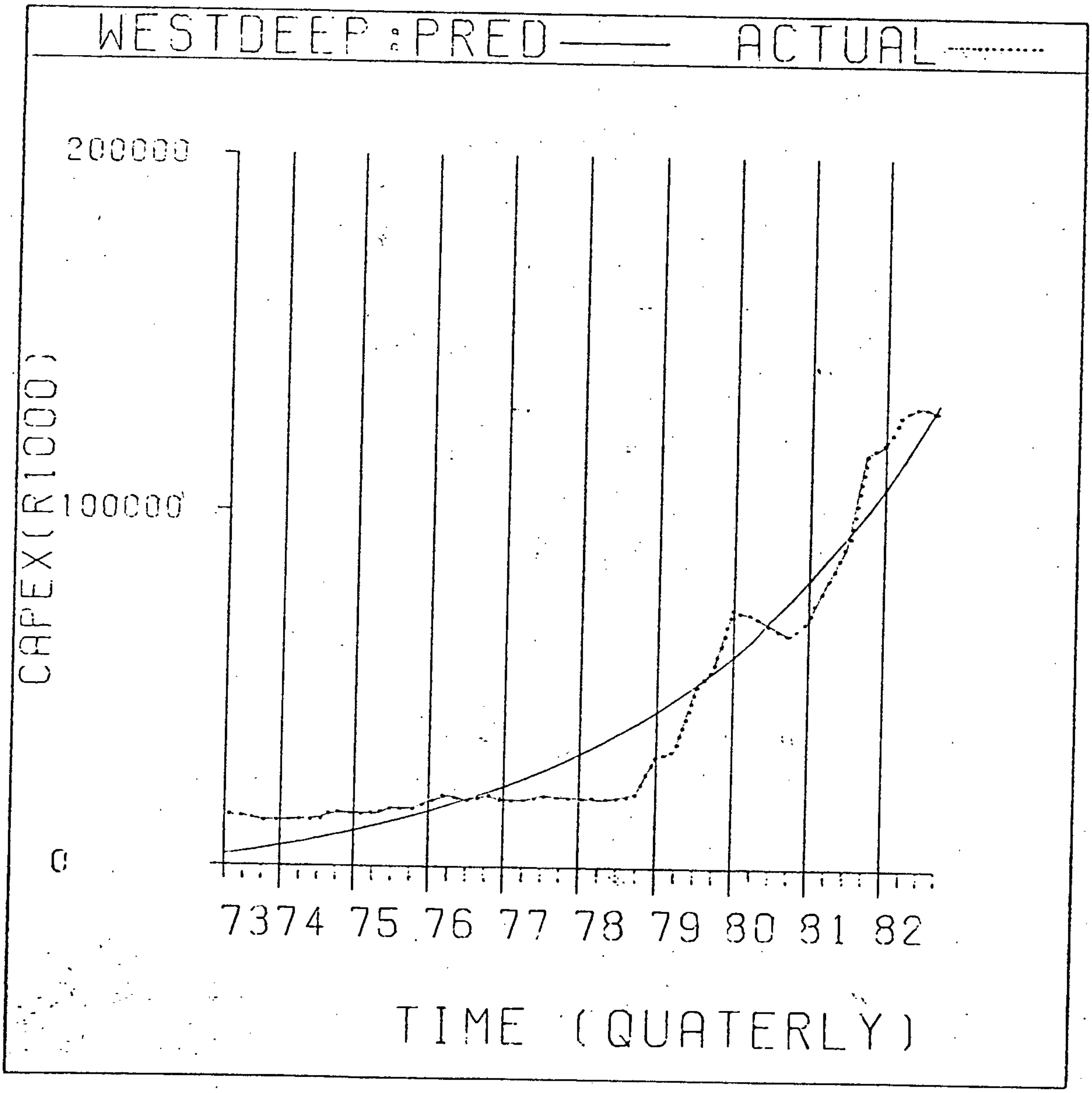

WESTDEEP : PRED
ACTUAL
200000
100000
0
CAPEX(R1000)
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE D.7

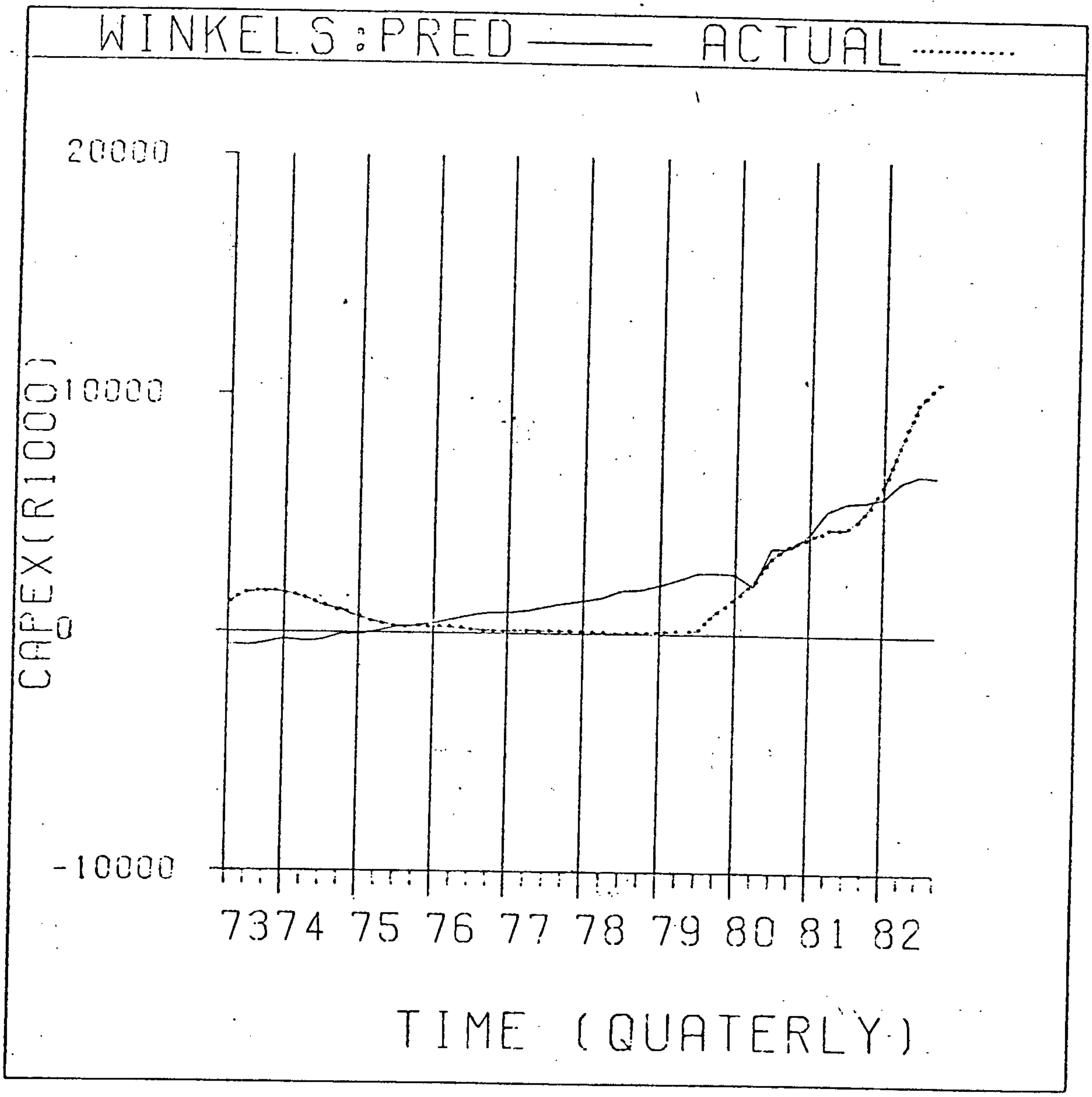

WINKELS:PRED ——— ACTUAL ....
20000
10000
0
-10000
CAPEX(R1000)
7374 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE D.8

APPENDIX E

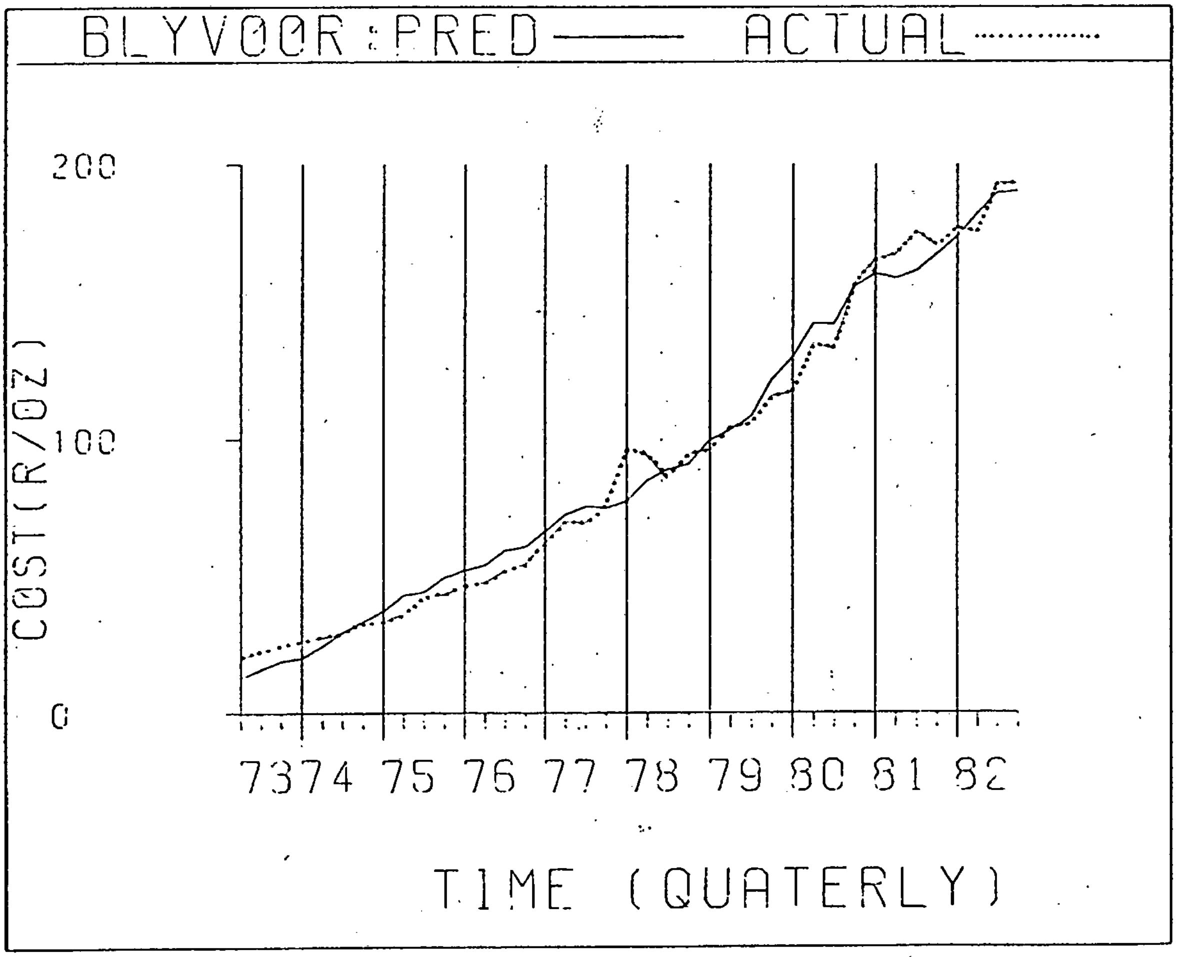


FIGURE E.1

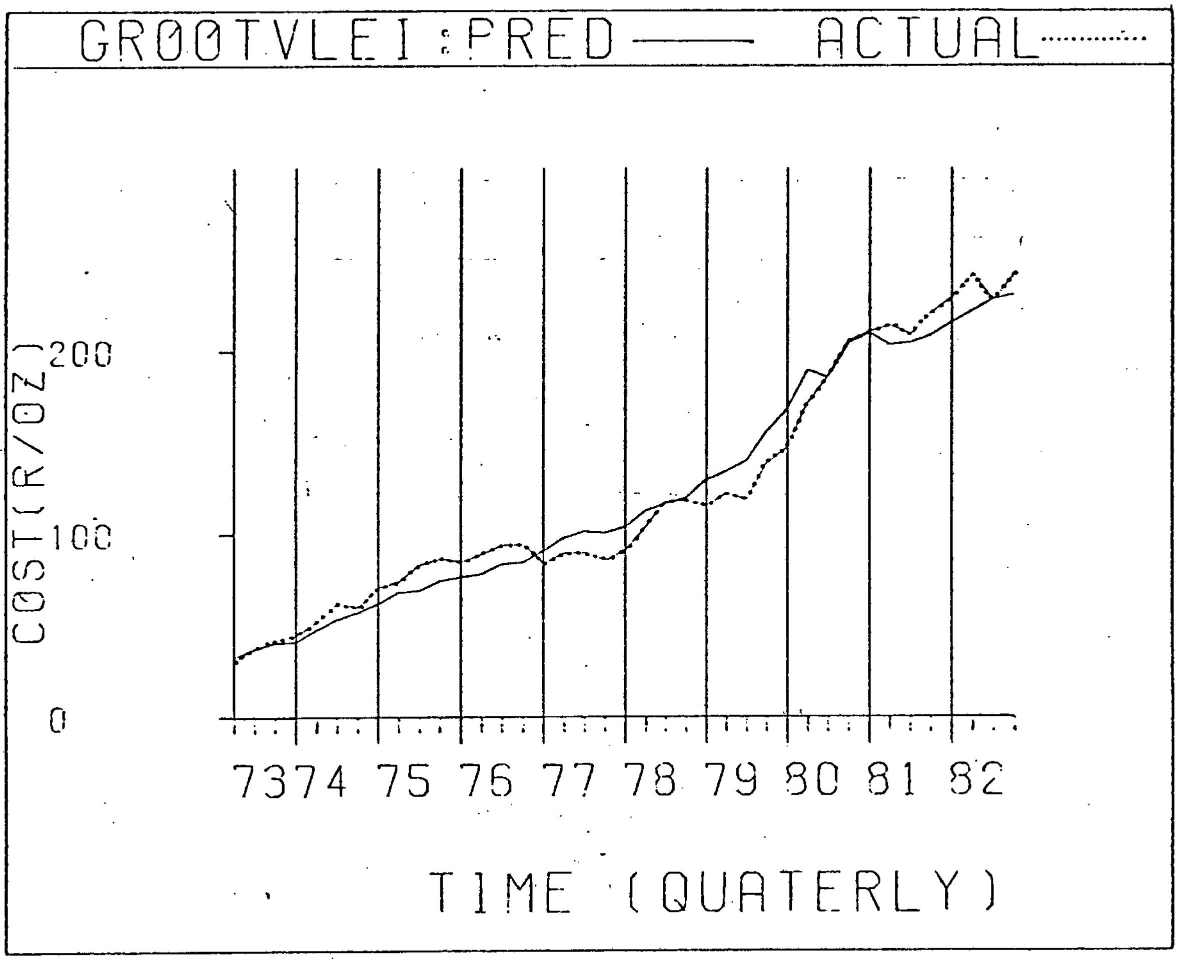

GROOTVLEI : PRED ——— ACTUAL ....
COST(R/OZ)
200
100
0
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE E.2

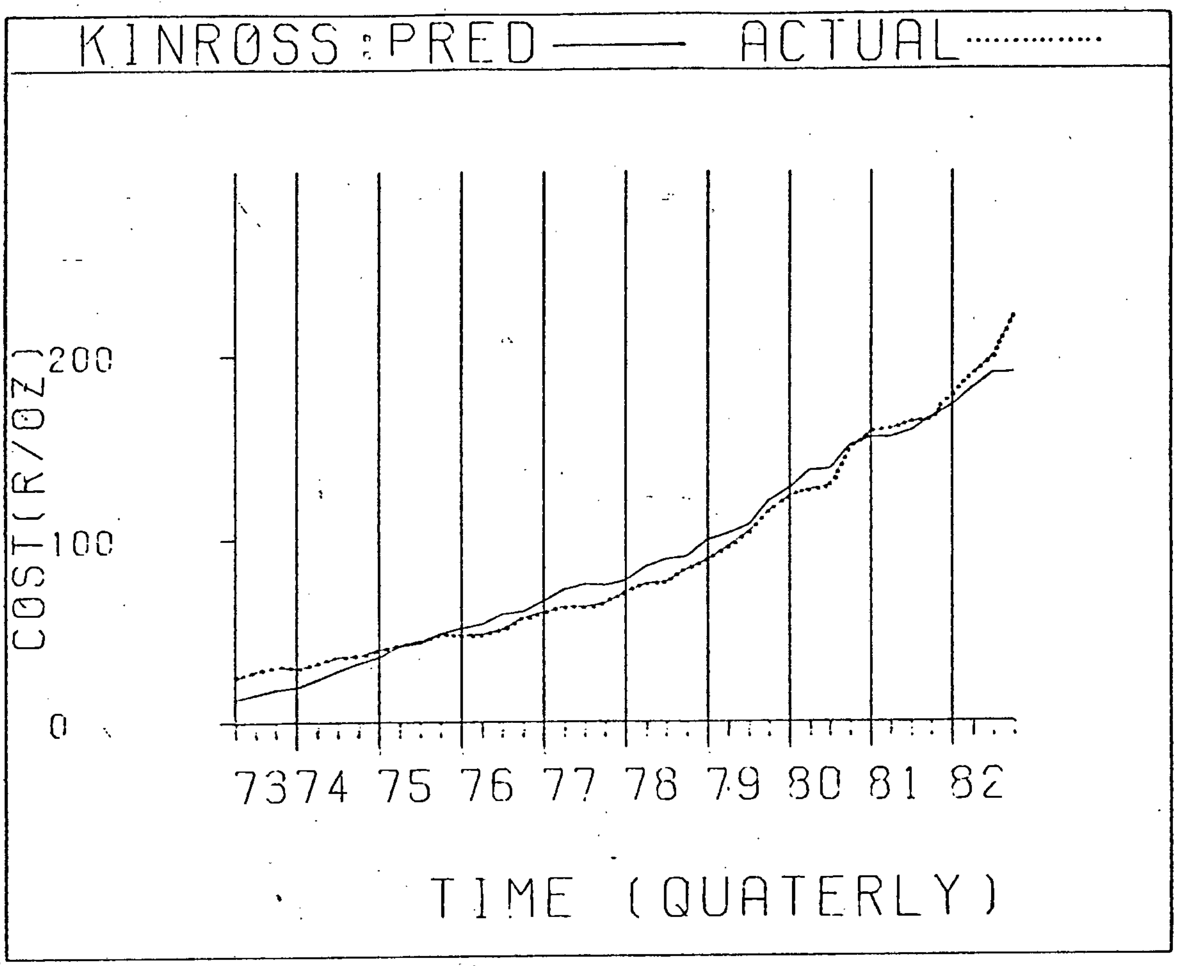

KINRØSS : PRED —— ACTUAL ·········
COST(R/OZ)
200
100
0
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE E.3

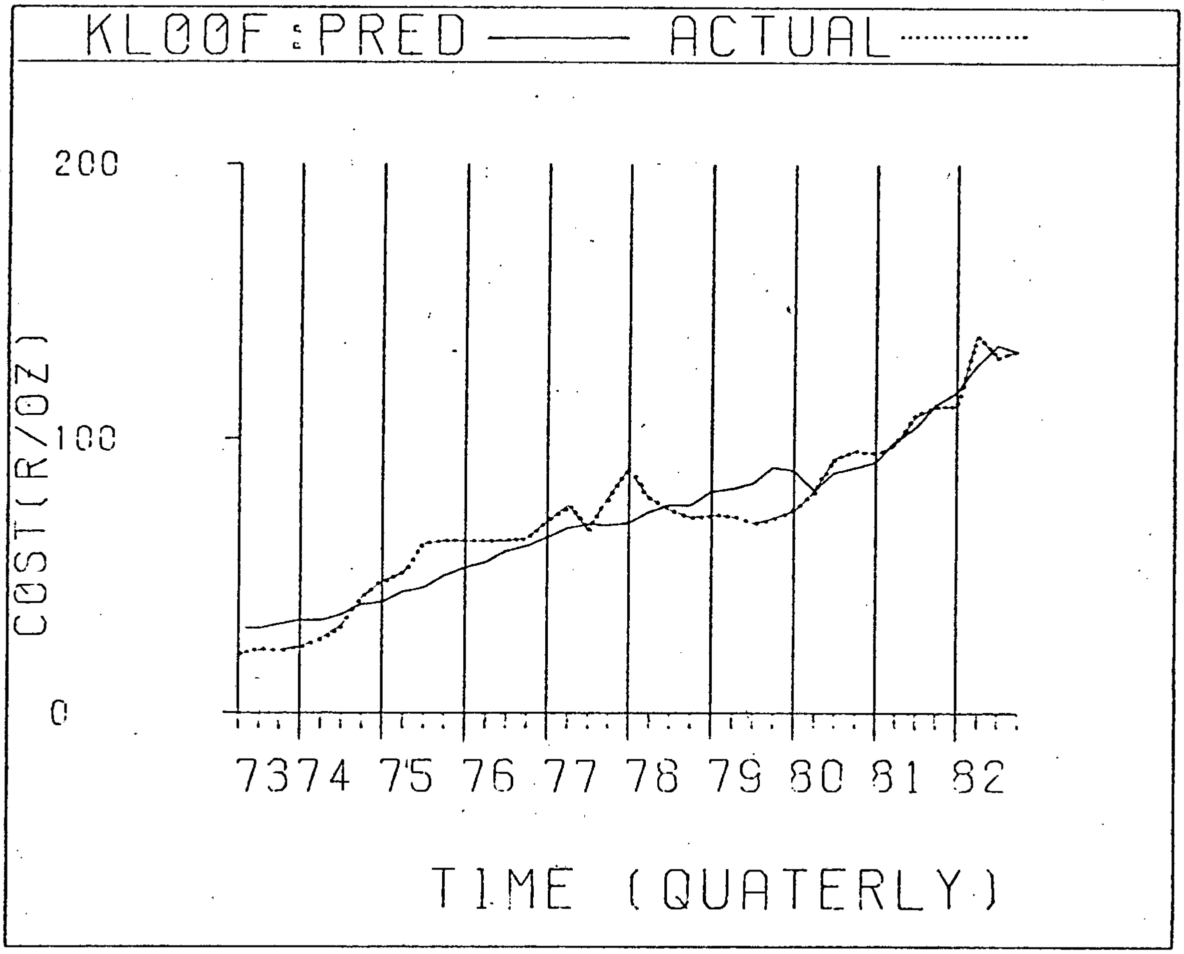

KLOOF : PRED ——— ACTUAL ....
200
100
0
COST(R/OZ)
73
74
75
76
77
78
79
80
81
82
TIME (QUATERLY)

FIGURE E.4

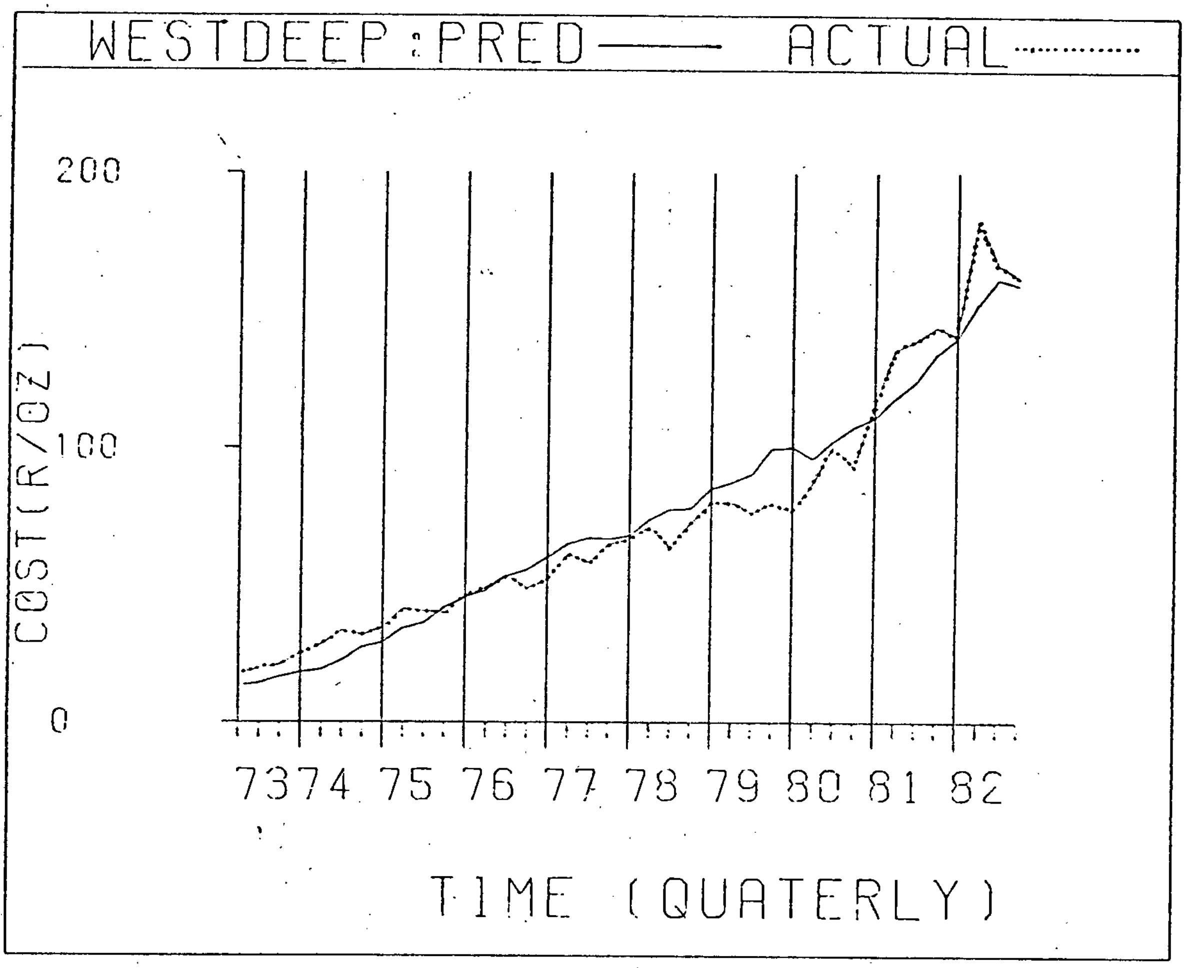

WESTDEEP : PRED ——— ACTUAL ·········
200
100
0
COST(R/OZ)
73 74 75 76 77 78 79 80 81 82
TIME (QUATERLY)

FIGURE E.5

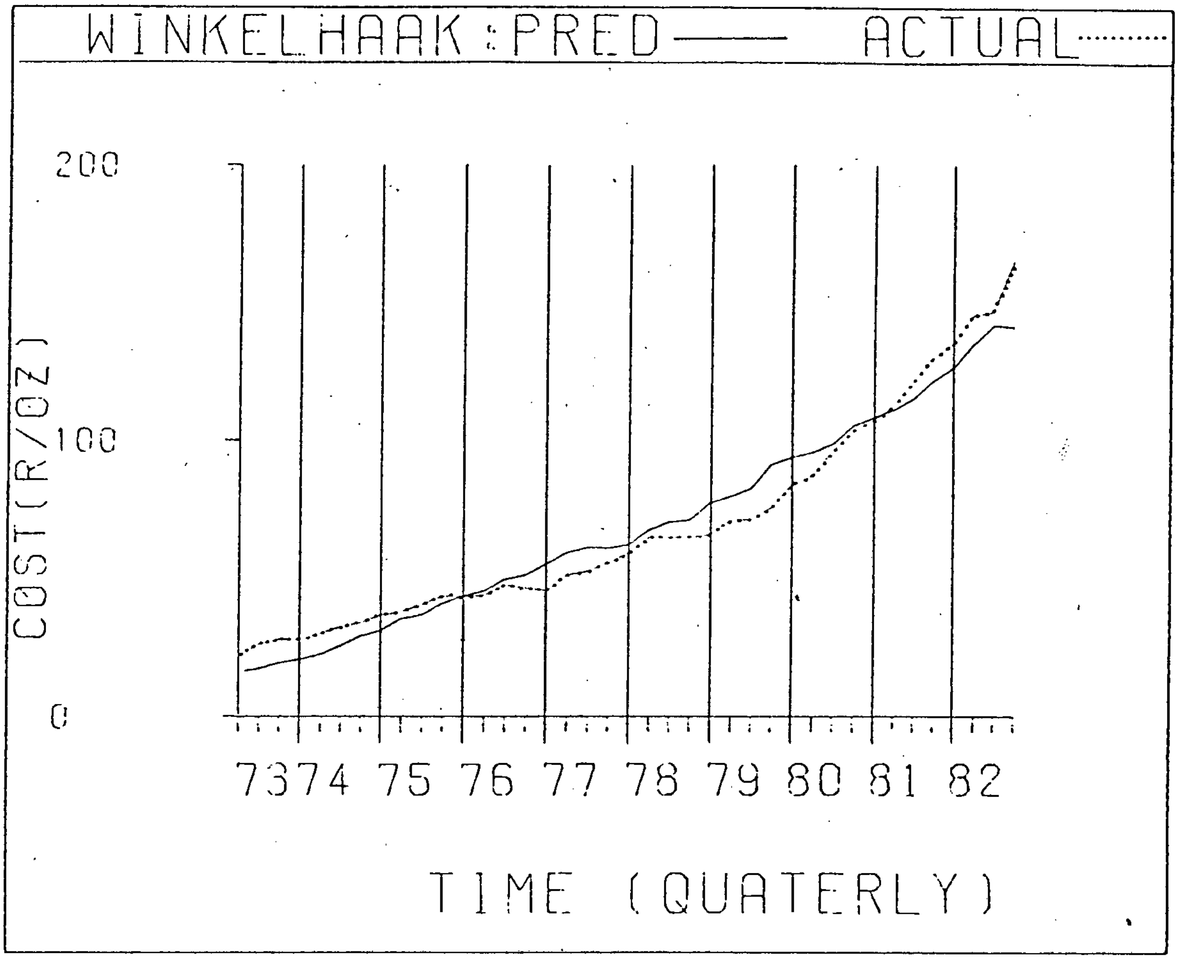


FIGURE E.6

TABLE E.1 : Serial Correlation Coefficients for lags of 1 quarter

	Cost	Production	Capital Expenditure
Blyvoor	0,4385	0,5999	0,7982
Grootvlei	0,4520	0,8602	0,8277
Kinross	0,7367	0,8789	0,8192
Kloof	0,7651	0,8665	0,8016
Westdeep	0,5653	0,7737	0,8804
Winkelhaak	0,8066	0,9141	0,9329

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