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The behaviour of industrial share prices in relation to Gross National Product and interest rates in South Africa

INTRODUCTION

In an article entitled "The stock market in perspective" which was published in the Harvard Business Review[1] in 1956, Professor J. Fred Weston, the co-author of the text "Weston & Brigham"[2] which is well-known to commerce students, describes a method for judging the "soundness" of the current level of ordinary share prices. It will be remembered that at that time the prices of industrial shares were rising rapidly on the New York Stock Exchange to new highs and many people began to question the soundness of these levels and wonder whether the events of 1929 were not about to repeat themselves. This question became the subject of an investigation of the Senate Committee on Currency and Banking at which Professor J. K. Galbraith testified and a very interesting personal account of this event is given in the introduction to later editions of his book "The Great Crash 1929".[3]

Weston's method was to test the current actual level of the industrials index against the level which was predicted by a linear regression equation which he had obtained expressing the industrials index as a function of GNP. By substituting the expected current value of GNP into this equation a predicted value of the industrials index could be obtained and this could be compared to the actual value. He points out that naturally there will be cyclical deviations about this long-term secular trend but in the long run share prices will obey this relationship.

His justification for postulating the existence of this relationship can basically be summarised as follows:

(1) There is a close relationship between GNP and sales in the aggregate.

(2) A good correlation also exists between sales and profits before taxes (although not so good over any extended period of time with profits after taxes).

(3) There is a close relationship between profits and dividends, and current and recent profits are the single most important influence on dividends.

(4) There is obviously a close relationship between dividends and share prices.

Thus, share prices can be linked directly to GNP and we should expect a straight line relationship between the two.

The purpose of the project now being reported was to investigate the same relationship for South African data. On the assumption that by far the majority of the fluctuations about this long-term trend will be caused by changes in interest rates, it was intended also to include some index of interest rates as an independent variable to see whether in this way an equation could be obtained which would account for most of these cyclical fluctuations. A rise in interest rates should lead to a drop in share prices since investors will then use a higher required rate of return in their calculations of the present value of expected future income from a security and will thus obtain a lower valuation of that security. In addition, higher interest rates are associated with periods of tight monetary policy and there are well-known reasons for periods of tight money being characterised by lower share prices.

It was also intended to investigate whether the inclusion of the value of the industrials index in the previous year as an additional independent variable may be helpful in explaining the short-term fluctuations. There are two possible reasons why a relationship such as this should exist: firstly, some investors may consider the industrials index itself to be a measure of the outlook for profits without attaching much weight to forces such as the rate of interest as one of its determinants. Secondly, some investors may actually think in terms of a long-run relationship between GNP and share prices similar to that postulated by Weston and when share prices fall below what is considered their long-term value they consider the probability of a rise in prices to become high; conversely, when they are above their long-term value, they consider the probability of a fall in prices to be high. The existence of both these types of investor behaviour would justify investigating the possibility of including values of the industrials index in previous periods as an independent variable.

DATA

The data used was obtained from various issues of the South African Reserve Bank Quarterly Bulletin which covered the period 1938 to 1974. The Reserve Bank's index of industrial share prices was used and 1938 was chosen as a base year (i.e. 1938 = 100). The yield on long-term government stock was used as a measure of interest rates. GNP figures were obtained from the national accounts and are expressed in market prices and not in real terms.

Using these data for the period 1950-1970 the following correlation matrix was obtained (where

s_t = value of industrials index
i = interest rate
g = GNP at market prices expressed in R millions
s_{t-1} = value of industrials index in the previous year):

	s_t	i	g
i	0,69		
g	0,88	0,93	
s_{t-1}	0,89	0,80	0,89

Data from 1938 — 1970 were used to calculate the equation expressing s_t as a function of g, since this is assumed to be a long-run relationship. To calculate s_t as a function of i and g and also to calculate s_t as a function of i, g and s_{t-1}, it was intended to use data from 1950 — 1970.

THE EQUATIONS

It was then intended to use these three equations to generate prediced values of s_t for the years 1971 — 1974 which could be compared to the actual values of s_t for those years by substituting the actual values of the independent variables i, g and s_{t-1} for those years into the three equations.

The following regression equations were obtained:

$$s_t = 95{,}089 + 0{,}0249\,g \quad (1)$$

$$s_t = 351{,}045 + 0{,}076\,g - 110{,}572\,i \quad (2)$$

$$s_t = 325{,}468 + 0{,}0594\,g - 102{,}623\,i + 0{,}3895\,s_{t-1} \quad (3)$$

To show how actual values of s_t compare with the predicted values generated by the equations, a graph of actual and predicted values of s_t is given for equations 1, 2 and 3 in Figures 1, 2 and 3 respectively. A study of these graphs will reveal that the inclusion of the two additional independent variables i and s_{t-1} (i.e. interest rates and the value of the industrials index in the previous period) does much to account for the fluctuations of the industrial share prices about the long-term trend given by Equation 1.

PROJECTIONS FOR 1971 — 1974 USING THE EQUATIONS

A study of the correlation matrix above reveals a high degree of correlation between the explanatory variables i, g and s_{t-1}. This is because the long-run trend of all three variables including interest rates has been upward over time. The existence of linear relationships among the explanatory variables gives rise to statistical problems which basically mean that the estimates of the regression coefficients become unreliable and this must be borne in mind when using the equations to predict values of the dependent variable s_t.

The actual values of all the independent variables and also the dependent variable for the years 1971 — 1974 are given in Table 1.

TABLE 1

Year	Industrial index	Interest rate	GNP at market prices
1971	335	8,50	13 390
1972	396	8,13	15 071
1973	460	8,00	18 183
1974	373	9,50	21 657

Substituting these values of the independent variables into the three equations, prediced values of s_t for these years can be obtained, which are given in Table 2 together with the actual values of s_t and the percentage error where this is calculated by actual s_t minus predicted s_t as a percentage of actual s_t.

TABLE 2

Year	Actual value of S_t	Equation 1		Equation 2		Equation 3	
		Projected	error %	Projected	error %	Projected	error %
1971	335	428,5	−27,9	428,8	−28,0	390,9	−16,7
1972	396	470,4	−18,8	597,5	−50,9	516,7	−30,5
1973	460	547,8	−19,1	848,4	−84,4	741,5	−61,2
1974	373	634,3	−70,1	946,5	−153,8	815,9	−118,7

Although statistical tests on the estimates of the equations indicate that they are significant, it is obvious that the errors shown in Table 2 are very large and one is led to reject the equations on this basis. A possible reason for the unreliability of equations 2 and 3 is the existence of the linear relationships among the explanatory variables, as explained above.

The equations do indicate, by the sign of the coefficient of i, the inverse relationship between interest rates and share prices. We would have expected a negative correlation between these two variables but the correlation matrix, shown above, shows a positive correlation between share prices and interest rates, which is a result of the fact that the long-run trend of both, over time, has been upward.

RELATIONSHIPS BETWEEN PERCENTAGE CHANGES IN THE VARIABLES

One possible way of escaping the problem caused by the positive correlation between s_t and i over an extended period of time is rather to look for an equation expressing the percentage change in s_t as a function of the percentage changes in the other variables. Using data obtained for the years 1950 — 1970 giving the percentage change in each variable from one year to the next, the following correlation matrix was obtained (where

P_s = percentage change in s_t

P_i = percentage change in i

P_g = percentage change in g):

	P_s	P_i
P_i	−0,70	
P_g	0,02	−0,09

From this it can be seen that there is, as would be expected, a high negative correlation between changes in the interest rate and changes in share prices and a virtually zero correlation between changes in interest rates and changes in GNP. Unfortunately, however, there is also a negligible correlation between changes in GNP and changes in share prices.

The following equation was obtained:

$$P_s = 12{,}013 - 1{,}656\,P_i \quad (4)$$

Graphs of the actual values of P_s for 1950 — 1970 and the predicted values of P_s generated by this equation are shown in Figure 4.

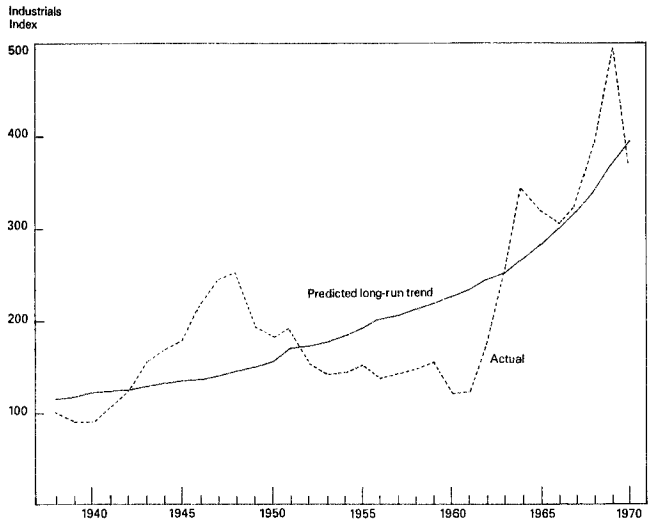

Figure 1. Equation 1: st = f(g)

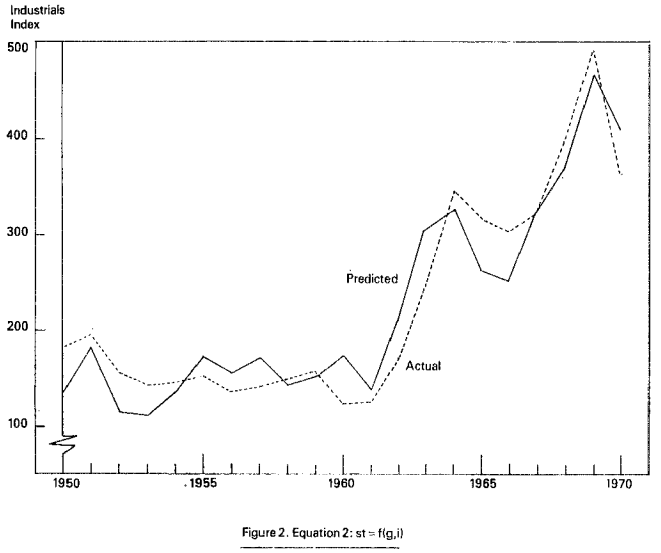

Figure 2. Equation 2: st = f(g,i)

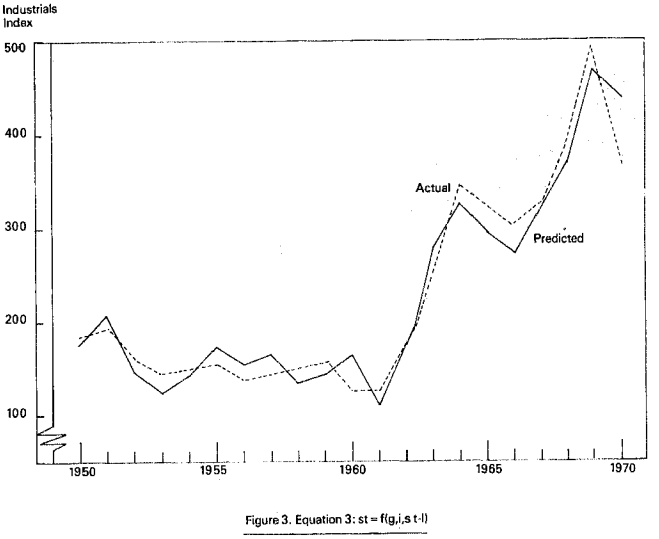

Figure 3. Equation 3: st = f(g,i,s t-l)

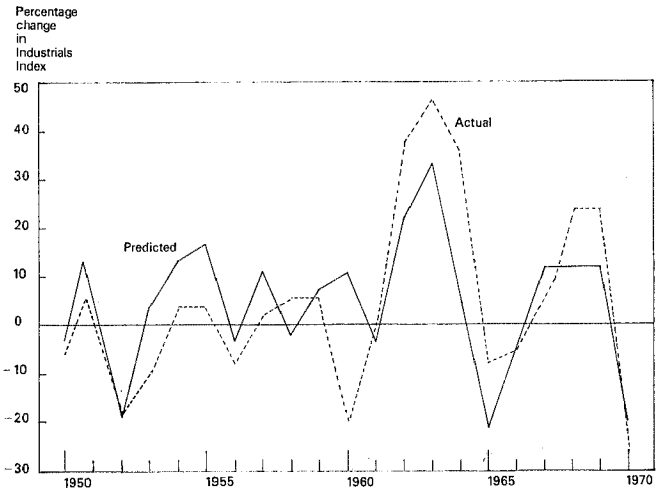

Figure 4. Equation 4: Ps = f(Pi)

PROJECTIONS FOR 1971 — 1974 USING EQUATION 4

The actual values of P_s and P_i for the years 1971 — 1974 are given in Table 3 together with the prediced values of P_s generated by substituting these values of P_i into equation 4.

TABLE 3

Year	Percentage change in interest rate	Percentage change in industrial index	
		Actual	Projected
1971	9,6770	−8,470	−4,012
1972	−4,3529	18,209	19,2214
1973	−1,5990	16,162	14,661
1974	18,750	−18,913	−19,037

Using these prediced values of the percentage change in s_t to calculate a prediced value of s_t from the value of s_t in the previous year, projected values of s_t for 1971 — 1974 were obtained. These are given in Table 4 together with the actual values of s_t for those years, and the percentage error where, again, this is expressed as actual value of s_t minus predicted value of s_t as a percentage of actual value of s_t. It can be seen from this that the equation generates prediced values of s_t which are very close to the actual values; the errors are very small indeed.

TABLE 4

Year	Actual value of industrial index	Projected value of industrial index	Percentage error
1971	335	351,3	−4,87
1972	396	396,9	−0,24
1973	460	444,4	3,38
1974	373	361,7	3,03

It would seem that the type of equation given by Equation 4 would be of considerably more use to the

professional investment analyst than the long-term relationship of Equation 1. One advantage is that working with percentage changes instead of absolute values overcomes the problem of perhaps having to express values of an index in terms of some other year before comparisons can be made between actual values prediced by an equation. Using percentage changes frees one from linking data to some base year.

CONCLUSION

The idea of a simple linear relationship between GNP and share prices does seem appealing; however, the relationship is so long-term that it is doubtful whether it is worth anything. For example, consider Figure 1: The trend of actual prices rose above the long-run line in 1942 and did not cross it again until 1952 after which it remained below until 1963. One cycle about the long-run line took twenty-one years to complete. The question is raised of whether such a long-run relationship is meaningful: it is possible that in less than the time required to complete this one cycle, structural changes can take place in the economy which alter this relationship. One example of an institutional change that has obviously affected the behaviour of share prices is the increasing proportion of investment that is managed by institutional investors such as pension funds, insurance companies and mutual funds. Another change is the high and accelerating rates of inflation that have characterised recent years[4].

The effects of inflation on the rates of interest will also mean that the relationship expressed in Equation 4 is a relationship which will only exist over a short period and will change over time. However, the regression can always be repeated intermittently using only the most recent data. Although in its calculation the data used were in the form of annual averages, there does not seem to be any reason why it cannot be done using daily, weekly or monthly data to get a relationship that is essentially the same: share price indices are available on a daily basis and call rates could perhaps be used as a measure of interest rates.

Whereas the only use of Equation 1 seems to be in the reassurance it gives that if GNP continues to rise, so must share prices in the very long-run, the professional analyst is able to take an equation such as Equation 4 and say that if interest rates have risen by so much, share prices should have dropped by so much and only if they have dropped more or have not dropped that much, is it necessary to seek further explanations. It is interesting to note here that when one considers the projections made using Equation 4 and which are given in Table 4, it is possible to account for the entire drop in share prices from their 1973 levels to those of 1974 in terms of the rise in interest rates caused by the tight monetary policy without any reference whatsoever to the political uncertainty caused by the Lisbon coup of April 1974 or the Rhodesian question. The latter reason was frequently mentioned in the press.

Given assumptions concerning changes in the interest rate that is used in the equation, it then becomes possible to use the equation to forecast movements in the index. This forecast can then be used to predict the movements in the prices of particular shares according to their "characteristic lines" which relates the return of the security to the return of the market.[5] In this way it can be predicted how individual portfolios will perform for given changes in interest rates.

APPENDIX

The percentage changes in each variable for the years 1950 — 1970 are given in Table A together with the predicted percentage change in s_t, i.e. P_s generated by Equation 4 which was obtained from this data. The graphs in Figure 4 were drawn from these actual and predicted values of P_s.

Table A

Year	Percentage change in g = P_g	Percentage change in i = P_i	Actual percentage change in s_t = P_s	Predicted percentage change in s_t
1950	11,87	9,01	−5,89	−2,90
1951	24,00	−0,83	5,49	13,39
1952	2,37	18,89	−18,49	−19,27
1953	9,16	5,14	−9,65	3,50
1954	8,24	−0,88	3,60	13,47
1955	6,80	−2,91	3,41	16,83
1956	9,32	9,24	−8,32	−3,29
1957	5,97	0,42	1,80	11,32
1958	3,87	8,00	5,37	−1,24
1959	6,42	2,34	5,03	8,14
1960	6,74	0,76	−20,26	10,76
1961	4,19	8,88	0,00	−2,69
1962	8,91	−5,56	38,22	21,22
1963	3,56	−12,68	47,36	33,01
1964	10,01	5,26	36,11	3,30
1965	9,23	20,00	−7,51	−21,11
1966	8,65	8,33	−4,69	−1,78
1967	11,31	0,00	5,57	12,01
1968	7,06	0,00	23,60	12,01
1969	12,25	0,00	23,87	12,01
1970	9,28	19,23	−25,76	−19,83

The data used to obtain Equations 1, 2 and 3 are given in Table B together with the prediced values of s_t generated by the equations for those years and the percentage errors (actual minus prediced as a percentage of actual). The graphs in Figures 1, 2 and 3 are drawn from these actual and predicted values of s_t.

Table B

Year	g	i	Actual value of s_t	Predicted values of s_t Equation 1		Equation 2		Equation 3	
				Predicted	error %	Predicted	error %	Predicted	error %
1938	925	3,45	100,0	118,12	−18,12	—	—	—	—
1939	960	3,70	93,4	118,99	−27,40	—	—	—	—
1940	1 048	3,40	93,0	121,18	−30,30	—	—	—	—
1941	1 157	3,00	109,6	123,90	−13,04	—	—	—	—
1942	1 300	3,00	127,6	127,46	0,11	—	—	—	—
1943	1 410	3,00	157,5	130,20	17,34	—	—	—	—
1944	1 530	3,00	170,3	133,18	21,79	—	—	—	—
1945	1 620	3,00	178,9	135,43	24,30	—	—	—	—
1946	1 710	2,89	219,1	137,67	37,17	—	—	—	—
1947	1 810	2,63	246,5	140,16	43,14	—	—	—	—
1948	2 062	2,90	252,3	146,43	41,96	—	—	—	—
1949	2 190	3,33	193,4	149,62	22,64	—	—	—	—
1950	2 450	3,63	182,0	156,09	14,24	135,89	25,34	173,64	4,59
1951	3 038	3,60	192,0	170,73	11,08	183,90	4,22	207,25	−7,94
1952	3 110	4,28	156,0	172,53	−10,24	114,18	27,04	145,63	6,95
1953	3 395	4,50	141,4	179,62	−27,03	111,52	21,13	126,18	10,76
1954	3 675	4,46	146,5	186,59	−27,37	137,22	6,33	141,06	3,72
1955	3 925	4,33	151,5	192,82	−27,27	170,60	−12,61	171,23	−13,02
1956	4 291	4,73	138,9	281,93	−45,38	154,19	−11,01	153,87	−10,78
1957	4 547	4,75	141,4	208,31	−47,32	171,44	−21,24	162,13	−14,66
1958	4 723	5,13	149,0	212,69	−42,74	142,80	4,16	135,56	9,69
1959	5 026	5,25	156,5	220,23	−40,72	152,56	2,52	143,20	8,50
1960	5 365	5,29	124,8	228,67	−83,23	173,90	−39,34	162,15	−29,93
1961	5 590	5,76	124,8	234,28	−87,72	139,03	−11,41	114,96	7,88
1962	6 088	5,44	172,5	246,68	−43,00	212,27	−23,06	177,39	−2,83
1963	6 305	4,75	254,2	252,09	0,84	305,06	−20,01	279,63	−10,00
1964	6 936	5,00	346,0	267,69	22,60	325,38	5,96	323,22	6,59
1965	7 576	6,00	320,0	283,72	11,34	236,45	17,67	294,29	8,03
1966	8 231	6,50	305,0	300,03	1,63	257,95	15,43	271,79	10,89
1967	9 162	6,50	322,0	323,21	−0,38	328,71	−2,08	321,27	0,23
1968	9 809	6,50	398,0	339,22	14,74	377,89	5,05	366,32	7,96
1969	11 011	6,50	493,0	369,25	25,10	469,25	4,82	467,26	5,22
1970	12 033	7,75	366,0	394,70	−7,84	408,72	−11,67	436,63	−19,30

Acknowledgement

"The author would like to acknowledge the assistance given to him by Mr D. Rees of the Economics Department, University of Cape Town who provided most valuable advice, and also that provided by Mr L. J. Berry who helped with the computation."

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4 See article by M. van den Berg, 'Some observations on inflation and the long-term rate of interest in South Africa', *The Investment Analysts Journal,* No. 4, June 1974.

5 See article by Richard Gross, 'Risk analysis of ordinary shares quoted on The Johannesburg Stock Exchange', *The Investment Analysts Journal,* No. 4, June 1974.