CYCLES AND TRENDS IN AUSTRALIAN SHARE PRICES

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Introduction

This paper is an attempt to identify the nature of the cycles and the cause of the long term trend of Australian share prices since 1875.

The amount of literature about share price fluctuations is considerable and has become increasingly mathematical. Literature about long term trends is somewhat less abundant. The interested reader is referred to Granger and Morgenstern (1970) for a comprehensive discussion of the subject.

For the purposes of this note, it is intended to presume that the Random Walk Theory remains substantially intact although some deviations from randomness have been discovered.

There are two major differences between the hypothesis presented here and the Random Walk Theory. First the existence of a slowly changing equilibrium and a model for its trend is postulated. Second, a particular type of random fluctuation about this trend is suggested.

Hypothesis:

The model which is suggested by the analysis and data that follow is threefold —

(a) There exists an equilibrium about which share prices fluctuate;

(b) This equilibrium changes slowly with time and is related to asset backing;

(c) The fluctuation about this equilibrium constitutes a high order auto-regressive process.

While most readers will be familiar with the concepts of equilibrium and asset backing, the idea of an auto-regressive process may require some explanation.

Consider a ping-pong ball lying on a concave surface, such as an ashtray. If the ashtray is left outside in a variable wind this will tend to move the ball about at random, but there will be two important deviations from completely random behaviour. First, when the wind stops the ball will tend to return to the centre. Second, when movement commences in any direction for any reason it will tend to continue as a result of inertia until other forces exert themselves.

This example is not particularly rigorous but it may assist in understanding the concept of second order auto-regression in that there is —

(a) a tendency to return to an equilibrium position;

(b) a tendency for movements to continue once they have been initiated; and

(c) a random element.

If the ashtray is now coated with a substance like oil, then the ability of the ping-pong ball to move under its own inertia will be removed. The result is a first order auto-regressive process. Finally, if the sticky ashtray is replaced by a similarly sticky but flat surface, the only force moving the ball about is the variable wind. The process now becomes a random walk.

Using the usual mathematical notation, these three processes can be expressed as follows —

Random Walk	$X_t = X_{t-1} + E_t$
First Order AR	$X_t = aX_{t-1} + E_t$
Second Order AR	$X_t = aX_{t-1} + bX_{t-2} + E_t$

It should be noted that by making a=1 and b=0 in the equation for the second order auto-regressive process, it becomes a random walk. The random walk is therefore a special case of the auto-regressive process.

Cycles:

The word cycle is often used by economists and share market observers. For example, one hears such phrases as "the capital market cycle", "counter-cyclical strategy", and so on. Although writers such as Dewey and Mandino (1971) produce graphical evidence of cycles in a variety of commodities and stocks, such "cycles" have defied accurate mathematical definition.

Using the highly sophisticated technique of spectral analysis, mathematicians have been so far unable to identify any major sinosoidal (i.e. regularly repeating) components in share or commodity prices. The fact that market observers continue to think they "see" cycles while the results of spectral analysis are not particularly conclusive, makes one wonder whether "cycles" have been not recognised as auto-regressive processes.

For example, many people would believe they can see "cycles" in the two graphs shown below. The first is an example of an auto-regressive process generated by throwing two coins while the second is a chart of the annual averages of the Sydney All Ordinaries Index with the trend removed.

Figure 1.

Second Order Auto-Regressive Process generated by throwing two coins.

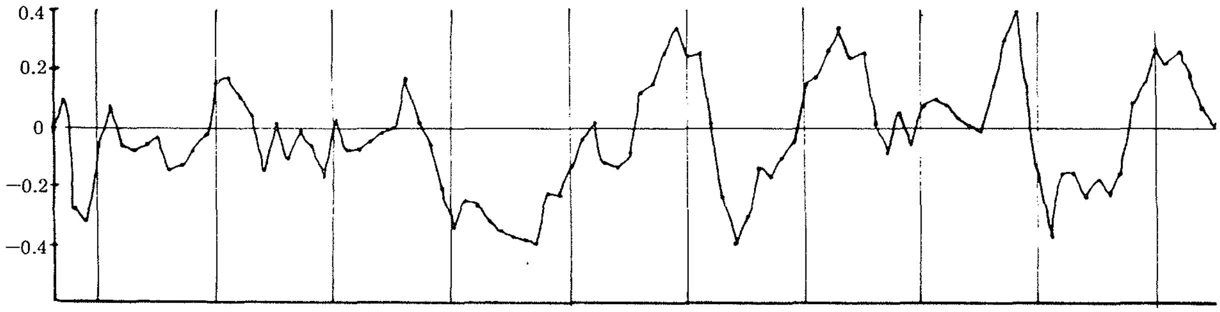
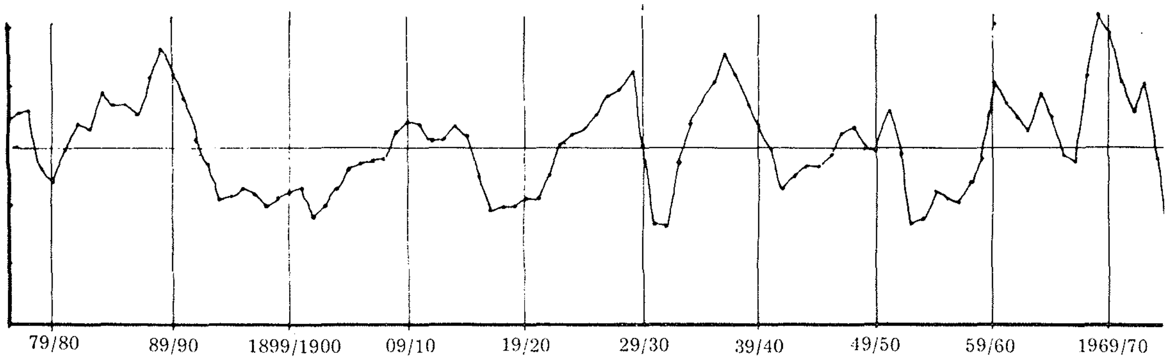


Figure 2.

Sydney All Ordinaries Index since 1875 with the trend removed.



Before explaining in some detail how the trend has been removed, it should be noted that the Sydney All Ordinaries dates back to 1936/37. Prior to that, there was a Commercial and Industrial Index. These two indices are published with the same base (1936/37=100) and are used as the one index here, although the current index has only existed since 1936/37. The chart above has a logarithmic vertical scale.

The results obtained for Figure 1 were generated by successive application of the formula —

$$X_n = X_{n-1} - 0.4 X_{n-2} + E_n$$

The series for E_n was generated by throwing two coins 111 times. Two heads counted as +.15, one head and one tail counted as zero, while two tails gave the value of $E_n = -.15$.

It will be appreciated that although the whole series was generated using the same formula, the first and second halves are not identical even though they have been generated by the same process. Is it not possible therefore, that the "formula" underlying the coin tossing series is the same as that underlying share price fluctuations?

The Long Term Trend of Share Prices:

In the last 100 years, the Sydney All Ordinaries Index has increased by a factor of roughly 80 or 4½% per annum compound. This long term upwards tendency has had a number of potential explanations including the following —

(a) Simple compound growth;

(b) Inflation.

Figure 3A shows share prices and inflation in the period 1930-78. It can be seen that the trend of the share price index and that of the general price level is roughly the same, namely 5% per annum compound. Figure 3B shows these two indicators over the period 1875-1930. In this earlier period the trend of share prices and the trend of the general prices level was not the same.

It should be noted that the trend in the share prices is roughly the same in the two periods. Is it not possible therefore that the same force is operating which has nothing to do with inflation?

Figure 3A

SHARE PRICES AND INFLATION 1930 – 1978

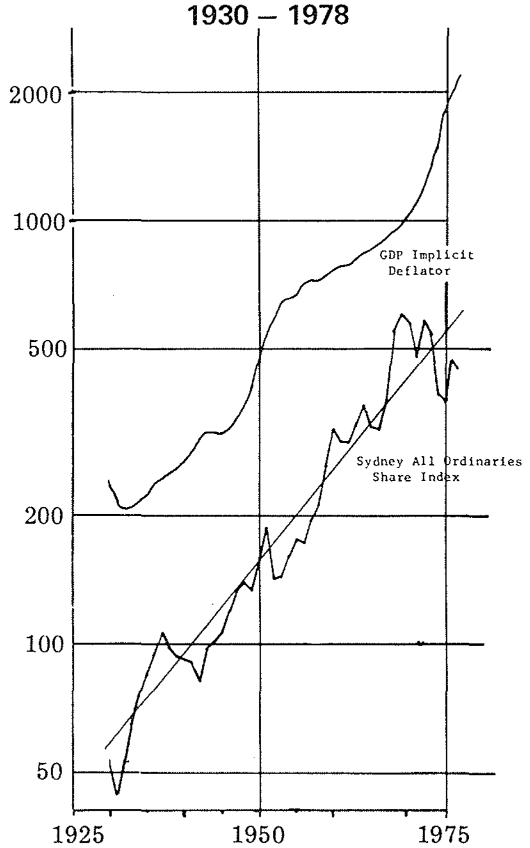
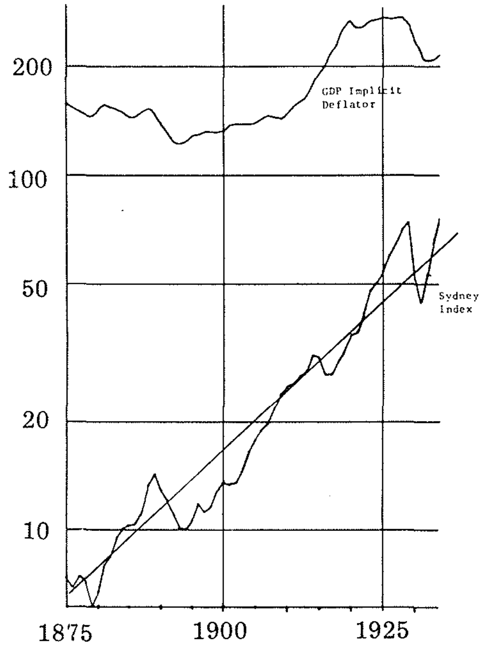


Figure 3B

SHARE PRICES AND INFLATION 1875 – 1930



However, it does seem that there has been a slight increase in the trend at this time. Statistically a model allowing for one rate of growth of 50 years and a different rate for the next 50 years is an improvement but the change in growth rate could also be explained by a partial adjustment with inflation.

Although there is no mathematical reason to prefer the partial inflation model to the "two growth rate" model there is a logical reason for doing so.

Suppose a company's *net* assets at the beginning of a period are \$100 of which \$30 is property. Now suppose the profit after tax is \$8 (8% of net assets) of which \$4 is paid in dividends, then the net assets at the end of the year will be \$104. Now suppose that in the year just ended the buildings increased in line with inflation of 20%, then the asset value would be \$110 (104 + 20% of 30).

In other words, the rate of increase in asset backing is 4% plus 30% of the rate of inflation. (The actual leased squares estimates obtained from the data were 3.9% compound growth plus 26% of inflation.)

Thus while this model fits the experience of asset backing of a hypothetical company, it may not explain the share index unless it can be shown that —

(a) the fitted trend is closely related to asset backing;

(b) roughly 4% of the net assets are ploughed back every year;

(c) roughly 30% of net assets are represented by property;

(d) property values roughly keep pace with inflation.

From a list of the largest companies as at 31/12/77, 10 stocks were selected with records extending back to 1947. This sample was not random since the companies were selected in decreasing order until 10 companies were obtained. The table below shows the average market premium on reported asset backing and the residual fluctuation, i.e. the difference between the Sydney index and its fitted long term trend. (Logarithms are used throughout.)

Figure 4

As at December	Logarithm of Ratio Market/ Net Assets	Logarithm of Ratio Market/ Fitted Trend
1947	0.58	0.08
1952	0.19	−0.28
1957	0.42	−0.15
1962	0.47	0.03
1967	0.64	0.20
1972	0.54	0.26
1977	−0.05	−0.33
Average	0.40	−0.03

The coefficient of correlation (i.e. the mathematical measurement of the extent to which these two columns move in parallel), is 0.90. Thus although the sample is fairly small, this does verify the assertion that stated asset backing and the estimated equilibrium are related. The estimated relationship is —

$$\log(\text{equilibrium}) = 0.43 + \log(\text{asset backing})$$

$$\text{or} \quad \text{equilibrium} = 1.5 \times \text{asset backing}$$

Whether 4% of shareholders' funds has been ploughed back every year is difficult to substantiate, particularly for the early years. It is nevertheless in rough agreement with experience of the Reserve Bank All Industries Constant Group over the last 20 years.

Similarly, it is difficult to establish whether periodic property revaluations account for a 30% partial movement with inflation. The average proportion of shareholders' funds represented by property in the 10 companies referred to above was .39. If one takes account of the fact that buildings are not usually depreciated in company reports and the size of this sample, these two figures are broadly consistent.

A paper by Alchian and Kessel (1959) also supports the "partial hedge" model. They divided a sample of U.S. stocks into net debtors and net creditors and compared the two groups over both inflationary and deflationary periods. Their conclusion was that net debtors out-performed net creditors during inflation and the reverse was true during deflation. Further, their investigation of banking shares in periods of very high (i.e. runaway) inflation led them to conclude that owners of banks suffered from inflation in real terms as predicted by the partial hedge model.

Some people may argue that stock and plant are real and the proportion of assets accounted for in real terms is considerably higher than the 30% represented by land and buildings. Whilst not denying that the value of stock and plant may move with inflation, they are rarely accounted for in real terms. Depreciation for example is usually based on the original cost of an article. Similarly, illusory stock profits are rarely removed from reported results except for the variable treatment of the recent tax concession on inventory profits. Accordingly, stock and plant are generally accounted for in money terms and when a company reports a profit it is after shareholders' funds in relation to these items which have been maintained in money terms. By contrast revaluation of buildings is usually treated as an extraordinary item.

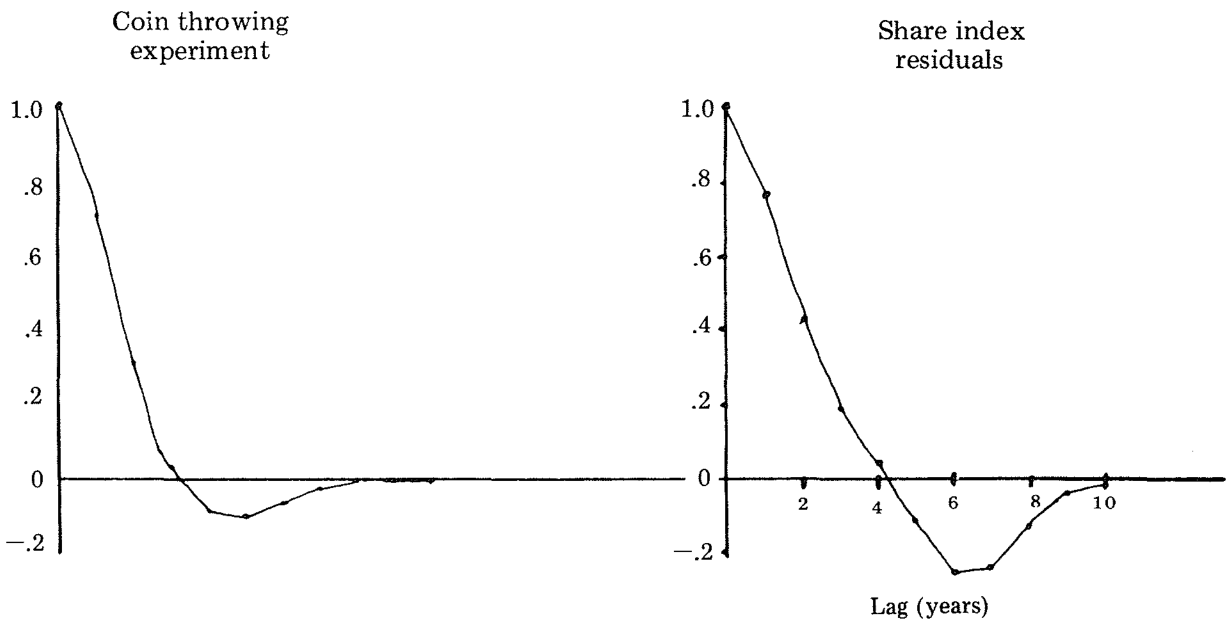
Fluctuations about the Trend:

Although the partial-hedge-compound-growth model has been used to estimate the equilibrium, there would not be much difference in this analysis if the simple compound model were used.

Accordingly, the investigation of the nature of the fluctuations that follow does not necessarily depend on the correctness of the model for the trend.

Having removed the trend, the correlation among the residual fluctuations was then investigated. The correlations between residuals 1, 2, 3, etc. years apart were calculated and the result is shown below. These charts are called correlograms. Also shown is the correlogram for the series generated by the coin tossing.

Figure 5



Because the mathematical background to the shape of correlograms is more complicated than the mathematics of random walks, it is not proposed to set out the details here. The interested reader is referred to Jenkins and Watts (1969).

However, it can be seen that these two correlograms have a similar shape. Because this shape is that of a second (or higher) order AR process, the residual fluctuation is not a random walk.

This conclusion is reinforced by the chart below. The 1200 months from 1875 were broken up into 11 over-lapping periods of 200 months. The residual variations from the equilibrium were then calculated monthly and the correlograms for the whole period (heavy line) and each of the 200 month periods were calculated and plotted.

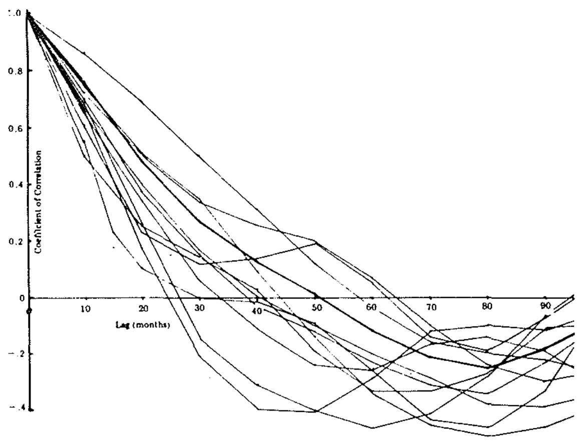
From the data used to plot the correlogram, it is possible to estimate the formula applying to the share index and compare it with the coin tossing experiment. The formulae are —

$X_n = 1.04\ X_{n-1} - 0.37\ X_{n-2} + E_n$ (share index)

$X_n = 1.00\ X_{n-1} - 0.40\ X_{n-2} + E_n$ (coin experiment)

In the case of the share index X_n is the logarithm of the ratio of the share price index to its fitted trend.

Figure 6



Conclusion:

One of the problems with writing articles on share price movements is that so many people have fixed ideas. For example, some observers believe there is a clearly defined 10-15 year cycle in the share market yet spectral analysis does not agree. This analysis suggests that the cycle could be an auto-regressive process which would explain both the apparent cycle and the fact that spectral analysis does not identify any major sinosoidal components.

The next problem is that if the identification of an AR process of second or higher order is correct, then the formula

$$X_n = 1.04\ X_{n-1} - .37\ X_{n-2} + E_n$$

can be rewritten —

$$X_n = .67\ X_{n-1} + .37\ (X_{n-1} - X_{n-2}) + E_n$$

(X_n is the logarithm of the ratio of the share price index to its fitted trend.)

The first term indicates a tendency to return to equilibrium and the second a tendency for trends to continue. Both these tendencies are contrary to the Random Walk Hypothesis.

I believe there is a fundamental difference between the analyses that are connected with the Random Walk model and this analysis. For whereas the Random Walk analyses are primarily concerned with price *differences* and the correlations between them over fairly short periods, this analysis is concerned with measuring the price *level* and comparing it to the subsequent movement over somewhat longer periods. Furthermore, the Random Walk model is a very good approximation to the AR model, particularly for short periods.

But what of the long term trend? Many people point out that share prices have broadly kept pace with inflation for fifty years. My model contends that the force behind the trend is primarily retained profits and that it is a coincidence that the average rate of inflation and retentions as a percentage of shareholders' funds have been roughly equal. That a share price index has moved upwards roughly parallel with inflation is therefore a result of this coincidence.

However, there is some evidence of a partial link with inflation corresponding with the proportion of shareholders' funds accounted for in real terms. This has two interesting consequences.

First, if we were to restrict our portfolio to the small number of companies where land and buildings were roughly equal to shareholders' funds, then the long term movement of the equilibrium level of this portfolio would exceed inflation, (in addition to dividends) because of retained profits.

Secondly, if Current Cost Accounting were introduced, plant and stock would be accounted for in real terms and the equilibrium level of the whole market would then exceed inflation by any retained profits.

Forecast:

With the benefit of hindsight, it is very easy to see when we should have bought and when we should have sold. Trying to determine what to do now is not so easy.

At the time of writing (July 1978), the Sydney index is 520 while the equilibrium level (i.e. the fitted trend) is 690. In five years time the equilibrium level should be approximately 900 which would represent compound growth of 11% over the next five years if the equilibrium were regained.

According to the AR model this is the best estimate available. According to the Random Walk Theory, the best estimate is either the historic average (4½%) or nil (share prices are equally likely to go up or down).

Perhaps this could be restated that while the Random Walk Theory would not lead us to expect any greater or lower rate of growth than normal in the next five years, the auto-regressive model predicts a very much higher growth rate for the share index.

Unfortunately, we will not be able to say in five years time that an 11% growth rate disproves the Random Walk Theory and a 4½% growth rate disproves the auto-regressive theory. A growth rate closer to 11% than 4½% may lead us to prefer the AR theory to the Random Walk and vice versa. However, in this particular instance, the difference between the two growth rates is so large that history may well judge the validity of my analysis.

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