Longterm trends in domestic metal prices under international conditions of differential inflation rates and unstable currency exchange rates

by D. G. KRIGE *, Pr. Eng., D.Sc. (Eng.) (Wits.) (Fellow)

SYNOPSIS

The problem of a realistic investment analysis for a new mining venture that sells its products on the international metal markets is studied against the background factors, firstly, of different inflation rates between the countries hosting the mines and those hosting the metal markets; and, secondly, of the changing pattern of currency exchange rates between such countries. The purchasing-power parity theory is used to establish a pattern of relationship between these two factors, and to develop a more logical approach to the longterm forecasting of metal prices in the currency of the country in which the mine is situated.

SAMEVATTING

Die probleem, van 'n realistiese beleggingsontleding vir 'n nuwe mynbou-onderneming wat sy produkte op die internasionale metaalmarkte verkoop, word bestudeer teen die agtergrondfaktore van, eerstens, die verskillende inflasiekoerse in die lande waar die myne geleë is en die lande waar die metaalmarkte is en, tweedens, die veranderende wisselkoerspatroon tussen sodanige lande. Die koopkragpariteitsteorie word gebruik om 'n verhoudingspatroon tussen hierdie twee faktore te bepaal en 'n meer logiese benadering van die langtermynvoorspelling van metaalpryse in die geldeenheid van die land waar die myn geleë is, te ontwikkel.

Introduction

In the present situation of high inflation rates, the return on the capital invested in new ventures is best measured in *real* terms, i.e. the return indicated by estimates of cash flow after the effects of inflation on cost and revenue estimates have been eliminated. This is usually done either

(i) by estimating the cash flow on unescalated prices and costs, or

(ii) by estimating the rates of currency inflation, and of costs and price escalations, and by discounting the resultant estimates of cash flow to real terms.

The second alternative is preferred, mainly because it can cater for differential inflation and escalation rates and also for the practical problem of budgeting, in *current* terms, for the funding of capital expenditure until the venture becomes self-financing, and for loan repayments, taxation, etc.

Under (ii) above a critical problem in any investment analysis for a new mining venture is that of a realistic longterm estimate of the relevant trends of metal prices[1]. Such estimates have to be expressed in current terms relative to whatever assumptions are made of the rates of inflation for the producing country and for the overseas country(ies) in which the metals are marketed.

Furthermore, the revenue received domestically for the metals sold at prices determined in a foreign currency will also depend critically on any changes in the relevant currency exchange rates.

These exchange rates will depend on a number of economic and political factors both internal and external to the producing country. For the purpose of longterm investment analysis, however, the 'purchasing-power parity' (P.P.P.) theory[2] seems to provide a convenient and workable basis for linking the trend in a currency exchange rate directly with one factor only, i.e. the differential trend in the corresponding inflation rates for the two countries concerned. According to this theory, the exchange rate between two trading countries tends to adjust itself in the longer run to correct for any differential in the domestic inflation rates for the countries concerned. This theory will be tested for South Africa relative to the U.K. and the U.S.A., and the results will be applied in a practical way to longterm trends in the copper and gold prices.

*Anglo-Transvaal Consolidated Investment Company Limited, Johannesburg.

Inflation and Exchange Rates

For this analysis, the escalations of domestic prices in South Africa, the U.S.A., and the U.K. have been measured by the published consumer price index (C.P.I.) and the retail price index (R.P.I.). These are reflected in Table I for the years 1955/77, as well as the relevant exchange rates. The domestic inflation rates are also shown in the form of internal depreciation rates, and the exchange rates as the effective revaluation rates of the rand (R) in terms of the dollar ($), and of the R and the $ both in terms of the pound (£).

These statistics are further analysed in Table II in the form of indexes showing

(a) the excess of the inflation rates of the U.K. over South Africa, South Africa over the U.S.A., and the U.K. over the U.S.A.;

(b) the corresponding relative revaluations of the currencies via changes in exchange rates, i.e. of the R over the £, the $ over the R, and the $ over the £; and

(c) the corresponding ratios of indexes (b) over (a) above, indexed to 100 for 1955.

If the P.P.P. theory holds, the ratios under (c) above should tend to remain at 100 in the longer term. These ratios are shown graphically in Fig. 1 with 'growth' trends fitted on least squares (time versus logarithms of ratios), and it is evident that there are significant

TABLE 1

INFLATION AND EXCHANGE RATES FOR THE U.S.A., THE U.K., AND SOUTH AFRICA

	U.S.A.		U.K.		South Africa		Exchange rates				
	C.P.I.* (1967=100)	Deprn index	R.P.I.† (Jan. 1962 =100)	Deprn index	C.P.I.‡ (1970=100)	Deprn index	$ to R		£ to R		$ to £ revaln index
							Rate	R revaln index	Rate	R revaln index	
Column no.	1	2	3	4	5	6	7	8	9	10	11
1955	80,2	100,0	84,5	100,0	68,4	100,0					
6	81,4	98,5	86,9	97,2	69,7	98,1					
7	84,3	95,1	90,1	93,8	71,7	95,4					
8	86,6	92,6	92,8	91,1	74,2	92,2					
9	87,3	91,9	93,3	90,6	75,1	91,1					
1960	88,7	90,4	95,1	88,9	76,1	89,9	0,717	100,0	2,008	100,0	100,0
1	89,6	89,5	97,9	86,3	77,6	88,1					
2	90,6	88,5	101,6	83,2	78,8	86,8					
3	91,7	87,5	103,6	81,6	79,7	85,8					
4	92,9	86,3	107,0	79,0	81,8	83,6					
5	94,5	84,9	112,1	75,4	85,1	80,4					
6	97,2	82,5	116,5	72,5	88,2	77,6					
7	100,0	80,2	119,4	70,8	91,2	75,0					
8	104,2	77,0	125,0	67,6	93,0	73,5	0,718	99,9	1,721	116,7	116,8
9	109,8	73,0	131,8	64,1	96,1	71,2					
1970	116,3	69,0	140,2	60,3	100,0	68,4					
1971 Jan/Jul	120,4	66,6	151,1	55,9	104,2	65,6	0,712	100,7	1,721	116,7	115,9
Aug/Nov	122,3	65,6	156,0	54,2	107,4	63,7	0,716	100,1	1,785	112,5	112,4
Dec	123,1	65,2	158,1	53,4	108,8	62,9	0,768	93,4	1,962	102,3	109,5
1972 Jan/May	124,0	64,7	160,6	52,6	110,0	60,2	0,752	95,3	1,962	102,3	107,3
Jun/Sep	125,6	63,9	165,0	51,2	113,0	60,5	0,802	89,4	1,962	102,3	114,4
Oct/Dec	126,9	63,2	168,9	50,0	116,0	59,0	0,785	91,3	1,840	109,1	119,5
1973 Jan/May	129,7	61,8	174,4	48,5	120,4	56,8	0,722	99,3	1,791	112,1	112,9
Jun/Dec	135,5	59,2	183,0	46,2	125,3	54,6	0,673	106,5	1,646	122,0	114,6
1974	147,7	54,3	208,2	40,6	137,6	49,7	0,681	105,3	1,608	124,9	118,6
1975 Jan/May	157,8	50,8	241,6	35,0	151,1	45,3	0,678	105,8	1,620	124,0	117,2
Jun/Aug	161,9	49,5	265,3	31,9	157,3	43,5	0,716	100,1	1,557	129,0	128,9
Sep/Dec	165,0	48,6	274,9	30,7	161,7	42,3	0,872	82,2	1,786	112,4	136,7
1976 Jan/Apr	167,4	47,9	288,6	29,3	167,4	40,9	0,872	82,2	1,708	117,6	143,1
May/Dec	172,0	46,6	307,8	27,4	176,7	38,7	0,872	82,2	1,504	133,5	162,4
1977 Jan/Sep	180,3	44,5	345,7	24,4	190,8	35,8	0,872	82,2	1,510	133,0	161,8
Oct/Dec	185,3	43,3	359,5	23,5	200,2	34,2	0,872	82,2	1,621	123,9	150,7

*From *The Survey of Current Business*
†From *Monthly Digest of Statistics* and *Annual Abstract of Statistics*
‡From *South African Reserve Bank Quarterly Bulletin*

Column 8 = 0,717 ÷ Column 7 × 100
Column 10 = 2,008 ÷ Column 9 × 100
Column 11 = Column 10 ÷ Column 8

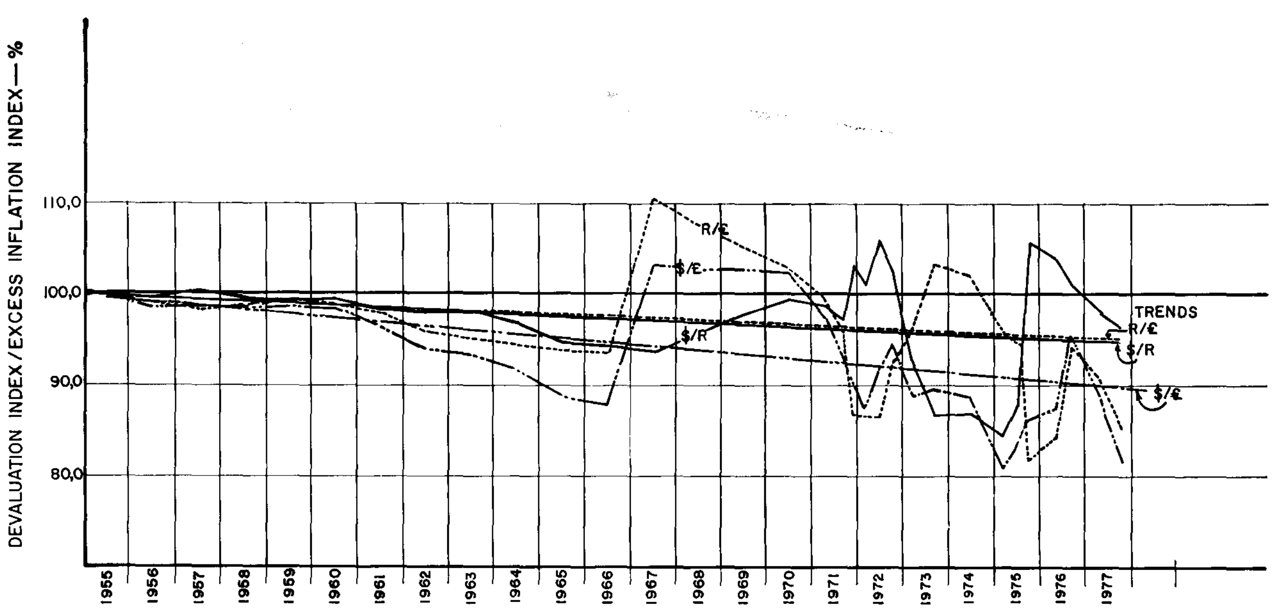

Fig. 1—Trends showing the link between devaluation and excess inflation indexes

TABLE II

COMPARISON OF EXCESS INFLATION AND DEVALUATION INDEXES

	Excess inflation index			Revaluation index			(Revaln/Excess infl) index		
	U.K./S.A.	S.A./U.S.A.	U.K./U.S.A.	R/£	$/R	$/£	£/R	R/$	£/$
Column no.	1	2	3	4	5	6	7	8	9
1955	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
6	100,9	100,4	101,3	100,0	100,0	100,0	99,1	99,6	98,7
7	101,7	99,7	101,4	100,0	100,0	100,0	98,3	100,3	98,6
8	101,2	100,4	101,6	100,0	100,0	100,0	98,8	99,6	98,4
9	100,6	100,9	101,4	100,0	100,0	100,0	99,4	99,1	98,6
1960	101,1	100,6	101,7	100,0	100,0	100,0	98,9	99,4	98,3
1	102,1	101,6	103,7	100,0	100,0	100,0	97,9	98,4	96,4
2	104,3	102,0	106,4	100,0	100,0	100,0	95,9	98,0	94,0
3	105,1	102,0	107,2	100,0	100,0	100,0	95,1	98,0	93,3
4	105,8	103,2	109,2	100,0	100,0	100,0	94,5	96,9	91,6
5	106,6	105,6	112,6	100,0	100,0	100,0	93,8	94,7	88,8
6	107,0	106,3	113,8	100,0	100,0	100,0	93,5	94,1	87,9
7	105,9	106,9	113,3	116,7	100,1	116,8	110,2	93,6	103,1
8	108,7	104,8	113,9	116,7	100,1	116,8	107,4	95,5	102,5
9	111,1	102,5	113,9	116,7	100,1	116,8	105,0	97,7	102,5
1970	113,4	100,9	114,4	116,7	100,1	116,8	102,9	99,2	102,1
1971 Jan/Jul	117,4	101,5	119,1	116,7	99,3	115,9	99,4	97,8	97,3
Aug/Nov	117,5	103,0	121,0	112,5	99,9	112,4	95,7	97,0	92,9
Dec	117,8	103,7	122,1	102,3	107,1	109,5	86,8	103,3	89,7
1972 Jan/May	118,3	104,0	123,0	102,3	104,9	107,3	86,5	100,9	87,2
June/Sep	118,2	105,6	124,8	102,3	111,9	114,4	86,5	106,0	91,7
Oct/Dec	118,0	107,1	126,4	109,1	109,5	119,5	92,5	102,2	94,5
1973 Jan/May	117,1	108,8	127,4	112,1	100,7	112,9	95,7	92,6	88,6
Jun/Dec	118,2	108,4	128,1	122,0	93,9	114,6	103,2	86,6	89,5
1974	122,4	109,3	133,7	124,9	95,0	118,6	102,0	86,9	88,7
1975 Jan/May	129,4	112,1	145,1	124,0	94,6	117,2	95,8	84,4	80,8
Jun/Aug	136,4	113,8	155,2	129,0	99,9	128,9	94,6	87,8	83,1
Sep/Dec	137,8	114,9	158,3	112,4	121,6	136,7	81,6	105,8	86,4
1976 Jan/Apr	139,6	117,1	163,5	117,6	121,6	143,1	84,2	103,8	87,5
May/Dec	141,2	120,4	170,1	133,5	121,6	162,4	94,5	101,0	95,5
1977 Jan/Sep	146,7	124,3	182,4	133,0	121,6	161,8	90,7	97,8	88,7
Oct/Dec	145,5	126,6	184,3	123,9	121,6	150,7	85,2	96,1	81,8

Column 1 = Column 6 ÷ Column 4 both in Table I
Column 2 = Column 2 ÷ Column 6 both in Table I
Column 3 = Column 2 ÷ Column 4 both in Table I
Columns 4 and 6 = Columns 10 and 11 both in Table I
Column 5 = 1 ÷ Column 8 in Table I
Column 7 = Column 4 ÷ Column 1 as %
Column 8 = Column 5 ÷ Column 2 as %
Column 9 = Column 6 ÷ Column 3 as %

Trend estimates of annual figures in Columns 7/9 on years 1955/77: Column 7: $100{,}2(0{,}9978)^n$
Column 8: $99{,}7(0{,}9976)^n$
Column 9: $99{,}9(0{,}9953)^n$

Note: The trends in natural logs were retransformed after the correction of $\frac{1}{2}$ (residual log. variance) had been added[3]

deviations from the theoretically correct horizontal trend in all three cases. However, the deviations are not serious and amount to annual compound rates of only −0,22 per cent, −0,24 per cent, and −0,47 per cent for the R/£, $/R, and $/£ relationships respectively.

It can be accepted that many factors other than differential inflation rates will affect exchange rates, and also that the relevant C.P.I. do not necessarily correctly reflect changes in the relative purchasing powers of these currencies in the export–import markets concerned. However, longterm trends cannot be predicted within narrow limits, and the conclusion to be drawn therefore is that, within such limits, the general principles of the P.P.P. theory can be a useful tool in longterm investment analyses.

It should be mentioned that not all currencies will show such close agreement with this theory. A similar analysis of the German mark relative to the $, for example, shows a serious departure from the horizontal trend over the years 1971/73, with reasonably horizontal trends on either side of this period. This was probably caused by a significant structural adjustment between the German and American economies over the years concerned, and does not invalidate the basic principles of the theory. Such structural adjustments are difficult, if not impossible, to forecast and could, in the absence of specific evidence, be ignored in longterm forecasts.

The Purchasing Power of the Rand

An alternative way of demonstrating the applicability of the P.P.P. theory is to compare, over the same period (1955/77), the purchasing power of the R in real (1955) terms within South Africa with its corresponding position within the U.S.A. and the U.K. The domestic

TABLE III

RELATIVE PURCHASING POWER OF THE R (REAL 1955 TERMS) IN SOUTH AFRICA, THE U.S.A., AND THE U.K.

	R purchasing power index		
	in U.S.A.	in S.A.	in U.K.
Column no.	1	2	3
1955	100,0	100,0	100,0
6	98,5	98,1	97,2
7	95,1	95,4	93,8
8	92,6	92,2	91,1
9	91,9	91,1	90,6
1960	90,4	89,9	88,9
1	89,5	88,1	86,3
2	88,5	86,8	83,2
3	87,5	85,8	81,6
4	86,3	83,6	79,0
5	84,9	80,4	74,4
6	82,5	77,6	72,5
7	80,1	75,0	82,6
8	76,9	73,5	78,9
9	72,9	71,2	74,8
1970	68,9	68,4	70,4
1971 Jan/Jul	67,1	65,6	65,2
Aug/Nov	65,7	63,7	61,0
Dec	60,9	62,9	54,6
1972 Jan/May	61,7	62,2	53,8
Jun/Sep	57,1	60,5	52,4
Oct/Dec	57,7	59,0	54,6
1973 Jan/May	61,4	56,8	54,4
Jun/Dec	63,1	54,6	56,4
1974	57,2	49,7	50,7
1975 Jan/May	53,8	45,3	43,4
Jun/Aug	49,6	43,5	41,2
Sep/Dec	40,0	42,3	34,5
1976 Jan/Apr	39,4	40,9	34,5
May/Dec	38,3	38,7	36,6
1977 Jan/Sep	36,6	35,8	32,4
Oct/Dec	35,6	34,2	29,1

Column 1 = Column 2 × Column 8 both in Table I ÷ 100
Column 2 = Column 6, Table I
Column 3 = Column 4 × Column 10 both in Table I ÷ 100

purchasing power of the R in real terms is determined by the South African inflation rate, whereas its corresponding position in the U.S.A. and the U.K. will depend on the ruling exchange rates and the depreciation of the $ and £ within the U.S.A. and the U.K. respectively.

Table III and Fig. 2 reflect these statistics, and again the overall agreement between the relevant trends is well within the limits of error of any prediction over such a long period.

Copper and Gold Prices

The practical implications of the P.P.P. theory in investment analyses for new mining ventures can conveniently be demonstrated by a comparison of metal prices in real terms within the U.S.A., the U.K., and South Africa over the same period (1955/77). If the price of a commodity on the world market (e.g. L.M.E.) is correlated in the longterm with the inflation index of the country in whose currency the market price is determined, the P.P.P. theory infers that the corresponding price in the domestic currency of a producing country would, in the longterm, be correlated similarly with the domestic inflation rate of that country as a result of adjustments in the currency exchange rate that are in line with any differential between the relevant inflation rates.

The L.M.E. copper prices for 1955/77 are shown in Table IV in current £s and converted into current Rs and $s at the ruling exchange rates, as well as the corresponding prices in real terms after the application of the relevant C.P.I. In the last three columns these real prices are indexed to the 1955 prices, which are taken as 100; these indexes are shown graphically in Fig. 3, together with the three 'growth' trends, fitted as on Fig. 1. These growth curves can be used to compare the differences in the longterm trends of the copper prices in real £, R, and $ terms. In terms of the P.P.P. theory, the trends of copper prices in real terms should coincide, whereas the fitted trends show overall growth rates in real terms of

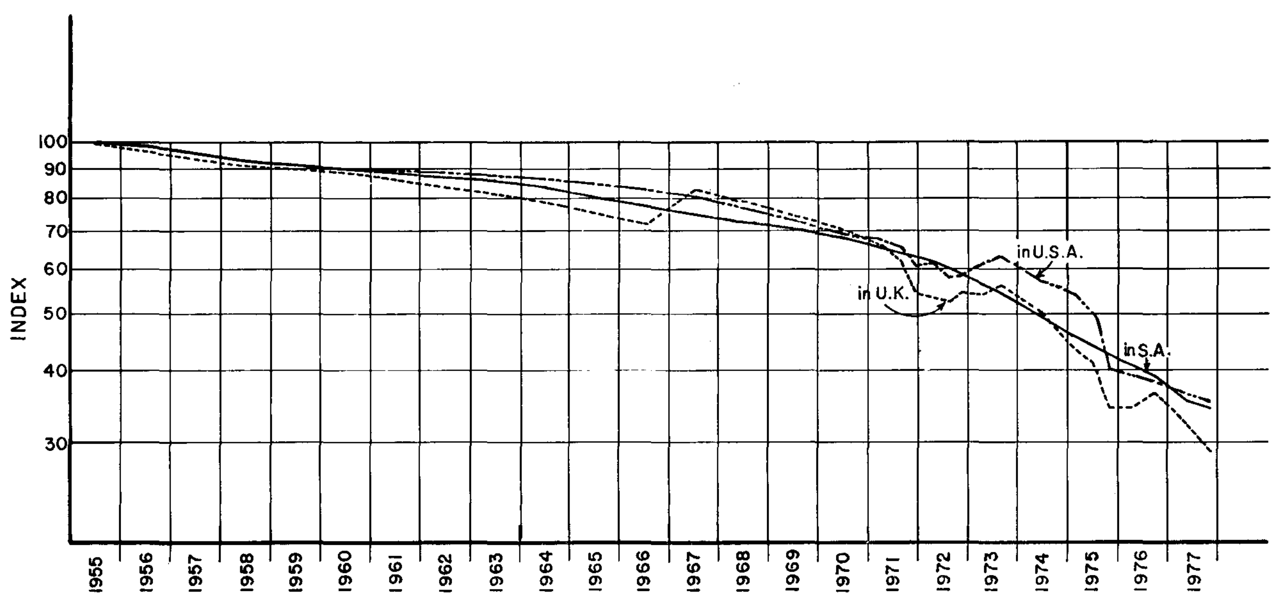

Fig. 2—Indexes of real purchasing power of the rand in South Africa, the U.S.A., and the U.K. indexed to 1955

(1) 0,28 per cent p.a. in £,
(2) 0,76 per cent p.a. in \$, and
(3) 0,50 per cent p.a. in R.

The differences between (1) and (3) of −0,22 per cent, between (3) and (2) of −0,26 per cent, and between (1) and (2) of −0,48 per cent compare directly with the trends of the indexes of currency revaluations/excess inflation rates as dealt with above, i.e. −0,22 per cent, −0,24 per cent, and −0,47 per cent p.a. respectively.

The results of a similar analysis of gold prices over the period 1955/77 are shown in Table V and Fig. 4. The fitting of trends in this case is complicated by the fact that the gold price was pegged at \$35 up to 1967 and can be accepted as having adjusted — largely, if not completely — to its true free trend level only over, say, the last five years. It seems more correct, therefore, to ignore the indexes for the years 1956/72 and to fit trends, admittedly still on a somewhat arbitrary basis, on the indexes for the years 1955 and 1973/77 only. The trends in Fig. 4 were fitted on this basis, and show annual growth rates in real terms of

(i) 2,6 per cent p.a. in £,
(ii) 3,3 per cent p.a. in \$, and
(iii) 3,0 per cent p.a. in R.

The differences between these rates agree reasonably with those found for copper above. The pertinent growth rates will, however, depend on the year from which the trend is fitted — taken above as 1955, whereas the South African price was pegged at about R25 per ounce as from the 1949 devaluation, and at \$35 per ounce as from before the Second World War.

Forecasts of Longterm Metal Prices

From the above it is evident that, although in *current* terms the price patterns for a metal could vary radically from one currency to another, the patterns in *real* terms

TABLE V

LONDON GOLD PRICES PER OUNCE TROY IN THE U.K., THE U.S.A., AND SOUTH AFRICA IN CURRENT AND REAL 1955 TERMS

	London gold price in S.A., R/oz		London gold price in U.K., £/oz		London gold price in U.S.A., \$/oz		Index of real prices		
	Current	Real	Current	Real	Current	Real	R	£	\$
Column no.	1	2	3	4	5	6	7	8	9
1955	25,031	25,031	12,466	12,466	34,911	34,911	100,0	100,0	100,0
6	24,974	24,499	12,437	12,089	34,831	34,309	97,9	97,0	98,3
7	24,965	23,817	12,433	11,662	34,819	33,113	95,2	93,6	94,8
8	24,923	22,979	12,412	11,307	34,760	32,188	91,8	90,7	92,2
9	24,932	22,713	12,416	11,249	34,773	31,956	90,7	90,2	91,5
1960	25,067	22,535	12,484	11,098	34,961	31,605	90,0	89,0	90,5
1	25,059	22,077	12,480	10,770	34,950	31,280	88,2	86,4	89,6
2	24,972	21,676	12,436	10,347	34,828	30,823	86,6	83,0	88,3
3	25,019	21,466	12,460	10,167	34,894	30,532	85,8	81,6	87,4
4	25,063	20,953	12,482	9,860	34,955	30,166	83,7	79,1	86,4
5	25,094	20,176	12,497	9,423	34,999	29,714	80,6	75,6	85,1
6	25,116	19,490	12,508	9,068	35,029	28,899	77,9	72,7	82,8
7	25,134	18,851	14,604	10,340	35,006	28,074	75,3	82,9	80,4
8	27,636	20,312	16,058	10,855	38,490	29,637	81,1	87,1	84,9
9	29,358	20,903	17,059	10,935	40,889	29,849	83,5	87,7	85,5
1970	25,673	17,560	14,917	8,995	35,756	24,672	70,2	72,2	70,7
1971 Jan/Jul	28,16	18,473	16,363	9,147	39,551	26,341	73,8	73,4	75,5
Aug/Nov	30,37	19,346	17,014	9,222	42,416	27,825	77,3	74,0	79,7
Dec	32,60	20,505	16,616	8,873	42,448	27,676	81,9	71,2	79,3
1972 Jan/May	36,89	22,946	18,802	9,890	49,056	31,739	91,7	79,3	90,9
Jun/Sep	51,27	31,018	26,131	13,379	63,928	40,850	123,9	107,3	117,0
Oct/Dec	50,43	29,754	27,408	13,704	64,242	40,601	118,9	109,9	116,3
1973 Jan/May	60,01	34,086	33,506	16,251	83,116	61,366	136,2	130,4	147,1
Jun/Dec	72,06	39,345	43,779	20,226	107,073	63,387	157,2	162,2	181,6
1974	108,31	53,830	67,357	27,347	159,046	86,362	215,1	219,4	247,4
1975 Jan/May	118,26	53,572	73,000	25,550	174,425	88,608	214,0	205,0	253,8
Jun/Aug	115,53	50,256	74,200	23,670	161,355	79,871	200,8	189,9	228,8
Sep/Dec	119,70	50,633	67,021	20,576	137,271	66,714	202,3	165,1	191,1
1976 Jan/Apr	113,73	46,516	66,587	19,510	130,424	62,473	185,8	156,5	178,9
May/Dec	106,00	41,022	70,479	19,311	121,560	56,647	163,9	154,9	162,3
1977 Jan/Sep	124,74	44,657	82,609	20,157	143,050	63,657	178,4	161,7	182,3
Oct/Dec	139,55	47,726	86,089	20,231	160,034	69,295	190,7	162,3	198,5

Column 1 from *South African Reserve Bank Quarterly Bulletin*
Column 2 = Column 1 above × Column 6 in Table I ÷ 100
Column 3 = Column 1 above ÷ Column 9 in Table I
Column 4 = Column 3 above × Column 4 in Table I ÷ 100
Column 5 = Column 1 above ÷ Column 7 in Table I
Column 6 = Column 5 above × Column 2 in Table I ÷ 100
Columns 7/9 = Columns 2, 4, and 6 indexed to 1955
Trend estimates (1955 and 1973/7) as on Table II: Column 7: $101{,}5(1{,}0302)^n$
Column 8: $103{,}4(1{,}0264)^n$
Column 9: $104{,}0(1{,}0328)^n$

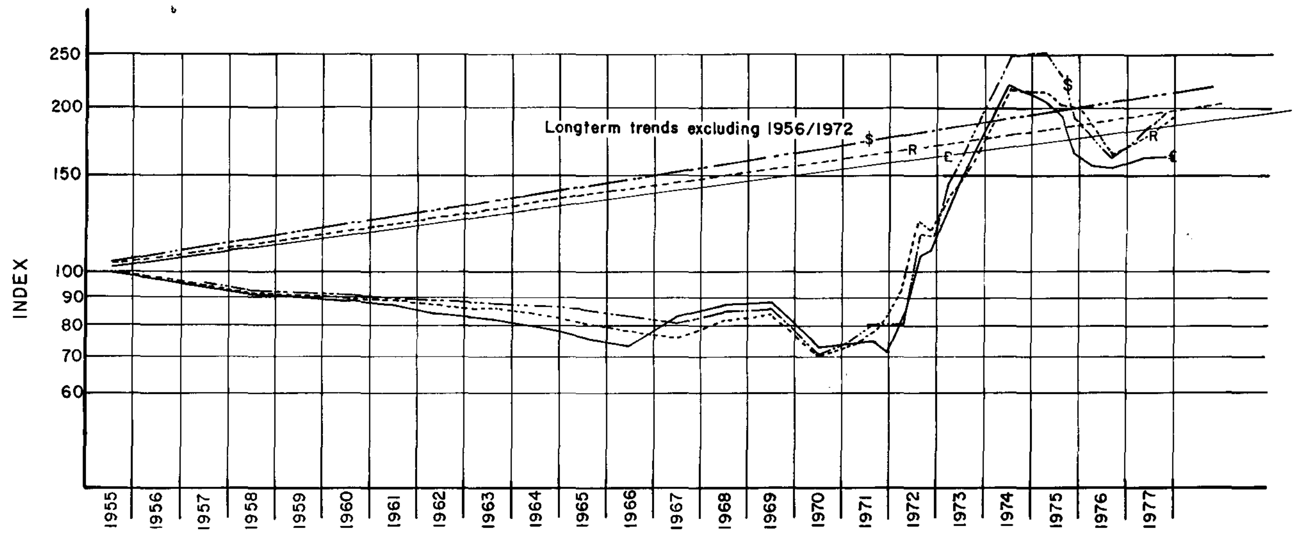

Fig. 4—The London gold price per ounce in real R, \$, and £ terms indexed to 1955

would normally be very similar. This means that there is justification for the estimation of longterm metal prices on the following basis for purposes of investment analyses.

(a) Estimate the longterm price trend in *present day-real* terms in any one of the currencies involved, preferably in the currency in which the world market price is established, e.g. £ for copper and \$ for gold. The model for this trend could be an exponential growth curve fitted on historical data, or any other model or subjective estimate that appears appropriate.

(b) Estimate the longterm trend of the domestic versus the outside ratio of currency revaluation index/excess inflation index (see Fig. 1 and Table II), and hence the indicated present 'correct' exchange rate.

(c) Estimate the longterm price trend (*present day-real*) in the domestic currency from the trend in (a) and the 'correct' exchange rate from (b).

(d) Estimate the longterm domestic price trend in *current* terms by applying the future *domestic* inflation rate(s) as estimated specifically for the investment analysis concerned.

(e) Assume a period during, and a pattern according to, which the current price will adjust to the longterm trend in (d).

From the above it will be seen that *the long-term domestic price in current terms should follow the expected longterm pattern in real market terms plus escalation at the domestic inflation rate;* that is, the estimated pattern or trend in real terms should not be escalated at the inflation rate of the country in which the metal is marketed. Thus, if the longterm inflation rate in the U.S.A. is predicted at, say, 6 per cent p.a. and that for South Africa at, say, 10 per cent p.a., the R can be expected to devalue in the longterm relative to the \$ at 3,8 per cent p.a. (1,10/1,06), and the domestic gold price in current terms in South Africa should therefore escalate faster than the corresponding \$ price.

Estimate of Longterm Copper Price in South Africa

According to the five estimating steps just outlined, the South African copper price is estimated as illustrated by the following example.

(a) Longterm trend in £ (real) as shown in Fig. 3.

£345,9 (0,754) $(1{,}0028)^n$ per ton,

where n=years from 1955, and £345,9 was the 1955 price;

i.e. 1977 price on trend line:

Real £277,4 per ton

Current £277,4/0,242 (see Table I)

= R1146 per ton

Future price, *real*=£1146 $(1{,}0028)^y$ in 1977 terms,

where y=years from 1977.

Note: The fitting of an exponential growth curve is not basic to the suggested approach; the choice of this or any other suitable model will remain largely subjective, particularly if the model is used for extrapolation into the future.

(b) Longterm trend of R revaluation index/U.K. excess inflation index from Table II and Fig. 1:

100,2 $(0{,}9978)^n$

= 95,4 for 1977.

With the 1977 excess inflation index (Table II) at 145,5, the corresponding 'correct' revaluation index for 1977 (R relative to £) should be

$=\frac{95{,}4}{100}\times 145{,}5=138{,}8$ (instead of 130,7 — Table II);

that is, the 1977 'correct' exchange rate R/£ should be=2,008/1,388=1,447 (see Tables I and II). This would correspond to a revaluation of the R in terms of the £ from 1,54 to 1,447. It is assumed for this analysis that from 1977 onwards the trend shown in Fig. 1 will be horizontal, i.e. the factor 0,9978 above will change to unity.

(c) Longterm trend in *real* 1977 R terms

=£1146 $(1{,}0028)^y$ (1,447)

=R1658 $(1{,}0028)^y$

(d) Longterm trend in *current* R terms

$$=\text{R}1658\left[1{,}0028\left(1+\frac{z}{100}\right)\right]^{y},$$

where z=estimated longterm domestic inflation rate in South Africa.

(Note: z need not be fixed but could be varied from year to year particularly in a case where, over the first few years, a current high inflation rate is expected to settle down gradually to a lower longterm rate.)

(e) The current 1977 copper price was R1150 per ton (see Table IV) and, if expected to adjust to the longterm trend over the years 1979/81, the detailed price estimates in current terms (relative to domestic inflation rates of say 10 per cent, 8 per cent, and 6 per cent p.a. for 1978 on 1977, 1979 on 1978, 1980 on 1979, and onwards respectively) could be

1982 onwards:

$$\text{R}1658\ (1{,}0028)^{y}\left(1+\frac{10}{100}\right)\left(1+\frac{8}{100}\right)\left(1+\frac{6}{100}\right)^{y-2}$$

$$=\text{R}2379 \text{ per ton for } 1982$$

1978/81: improving from R1150 for 1977 and 1978 to R2379 in 1982.

Conclusions

If based on growth curves, the longterm price trend for any metal determined on the above approach will depend very largely on the period(s) over which past results are used to estimate longterm trends for the relevant prices in real terms and for the currency/inflation factors. Furthermore, it is dependent entirely on the assumption that such trends can be extrapolated into the future; the alternative is to use some other suitable model or subjective estimate[1]. Whatever basis is used for the forecasting of price trends in real terms, the approach suggested will at least ensure that, in the conversion to current terms, no anomalous assumptions are made regarding the relative effects of differential inflation rates and consequential changes in currency exchange rates.

The whole process of such longterm estimates will therefore remain basically subjective, but will at least allow the introduction of some objectivity in a significant part of the process.

Acknowledgement

The opportunities offered by Anglo-Transvaal Consolidated Investment Company Limited to research these aspects, as well as the permission to publish the results, are appreciated.

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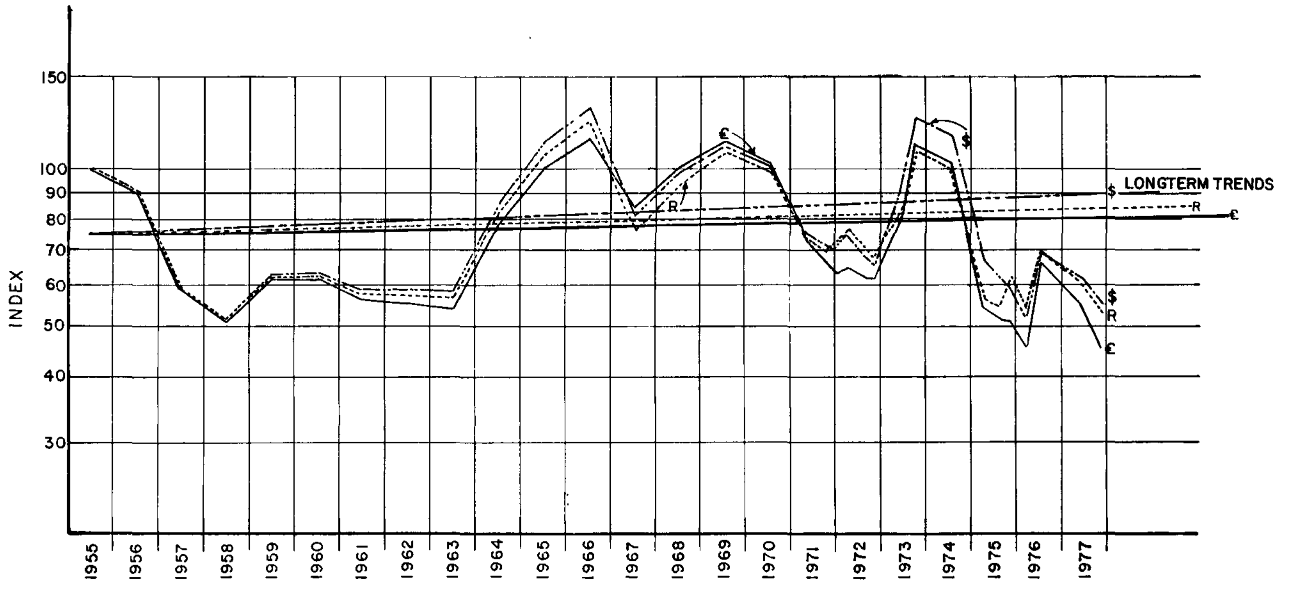

Fig. 3—The L.M.E. copper price per ton (1000 kg) in real R, $, and £ terms indexed to 1955

TABLE IV

L.M.E. COPPER PRICES PER TON* IN THE U.K., THE U.S.A., AND SOUTH AFRICA IN CURRENT AND REAL TERMS

	U.K. — L.M.E. copper price £/t		L.M.E. price in S.A. R/t		L.M.E. price in U.S.A. $/t		Index of real prices		
	Current	Real (1955)	Current	Real (1955)	Current	Real (1955)	£	R	$
Column no.	1	2	3	4	5	6	7	8	9
1955	345,9	345,9	694,6	694,6	968,7	968,7	100,0	100,0	100,0
6	323,7	314,6	650,0	637,7	906,5	892,5	91,0	91,8	92,2
7	216,0	202,6	433,7	413,7	604,9	575,3	58,6	59,6	59,4
8	194,3	177,0	390,2	359,8	544,1	503,8	51,2	51,8	52,0
9	234,0	212,0	469,9	428,1	655,3	602,2	61,3	61,6	62,2
1960	242,1	215,2	486,1	437,0	678,0	612,9	62,2	62,9	63,3
1	225,9	195,0	453,6	399,6	632,6	566,2	56,4	57,5	58,4
2	230,3	191,6	462,4	401,4	645,0	570,8	55,4	57,8	58,9
3	230,6	188,2	463,0	397,3	645,8	565,1	54,4	57,2	58,3
4	345,5	272,9	693,8	580,0	967,6	835,0	78,9	83,5	86,2
5	460,7	347,4	925,1	743,8	1290,2	1095,4	100,4	107,1	113,1
6	546,2	396,0	1096,8	851,1	1529,7	1262,0	114,5	122,5	130,3
7	411,4	291,3	708,0	531,0	986,1	790,9	84,2	76,4	81,6
8	517,0	349,5	889,8	654,0	1239,2	954,2	101,0	94,2	98,5
9	610,9	391,6	1051,4	748,6	1464,3	1068,9	113,2	107,8	110,3
1970	589,4	355,4	1014,4	693,8	1412,8	974,8	102,7	99,9	100,6
1971 Jan/Jul	459,9	257,1	791,5	519,2	1111,6	740,3	74,3	74,7	76,4
Aug/Nov	425,7	230,7	759,9	484,1	1061,3	696,2	66,7	69,7	71,9
Dec	410,6	219,3	805,6	506,7	1049,0	683,9	63,4	72,9	70,6
1972 Jan/May	429,0	225,7	841,7	523,5	1119,3	724,2	65,3	75,4	74,8
Jun/Sep	424,2	217,2	832,3	503,5	1037,8	663,2	62,8	72,5	68,5
Oct/Dec	430,7	215,4	792,5	467,6	1009,5	637,8	62,3	67,3	65,8
1973 Jan/May	569,7	276,3	1020,3	579,5	1413,2	873,4	79,9	83,4	90,2
Jun/Dec	839,5	387,8	1381,8	754,5	2053,2	1215,5	112,1	108,6	125,5
1974	877,6	356,3	1411,2	701,4	2072,2	1125,2	103,0	101,0	116,2
1975 Jan/May	539,2	188,7	873,5	395,7	1288,4	654,5	54,6	57,0	67,6
Jun/Aug	561,8	179,2	874,7	380,5	1221,7	604,7	51,8	54,8	62,4
Sep/Dec	574,3	176,3	1025,7	433,9	1176,3	571,7	51,0	62,5	59,0
1976 Jan/Apr	540,2	158,3	922,7	377,4	1058,1	506,8	45,8	54,3	52,3
May/Dec	834,5	228,7	1255,1	485,7	1439,3	670,7	66,1	69,9	69,2
1977 Jan/Sep	776,5	189,5	1172,5	419,8	1344,6	598,4	54,8	60,4	61,8
Oct/Dec	667,0	156,7	1081,2	369,8	1239,9	536,9	45,3	53,2	55,4

Column 1 from *Metal Statistics*, Metallgesellschaft Aktiengesellschaft.
Column 2 = Column 1 above × Column 4 in Table I ÷ 100
Column 3 = Column 1 above × Column 9 in Table I
Column 4 = Column 3 above × Column 6 in Table I ÷ 100
Trend estimates as on Table II: Column 7: $75,4(1,0028)^n$
Column 8: $74,9(1,0050)^n$
Column 9: $75,4(1,0076)^n$

Column 5 = Column 3 above ÷ Column 7 in Table I
Column 6 = Column 5 above × Column 2 in Table I ÷ 100
Columns 7/9 = Columns 2, 4, and 6 indexed to 1955

*1t = 1000 kg

NIM reports

The following reports are available free of charge from the National Institute for Metallurgy, Private Bag X3015, Randburg, 2125 South Africa.

Report no. 1962

Supergene alteration of sulphide ores. I. Literature survey, measurement, and effect on floatability and leachability. (14th Jul., 1978.)

Supergene alteration of sulphide ores forms part of the exogenic cycle of the elements in the Earth. The aqueous chemical confines in which this alteration takes place in nature are well defined and can be illustrated in diagrams of oxidation potential against acidity. Under special conditions, the oxidation of sulphide ore-bodies near the surface may trigger off a galvanic process that leads to corrosive activities at deep levels far below the water table.

Definite reaction series are involved in the supergene alteration of sulphide ores, and in most instances these series follow the same general trend, i.e., cations are first removed from the primary minerals until sulphur is left, which then oxidizes to sulphate. The completeness of a given series of minerals depends on the chemical nature of the environment, which in turn is the product of the composition of the ore and the country rock.

The degree of oxidation of sulphide ores affects their flotation properties. Evidence of this effect is given, and typical indications of oxidized sulphide ore in the flotation cell are tentatively identified.

A definition of the degree of supergene alteration is given, and microscopic and chemical methods for the definition of this parameter are discussed and developed. The microscopic method is based on semiquantitative data for mineral abundances and reactions, and the chemical method hinges on the solubility of ores in water and the resultant oxidation potentials and acidity imparted to the solution.

Methods are given for the ranking of sulphide ores in terms of their floatability and leachability. However, these methods are of a general nature and probably need to be modified for each specific ore-body studied.

Report no. 1967

The movement of the burden in submerged-arc furnaces for the production of high-carbon ferromanganese. (12th Jun., 1978.)

The mechanism by which the burden moves in a submerged-arc furnace was investigated in two large industrial furnaces by the stimulus–response technique with a radiotracer of the radio-isotope $^{59}_{26}Fe$ as the stimulus. As this radio-isotope was suitable only for the measurement of residence-time distributions in the alloy phase, the analysis of the experiments was limited to that phase.

The residence-time distributions obtained by the measurement of alloy samples obtained during tapping were analysed by various techniques. The truncation of most of the residence-time distributions meant that a single-parameter description of these distributions was possible in only three experiments. This analysis verified the existence of stagnant zones within the furnace, and showed that the movement of the burden through the furnace could not be described by either of the two idealized patterns of flow, i.e., plug flow or mixed flow.

A composite model to describe the movement of the burden through the furnace was developed by consideration of the mechanism and position of heat generation within the furnace, the inner structure of the furnace, the general form of the measured residence-time distributions, and the mode of burden descent through the furnace. The composite model consisted of a dispersed plug-flow region in the upper regions of the furnace discharging into a constantly stirred tank reactor beneath the electrode tips.

Non-linear regression analysis of the equations developed from the composite model permitted the selection of optimum values of model parameters to give computed curves that approximated to the residence-time distributions. Since the computed results used realistic values of the model parameters, it was concluded that the model was a valid representation of burden movement through the furnaces. No important quantitative correlations could be found between the operating parameters and the optimum model parameters.

The role of factors such as the position of the radiotracer addition, the energy input to the furnace, the mode of heat distribution in the furnace, and variations in the feed rate of raw materials was analysed in an attempt to describe the influence of furnace operating conditions on the values of the model parameters.

Report no. 1972

The preparation and certification of a reference sample of high-carbon ferrochromium. (5th Jun., 1978.)

A sample of approximately 285 kg of high-carbon ferrochromium was analysed by twenty-nine laboratories, and the analytical results were used, after a thorough statistical examination, in the assignment of certified values to the constituents. The statistical evaluation shows that this sample is sufficiently homogeneous to be used as a reference material.

The certified values are as follows:

Carbon 6,99%	Phosphorus 173 p.p.m.
Cobalt 512 p.p.m.	Sulphur 611 p.p.m.
Chromium $53{,}7_0$%	Silicon 1,95%
Iron $36{,}0_4$%	Titanium 0,20%
Manganese 0,16%	Vanadium 0,32%
Nickel 0,19%	