

A Simple Model for the Determination of Stock Prices on Wall Street 1871-1990

Cees J. Prins

Bank Cantrade NV, PO Box 231, 1000 AE Amsterdam, The Netherlands

Summary

Many people regard the Stock Exchange as the beating heart of the economy. The main elements in the daily economic progress (inflation, interest rates, GNP growth) therefore play an important role in the determination of stock prices. This price level consists of two parts. The first one is the valuation of the Stock Exchange (price earnings ratio) measured by all kinds of economic indicators; the other one is the level of earnings itself. It is the objective of this paper to produce some solid estimations of a simple model for stockprices in the United States that gives the elements of both prices earnings ratio and earnings as well as the significance levels.

Résumé

Un Modèle Simple pour Déterminer le Prix des Actions a Wall Street 1871 - 1990

Bon nombre de gens considèrent la Bourse comme le coeur même de l'économie. C'est pourquoi, les principaux éléments de la progression économique journalière (inflation, taux d'intérêts, croissance du PNB) jouent un rôle important dans la détermination des prix des actions. Ce niveau de prix est constitué de deux parties. La première est l'évaluation de la Bourse (rapport cours-bénéfice) mesuré par toutes sortes d'indices économiques; la deuxième est le niveau de bénéfice lui-même. Le but de cet article est de produire des estimations solides d'un modèle simple pour les prix des actions aux Etats-Unis qui donne à la fois les éléments du rapport cours-bénéfice et des bénéfices et les seuils de signification.

STRUCTURES ON WALLSTREET

Introduction

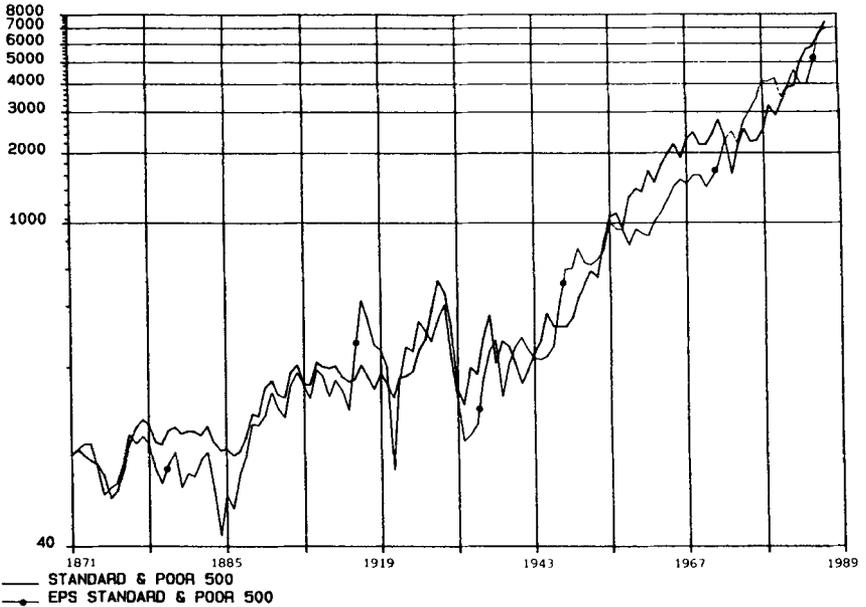
Many people regard the stock exchange as the heart of the economy. If a country's economy is performing well, the stock exchange will reflect this. However, little systematic research has been conducted into the relationship between stock market indices and macro-economic factors, certainly in the Netherlands. Although the Netherlands has a distinguished tradition in securities trading, there are a few reliable statistics allowing the analysis of long, uninterrupted periods on a monthly or quarterly basis. No continuous stock exchange index, such as that of the United States, is available for this century, for instance.

In comparison with countries such as Britain and the US, therefore, the Netherlands has not done particularly well in preparing and maintaining chronological records. There are no official quarterly records of GNP, although the Nederlands Central Bank has done a great deal of work in this area. Because a detailed analysis of shares and the economy demands a large amount of statistical material, the United States was chosen for this study. This report focuses on the principle relationships between stock market sentiment and developments at the macro economic level, as referred to above.

Summary of the main points

Figures are available for the United States for a period of more than a century. They relate not only to average annual prices, but also to matters such as profits and dividends. Graph 1 illustrates average annual prices and profit movements. Although these are annual averages, the crises of 1906, 1929 and 1973/1974 are clearly visible, as is the Second World War.

Graph 1. De S&P 500 index and profit movements (1871-1989)



The crash of October 1987 has been 'averaged out' and it cannot be seen in the annual figures. The two lines follow a remarkably similar path, providing practical confirmation of the theoretical link between

profits and share prices. However, a closer examination of the graph shows that profits remained unchanged for the first two decades, while share prices rose. In the last 10 years, profits have risen by almost 70%, while share prices have increased by 200%. There are therefore other factors which influence these movements.

The following table shows the percentage increases in share prices, profits, inflation and nominal wages between 1871 and 1988, in totals for the period and in average annual increases.

	% Rise, 1871-1988	Average annual rise in % 1871-1988
S & P 500 Prices	7429	3,7
S & P 500 corporate profits	6953	3,6
Inflation	1374	2,2
Nominal wages	5173	3,4

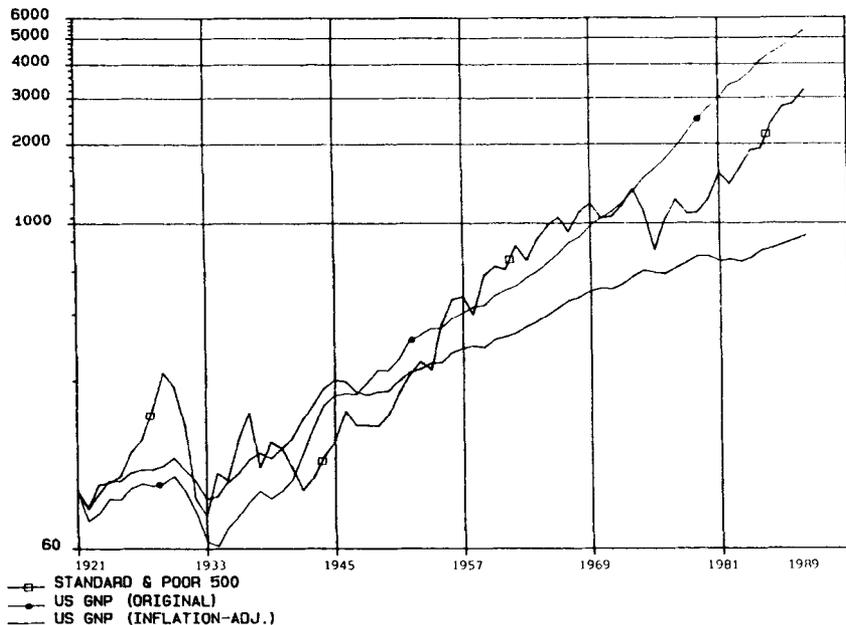
Source: Standard and Poor; F.K. Lage, *Secular Inflation*, 1961; Statistical Abstract of the United States; OECD.

In the last 120 years, therefore, share prices have followed profit movements on a structural basis. The increase was more than enough to keep pace with inflation and in fact slightly higher than the rise in (nominal) wages.

From 1921 onwards, rather more macro-economic factors can be included. The following graph relates average annual prices and nominal GNP, both with 1921 as the base. Overall, nominal GNP has risen more than the (likewise nominal) S & P 500 index. Although price/earnings (P/E) ratios fluctuated sharply in this period, the difference between 1921

(P/E = 10) and 1989 (P/E = 11,5) is relatively small. The difference in growth is not therefore due to a difference in valuation levels. If GNP is corrected for inflation, the rise in the S & P 500 index is much sharper than that of GNP (in volume terms). The latter variable is also shown in the graph.

Graph 2. Movements in GNP and the S & P 500 (1921-1989)



The S & P index has kept pace with profit movements in recent decades. Unexpectedly, however, the growth of nominal GNP does not provide a conclusive explanation for the general price movements.

Clearly, annual figures can only show very rough patterns, which are valid only with an adequate number of observations. For a more detailed view, we are forced to resort to quarterly or monthly figu-

res. In order to find figures covering a sufficiently long period, we must once again turn to the United States.

Some quantitative indicators for pricing of US shares

Quarterly figures for the stock exchange in the United Nations, including profit and dividend figures, are available from 1936. Reliable quarterly figures on the national economy are available from the Second World War onwards. The 1960-1990 (II) period selected here is sufficiently long, with 122 observations, to allow statistically significant statements to be made.

The following equation provides the simplest determination of the level of S & P 500 index:

$$S \ \& \ P \ 500_t = EPS_t * P/E_t$$

To establish this level, the S & P 500 earnings per share (EPS) and P/E ratio are needed. The latter variable is the most crucial, as it reflects price levels on the Stock Exchange. Shares are priced on the basis of an assessment of the risks and returns. The return is ultimately determined by profit movements (G^{EPS}). Current prices are known to take future expectations into account. A difference of two to four quarters is often used. Risks can be assessed on the basis of earnings fluctuations. The variation coefficient of profit growth (VC^{EPS}) over a period of 16 quarters is used here. The best estimation was as follows:

$$P/E_t = 18,57 + 0,05 G_{t+3}^{EPS} - 38,86 VC_t^{EPS} \qquad R^2 = 0,18$$

(15,7) (1,8) (-4,5)

The above result shows that the stock market anticipates events nine

months ahead. The coefficients signs are correct in each case and the coefficients themselves are reasonably significant. However, the explanatory power proves to be insufficient. The model can therefore be said to be insufficiently. More is needed to determine the level of the P/E ratio. Other theoretical concepts must therefore also be studied.

We know from the dividend discount model in economic literature that price levels imply a discounting of future dividends.

$$P = \frac{D}{R - G}$$

Where P is the price level, D the dividend, R the discounting factor and G the rate of growth. The dividend can be divided into earnings (E) and the pay-out ratio (POR).

$$P = \frac{E \cdot \text{POR}}{R - G}$$

If the right- and lefthand sides of the equation are divided by E, this produces an equation for the P/E ratio:

$$P/E = \frac{\text{POR}}{R - G}$$

The simplest model for the P/E ratio is therefore a function of the pay-out ratio, the interest rate and the growth rate. This simple model can be tested against available historical data where several

possible definitions of both growth and discounting factor have been tried out. The result of the estimation was as follows:

$$P/E_t = -1,71 - 0,52 R_t^L + 38,90 POR_t + 0,050 G_{t+3}^{EPS} \quad R^2 = 0,84$$

(-1,1) (-7,7) (16,1) (4,0)

The theoretical connection outlined above is therefore reflected in full, with all coefficients sufficiently significant, as the 't' values in brackets show. The signs are also correct in each case. The 84% accuracy achieved is highly acceptable, although there is some autocorrelation in the residuals, which often occurs in such time series. The results of the estimations show, however, that the P/E ratio anticipates profit movements by nine months. This is in line with the time lag found earlier.

Because stock market prices depend on market sentiment, it seems likely that prices will be higher in periods of economic growth than in periods of economic decline. A simple business cycle index has been constructed for this purpose, consisting of three variables: GNP, unemployment and utilisation of production capacity. Principal component analysis has been used to investigate the main cyclical structure of these economic variables. The main component extracted from this data accounted for more than 87% of total variance. This economic index was then used to discount the 'sentiment effect', producing the following result:

$$P/E_t = -5,21 + 0,96 BC_t - 0,29 R_t^L + 42,69 POR_t + 0,048 G_{t+3}^{EPS}$$

(-3,6) (6,1) (-4,2) (19,3) (4,5)

$R^2 = 0,88$

From the significance of the economic index, one can deduce that the

P/E ratios will therefore clearly be higher in a period of economic growth than in a period of economic recession.

For some time, ample liquidity has been regarded as an important stimulus for the stock markets. A 'reservoir' of liquid assets could account for an adjustment in price levels. A sudden fall in liquidity will not only affect the stock market climate through a rise in interest rates, but often has an independent effect as well. The liquidity ratio is used for this purpose (M2) money supply divided by nominal GNP. The result of the estimation builds on the previous equations.

$$\begin{aligned}
 P/E_t = & 27,19 + 1,0 BC_t - 0,22 R_t^L + 40,45 POR_t + 0,028 G_{t+3}^{EPS} + \\
 & (-5,2) \quad (6,8) \quad (-3,3) \quad (19,1) \quad (2,5) \\
 & + 37,32 (M2/GNP_t) \quad R^2 = 0,90 \\
 & (4,3)
 \end{aligned}$$

Ample liquidity therefore has an independent positive effect on price levels. The signs and significance are more than adequate, as is the total explanatory power.

To obtain a full picture of the S&P 500, another estimate of earnings is needed. The simplest hypothesis is that profit growth depends on earnings movements in GNP; the higher the GNP, the higher the earnings. Estimation of this simple, loglinear equation produced the following result, which proved to be more accurate than an additive relationship.

$$\begin{aligned}
 \ln EPS_t = & -3,594 + 0,776 \ln GNP_t \quad R^2 = 0,97 \\
 & (-36,5) \quad (58,6)
 \end{aligned}$$

The economic conditions can play a role in the determination of earnings, as it did in determining the level of the P/E ratio. After all, in the economic growth phase, rising demand will increase the opportunities to expand margins. In a shrinking economy, growing stocks can sometimes lead to dumping, placing margins under pressure. Using the same indicator for the economy as that described above, the following estimation is produced:

$$\ln \text{EPS}_t = -3,736 + 0,794 \ln \text{BNP}_t + 0,050 \text{BC}_t \quad R^2 = 0,97$$

(-40,3) (63,7) (5,3)

The signs and significance of the variables in the above regression equation are satisfactory. In a period of high economic growth, there does indeed appear to be scope for increasing margins, while the opposite occurs in the periods of economic decline. The explained variance in absolute terms (not logarithmic) is more than 94%.

The opportunities for increasing margins are not always equal. Profitability can also sometimes be reasonably well sustained in periods of economic decline. This is related primarily to the level of inflation. Higher margins can be introduced more easily in times of high inflation than when prices are stable. The following equation outlines the effect of the growth of the GNP price level: P_t^{GNP} :

$$\ln \text{EPS}_t = -3,673 + 0,771 \ln \text{GNP}_t + 0,062 \text{BC}_t + 0,023 P_t^{\text{GNP}} \quad R^2 = 0,98$$

(-47,9) (72,0) (7,9) (7,6)

Here again, the signs are correct and the significance more than adequate. Inflation has a positive, albeit limited impact on earnings levels. The total explanatory power (not logarithmic) rises to more than 97%. One problem is that the results correspond only moderately with the actual situation in the final quarters of 1989. Because the

EPS are multiplied by the P/E ratio, the underestimation is magnified. The additive model was therefore tried again, as the highest value carry relatively more weight here than in the loglinear model. However, the outcome was less satisfactory.

Evaluation of results

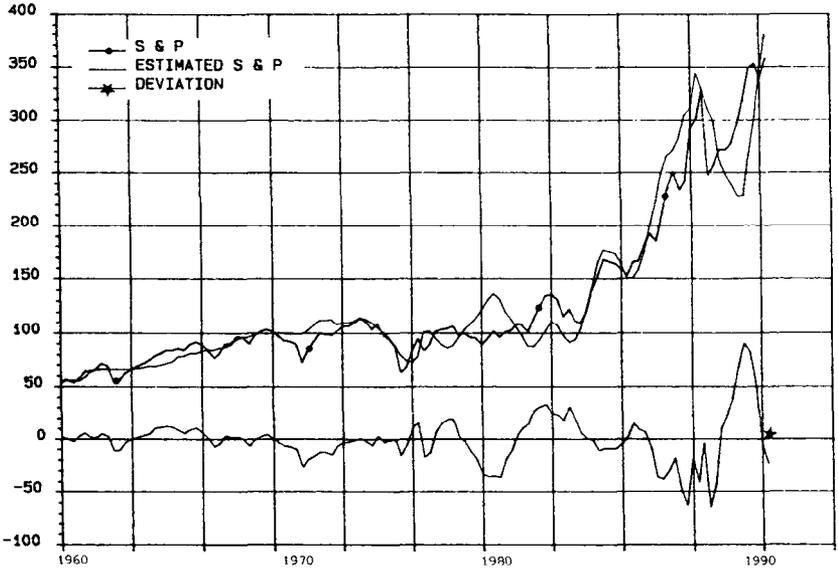
The following graph shows the correspondence between the simple model for the S&P 500 and the actual situation. Both equations have been combined, with the estimation of EPS multiplied by the estimated value for the P/E ratio. This produces the estimated value of the S&P 500. The two equations together have an explanatory power of more than 91% for the period as a whole. Since any error in the P/E ratio will be multiplied by potential estimation errors in the EPS, this is no poor result. If the above mentioned 'bad' estimations (four observations) are disregarded, the explanatory power rises to over 94%.

The reason for the only moderate explanatory power during part of the last two years is a phenomenon which is not unfamiliar. Stock market analysts have pointed out that the S&P 500, as an index weighted by market capitalisation, scores almost 20% higher than the unweighted Value Line Index^{*}). The system of program trading, which affects the top one hundred companies in the S&P 500, plays an important role here. The fact that this effect was less important in 1990 can be explained by the measures which have since been taken to control the negative side effects of program trading. One could conclude that the stock market was overvalued in 1988 and early 1989, but that the temporary nature of this was anticipated. Another notable point is the cyclic nature of over- and under-valuation on the stock market. These periods can be relatively long. The extreme points also seem to be

*) Push-me-pull you, The Economist, February 24, 1990, blz. 88.

good indicators of buying and selling times. In the period studied, only in 1984 and in 1988/1989 were the selling indicators incorrect. The latter discrepancy was a prolonged estimation of the crash in 1987. According to the model, this would have been a gradual process, but in reality, it was completed within a few weeks.

Graph 3. The model and the S&P 500 (in volume terms) 1960 - 1990



Two specific variables relating to the S&P 500 shares, namely the growth of EPS and the POR, together with five macro-economic factors - the economy interest rates, the money supply, GNP and inflation - can accurately describe movements in the S&P 500. Macro-economic factors are clearly the determining ones here.