A STATISTICAL ANALYSIS OF STOCK MARKET PRICES: THE CASE OF THE ATHENS STOCK EXCHANGE*

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Introduction

Although the bibliography concerning the analysis of stock market prices for various stock exchange centres over the world is quite rich, as far as we know the bibliography with respect to the Athens Stock Exchange is very short. The latter, taking into account either methods of work or models used in the analysis, is summarised below:

a. With respect to "efficient markets": Papaioannou (1979),
b. With respect to "Capital Asset Pricing Models": Phsilos (1964), Glezakos (1987).
c. With respect to "Statistical Analysis": Christodoulopoulos (1968), Niarchos (1972).

It is known that the price of a share of stock is the perceived present value of the future earnings per share of the stock (Ruffin, et al., 1988). However, due to the fact that no one knows for sure what the future earnings of any company might be, stock prices fluctuate dramatically over time. Therefore, the willingness of a person to buy or sell shares of stock is determined by factors which cannot be safely predicted. No one, for example, can predict how the economy as a whole will change in the future or similarly, no one can predict for sure whether a specific company's economic position will improve, deteriorate, or remain the same.

For these reasons, in this paper we are not trying to investigate the factors that affect demand and supply of shares, but on the contrary we are trying to investigate the profile of the reduced form variable "price of a share of stock" of the relevant demand-supply systems. In other words, we are trying to categorise various economic factors of the firm, according to the degree in which they determine the prices of shares of stocks in Greek reality.

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For this investigation we are using data from 58 firms divided into five industrial branches; textiles (19 firms), foodstuffs (15 firms), chemicals (7 firms), building materials (6 firms) and metallurgical (11 firms). These firms cover approximately the 80% of all the firms reported at the Athens Stock Exchange Statistical Bulletin.

Method of analysis

In this part of the paper, we will present the structural and the technical steps followed in the present research.

(a) *The rationale of the model:* The most classic measures of the financial condition of a firm that can be derived from the balance sheet (which measures the risk-bearing ability or financial solvency of the firm, i.e., it shows the margin by which debt obligations would be covered if the business was terminated and all assets sold, and also indicates the financial structure of the business, i.e., liabilities that must be repaid within the current year, liquid assets available for sale to pay current obligations, and longer-term obligations and assets) are the "current ratio" and the "equity to debt ratio". The first ratio, which is equal to total current assets/total current liabilities, indicates the extent to which current assets, if liquidated, would cover current liabilities outstanding; the second ratio, which is equal to owner equity/total liabilities, is commonly used as an overall measure of solvency.

The most important measure of profitability of a firm that can be derived from the income statement, which reveals the success or failure of a business over time as well as the costs and returns associated with the use of varying amounts of capital and credit, is the "rate of return to equity". This ratio, which is equal to the return to equity/owner equity, refers to that capital which would be available for alternative investments, should the business be liquidated, and it is useful to compare its return with returns from alternative investments.

According to the discussion above, we assume that the price of a share of stock over time depends on the financial solvency and on the profitability of the firm. In other words, this dependence is expressed with the following function:

$$P_t = f(I_{1t}, I_{2t}, I_{3t}, t) \qquad (1)$$

where: P = price of share of stock,
I_1 = current ratio,
I_2 = equity to debt ratio,
I_3 = rate of return to equity, and
t = time.

The technical and economic restrictions associated with function (1) are the following: As the three ratios in (1) result from the "annual" balance sheets and income statements of the firms, therefore, the prices of the shares of stocks must also be in annual terms, and hence, P is measured as the average annual price of share of stock. This price has also been deflated with the Consumer's Price Index in order to reduce the distortive effects of inflation.

We assume that the sign of $\theta P/\theta I_1$ is free. This assumption, although it may look problematic, as the sign of this partial derivative would be expected to be non-negative, as far as the Greek market is concerned, this is not so unrealistic, owing to the fact that current assets also include inventories. The preceding makes the cautious Greek investor to contest, if an increase in the current ratio is a real one, or if it is the result of the firm not following the accounting methods of "conservatism" and "consistency" in valuating inventories. In other words what the Greek investor is afraid of is the so-called "cooking of data". However, even in the case where the firm is consistent in preventing accounting data, an increase in inventories beyond specific levels for each case would make the investor to be more cautious in investing, due to possible difficulties in liquidating increased levels of inventories (Weston et al., 1982). The problem of the ambiguous sign of this derivative could probably be overcome by using the "quick ratio". In this case, however, we believe that we are losing information with respect to the behaviour of the Greek investor.

We assume that the sign of $\theta P/\theta I_2$ is positive. In other words, the investor is attracted by the firm when the distribution of capital moves in favor of owner's equity, a fact which indicates that the financial position of the firm becomes stronger.

We assume further that the sign of $\theta P/\theta P_3$ is also positive. In other words, the investor is also attracted by the firm, when profitability of the firm is increasing. The return to equity has been calculated by dividing earnings after tax in current terms by owner's equity. Although the prices of the shares of stocks have been expressed in real terms, profitability was kept in current terms, owing to our belief that it is the trend of profitability that matters to the investor, and not whether the level of profitability is possibly temporarily greater than inflation (Jones et al., 1978).

The variable of time, t, includes all the other possible effects of the economy that determine the prices of the shares of stocks.

In function (1) all the independent variables appear without a time lag, because the data we are using is annual and therefore a time lag of one year is very unrealistic in our case. The mistakes from a possible dynamic misspecification of the model are very small and allocated evenly along the whole year (Brown et. al., 1976; Ball, 1978). For the same reasons, the dependent variable is also not appearing with a time lag. Moreover, most of the "random walk" studies confirm the belief that lagged price changes are generally statistically independent. From the discussion above it follows that our model satisfies implicitly the assumptions of efficient markets (Fama, 1970).

In a parallel manner, function (1) could also be used in the investigation of the price of a share of stock excluding the dimension of time. For this analysis, and mainly for estimation purposes, function (1) takes the following form:

$$\Delta P_k = F(I_{1k}, I_{2k}, I_{3k}, M_k) \tag{2}$$

where: k = firm,
M_k = relative size of firm k in the industrial branch, with respect to owner equity,
Δ = difference refering to two successive years.

The reason for modifying function (1) into function (2) is obvious. Firstly, the percentage change in the price of a share of stock was introduced into function (2) in order to homogenize the units of measurement of prices among firms. Secondly, the relative size of the firm was employed for better identification of the cross-section model. In measuring the relative size of the firm we prefered to use the owner equity, and not the total assets of the firm, this was because this variable is thus associated with the equity to debt ratio and the rate of return to equity. Furthermore, the relative size variable measured in this particular way, introduces another element of business risk beyond that expressed with the asset structure of the firm. For these reasons we assume that the sign of the coefficient attached to M is free.

In summary, we understand that the two functions (1) and (2), that constitute our model, include the business risk, which is created by holding certain assets and competing in certain markets, and financial risk, which is created by the particular combination of financing instruments that the firm utilizes. Profits and risk, therefore, combine to establish the price of firm's share of stock (Mathur, 1979).

In this paper, in the place of business risk, which is determined directly by the asset structure, we have employed the equity to debt ratio and the relative size of the firm with respect to owner equity; instead of financial risk, which is determined directly by the financial structure, we have employed the current ratio; and instead of profits, which are determined by both the asset and financial structure, we used the rate of return to equity. Although the external environment affects prices of stocks indirectly through the financial considerations and decisions of the financial managers, this environment also affects prices in a direct way. To measure this directly, we introduced a time trend variable into our model.

(b) *Estimation:* From the model set out in the previous section function (1) was estimated by the methods of (i) ordinary least squares (OLS), and (ii) first order autoregressive least squares (AR1), and function (2) was estimated by the OLS method. The functions used in the estimation were (i) of the linear form, and (ii) of the log-linear in variables form, for function (1) and of the linear form only for function (2). All the data used in the estimation are published at the Athens Stock Exchange Statistical Bulletin and cover the period 1973-1985. Furthermore, function (2) was estimated cross-sectionally for the years 1973, 1980 and 1984 in order to trace possible changes in the relative importance of the factors that determine the prices of shares of stocks.

It is obvious that it is impossible to present the OLS and AR1 estimates of the 58 firms for the linear and the log-linear forms of function (1), and the 15 OLS estimates of function (2) for the five industrial branches and the three years used in the cross-section estimation. Here we only report that, following the usual statistical tests and the *a priori* restrictions for the parameters set out in the previous section, the results using the linear form of (1) were more preferable. The majority of the R^2 were very high, with an average for all equations equal to 0.859 for function (1) and equal to 0.661 for function (2). In addition, from the 58 equations only 12 had significant autocar-relation coefficient in the residuals.

Table 1 presents the significance of the estimated time series equations with respect to the independent variables and the signs of the estimated coefficients of the current ratio and the time trend variables.

Table 2 presents the significance of the estimated cross-section equations with respect to the years in which the independent variables were significant. It also presents the signs of the estimated coefficients of the current ratio and the relative size of the firm variables.

(c) *Ex post simulations:* A statistical model can be judged either by the ability of individual estimated equations to illuminate the economic structure, or by the accuracy with which the equations forecast the dependent variables. However, the fulfilment of the first criterion by no means implies fulfilment of the other.

Evaluation of the model on its ability to explain the underlying economic

Table 1: *Significance of time-series equations*

Branch	I_1	I_2	I_3	Time
Textiles	8 (+) S	15 S	10 S	
	9 (−) S			15 (−) S
	2 NS	4 NS	9 NS	4 NS
Foodstuffs	6 (+) S	9 S	7 S	
	4 (−) S			11 (−) S
	5 NS	6 NS	8 NS	4 NS
Chemicals	2 (+) S	4 S	5 S	
	2 (−) S			3 (−) S
	3 NS	3 NS	2 NS	4 NS
Building materials	1 (+) S	4 S	4 S	
	1 (−) S			3 (−) S
	4 NS	2 NS	2 NS	3 NS
Metallurgical	4 (+) S	6 S	4 S	1 (+) S
	3 (−) S			8 (−) S
	4 NS	5 NS	7 NS	2 NS

S = significant, NS = non-significant, in parentheses the sign of the estimated coefficients.

Table 2: *Significance of cross-section equations*

Branch	I_2	I_2	I_3	M_k
Textiles	(−) 73, 80, 84	80	80	(−) 80, 84
Foodstuffs	(−) 73, 80, 84	—	73, 84	(−) 84
Chemicals	(−) 73, 80, 84	—	73, 80, 84	(−) 73
Building materials	(−) 80	80	—	(−) 73
Metallurgical	(+) 80 (−) 73	73	80, 84	(−) 73

relations can be carried out by investigating the estimated parameters of the equations. Actually, these parameters turned out to have the expected sign in all cases. As far as their magnitude is concerned, little can be said with certainty, given the limited number of observations available, the even more limited variety and quality of statistical data and the non-existence of similar statistical models concerning the Greek reality.

Evaluation of the second criterion, by investigating the tracking performance of the "simulated" equations can be carried out with the help of Table 3, where r and RC are the correlation and regression coefficients between the real and the simulated variables respectively; U is Theil's (1966) inequality coefficient, and UM, US, and UC are its decomposition into the inequality proportions.

Table 3: *Average values of simulation performance coefficients*

Branch	r	RC	U	UM	US	UC
Textiles	0.946	0.974	0.054	0.018	0.054	0.927
Foodstuffs	0.950	0.983	0.044	0.017	0.023	0.959
Chemicals	0.931	1.004	0.069	0.001	0.044	0.955
Building Materials	0.955	0.932	0.048	0.18	0.048	0.934
Metallurgical	0.918	0.974	0.072	0.007	0.027	0.965

The magnitude of these coefficients, together with the plots of the real versus the simulated series of the variables, suggested that the tracking performance of the model was highly satisfactory.

(d) *The statistical analysis:* To make statements about the relative importance of the independent variables in the models, a fact which was one of the main targets of this research, we determined the "beta coefficients" (β_{ijk}, where i = independent variable, j = branch and k = firm). To compare these coefficients, with, respect to the independent variables and to the branches, we used the A×B factorial design, with factor A having three levels (the three main independent variables) and factor B having five levels (the five branches) and/or the oneway design. In the analysis of variance of these designs, in order to test the homogeneity of the variances, we used Bartlett-Box's test, and in order to test equality of the means Duncan's test was used.

Implications of the estimates

From the results in Table 1 we see that the current ratio variable is positively significant in 36.2% cases, negatively significant in 32.8% cases and non-significant in 31.0% cases. This result infers that in about ⅓ of the cases the investor is questioning the increase in the current ratio. The equity to debt ratio variable is significant in 65.5% cases and non-significant in 34.5% cases, and the rate of return to equity is significant in 51.7% cases and non-significant in 48.3% cases. These results mean that in about ⅔ of the cases the leverage ratio, and in about ½ of the cases the profitability of the firm play a significant role in determining the price of the shares of stocks.

The preceding observations can be partly supported by the results in Table 2. From this table, we observe that the current ratio variable is positively significant in 13.3% cases, negatively significant in 73.3% cases and non-significant in 13.4% cases. The equity to debt ratio variable is significant in 20.0% cases and non-significant in 80.0% cases. The rate of return to equity is significant in 53.3% cases and non-significant in 46.7% cases. Finally, the relative size variable is positively significant in

0.0% cases, negatively significant in 40.0% cases and non-significant in 60.0% cases. The latter observation determines that the growth of the firm, in terms of owner equity in the industrial branch, is associated with higher levels of risk, a fact which is indicated by the negative estimated coefficients of the relative size variable in all significant cases.

An important conclusion that can also be derived from Table 1 is that most of the investors foresee a declining general state of the economy, this being depicted by the negatively significant time trend coefficients.

In Table 4, we present the average elasticities (with their standard errors in parentheses), that have been estimated at the points of sample means, of the prices of shares of stocks with respect to the three independent variables using the estimated parameters of the time-series equations.

Table 4: *Average elasticities from time-series estimtes*

Branch	I_1	I_2	I_3
Textiles	1.06(±4.36)	1.95(±0.87)	0.19(±0.08)
Foodstuffs	-0.73(±0.52)	0.73(±0.24)	0.24(±0.13)
Chemicals	-0.20(±0.71)	1.30(±0.58)	0.14(±0.07)
Building materials	-0.32(±0.44)	1.04(±0.41)	0.10(±0.06)
Metallurgical	0.44(±0.31)	0.47(±0.16)	0.26(±0.17)

From the elasticities in Table 4, it can be seen that for all branches the elasticity with respect to profitability is much smaller (in absolute terms) than those with respect to the other two independent variables, and the elasticities with respect to current ratio are all smaller than those with respect to equity to debt ratio. Also, the vast majority of the average elasticities shows inelastic behaviour of the prices of shares of stocks with respect to the three independent variables used in our model.

Although the average elasticities reported in Table 4 give some information about the sensitivities of the prices of stocks with respect to changes in the three economic ratios we are using, Table 5 shows the distribution of these elasticities in terms of the degree of the mentioned sensitiveness.

From the results in Table 5, it is now clear that the behaviour of stock prices with respect to profitability is, in all cases, inelastic. On the contrary, the behaviour of stock prices with respect to the current ratio and to the equity to debt ratio is ambiguous, depending on the specific branch. However, for all branches simultaneously this behaviour is slightly more elastic.

Table 5: *Distribution in % of the elasticities from time-series estimates*

	I_1		I_2		I_3	
	Elast.	Inelast.	Elast.	Inelast.	Elast.	Inelast.
Textiles	76.5	23.5	53.5	46.7	10.0	90.0
Foodstuffs	46.2	53.8	44.4	55.6	12.5	87.5
Chemicals	40.0	60.0	100.0	0.0	0.0	100.0
Building materials	50.0	50.0	40.0	60.0	0.0	100.0
Metallurgical	42.9	57.1	42.9	57.1	25.0	75.0
All branches	56.8	43.2	52.5	47.5	9.7	90.3

Table 6 presents for the three years 1973, 1980 and 1984, the means of the average elasticities of the percentage changes of the prices of shres of stocks with respect to the four independent variables, using the estimated parameters of the cross-section equations.

Table 6: *Mean elasticities from cross-section estimates*

Branch	I_1	I_2	I_3	M
Textiles	2.41(±0.53)	−0.24	−0.01	0.69(±0.64)
Foodstuffs	0.94(±0.16)	—	−0.15	0.23
Chemicals	1.65(±1.06)	—	1.10(±0.24)	0.05
Building materials	0.06(±0.62)	−0.38	—	0.14
Metallurgical	0.69(±0.89)	−0.86	−0.67	0.51

Although the elasticities in the above table are not comparable in both size and sign with the elasticities presented in Table 4, this being due to the difference in the dependent variables, however, from Table 6 we can derive almost the same general conclusions with those of Table 4.

From the statistical analysis of the beta coefficients of the time-series regressions, we derived the following results: For textiles, the variables of the current ratio and the equity to debt ratio are equally important in determining the prices of shares of stocks. On the contrary, the relative importance of the rate of return to equity variable is smaller as compared to the other two independent variables. For foodstuffs, chemicals and metallurgical, the three independent variables are equally important in determining the prices of the shares of stocks. Finally, for building materials the current ratio and the rate of return on equity ratio are equally important, but with their importance being smaller than that of the equity to debt ratio.

From the corresponding beta coefficients of the cross-section regressions, we derived the following results: For textiles and metallurgical the conclusions are the same with those obtained by the time-series estimates. For foodstuffs and chemicals the results with respect to the variables of the current ratio and the rate of return on equity, and for building materials the results with respect to the current ratio and the equity to debt ratio are generally the same with the corresponding time-series results. It is worth noting that in all branches the relative size of the firm variable is of less importance than the other three variables when determining the prices of the shares of stocks.

Concluding comments

In order to make definite statements about the relative importance of financial ratios introduced simultaneously into regression models, the models must be efficient in terms of their forecasting power (Weston, et. al., 1982). In this paper, the forecasting performance of our model proved to be highly satisfactory. The average RC coefficient, from table 3, is equal to 0.973 ($\pm$0.012), indicating that our model is underestimating the prices of shares of stocks by only 2.7% on average.

In light of the above, the results obtained from the structural estimated coefficients of our model can be summarised as follows:

There is a general downward movement in stock prices, depicted by the negative coefficients of the time trend variable, which could be attributed to the general declining of the level of economic activity in Greece, and also to the high interest rates prevailing in our sample period.

The firm's profitability, although showing the same relative importance in determining stock prices with the other two factors in the branches of foodstuffs, chemicals and metallurgical, is very inelastic in increasing the real values of stock prices in the Greek economy. This being due to the fact that both economic instability and interest rates in Greece were at very high levels in our sample period.

The asset and financial structure of the firm, are equally important in determining real stock prices in all branches, except building materials. This asset and financial structure of the firm is, however, very different in changing the actual levels of stock prices. In the branches of foodstuffs and chemicals the average elasticities with respect to the financial structure variable are negative, in contrast to the positive average elasticities with respect to the asset structure variable. This observation indicates that the Greek investors, creditors, lenders, and other interested groups in evaluating the financial performance of a firm, are particularly careful when dealing with very short run information.

The growth of a firm in terms of its relative size of owner's equity in the industry, although being less important in determining the prices of the shares of stocks than the other factors investigated in this paper, still proved to have a negative impact on prices. This was due to the political and economic instability that prevailed in Greece after 1973, which resulted ultimately in pushing business risk to higher levels.

Finally, in light of our findings, the Greek manager should thus try to take financial decisions in order to adjust individual factors which could have an influence on increasing the prices of shares of stocks.

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