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DISTRIBUTIONAL CHARACTERISTICS AND PROPORTIONALITY OF MARKET-BASED SECURITY RATIOS

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The distributional characteristics and the proportionality of two market-based security ratios, the Earnings Yield and the Dividend Yield, are tested using Finnish data. The results indicate both of the ratios to be proportional in nature. However, being positively skewed, the Dividend Yield ratio requires transformation to achieve normality. This is due to the fact that this ratio has a technical limit to zero.

1. Introduction

1.1 Background

In recent years the use of the so-called market based security ratios has increased considerably in Finland. When using these ratios to support their decision making, investors, management, auditors, researchers, and other interest groups commonly apply various statistical procedures. These procedures commonly presume certain restrictive assumptions, which have to be taken into account.

In this article, we concentrate on the two most usual assumptions underlying the use of ratio data in statistical analysis. Firstly, the normality assumption of ratio distributions is considered. The main implication of this assumption is that assuming the ratio data to be normally distributed, we can characterize the whole distribution with only two parameters, the mean and the standard deviation. This is essential when constructing parametric tests for the underlying data. Secondly, the proportionality assumption of the ratio form is discussed. This assumption concerning the ratio form itself requires a strict proportional relationship between the numerator and the denominator of the ratio. This means that the relationship between the items of the ratio is linear, and the constant is zero. Even if some work on the basic assumptions of the traditional financial ratios has been carried out in recent years, very little attention has been paid to the market-based security ratios in this context.

In a traditional financial ratio the numerator as well as the denominator are accounting numbers based on the historical valuation of assets. In a security ratio, however, the items are collected from two different information sources, from the financial statements of the firm and from the security market.

Since the items of a traditional financial ratio are determined by one specific process, we can intuitively assume a proportional relationship between them. On the other hand, the proportionality of a security ratio is far more difficult to accept. This is due to the fact that

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in security ratios the historical valuation of assets is related to the market value of a security that mainly reflect future expectations. For instance, in the well-known Price/Earnings ratio, the numerator is clearly affected by the future growth opportunities of the firm while the denominator mainly reflects the historical success of the firm.

1.2 Security ratios

There are two main security ratios commonly applied by both practitioners and researchers: the Earnings Yield (or the P/E-ratio in its reciprocal form) and the Dividend Yield. The Earnings Yield indicates how much investors are currently paying for earnings. This ratio is computed as follows:

$$\text{Earnings Yield} = \frac{\text{Annual earnings per share}}{\text{Market price per share}}$$

The empirical evidence strongly suggests that investors use the Earnings Yield as one of the key ratios when making their portfolio decisions. This kind of a conclusion can be drawn from a wide number of surveys on the topic (see e.g. Lee, 1981) and from the existence of the co-called Earnings Yield or P/E-anomaly, which indicates that by investing in portfolios with high Earnings Yield ratios, high abnormal returns have been achieved (see Dimson, 1988, and the literature cited there). This is a somewhat puzzling finding, since according to the theory of finance, a low Earnings Yield ratio purely indicates that investors expect high dividend growth, the stock has low risk and the investors have low prospective return for a stock, or the company is expected to achieve average growth while buying out a high proportion of earnings (see e.g. Brealey and Myers, 1984: 577).

The second important security ratio applied in literature is the Dividend Yield ratio. This ratio is commonly computed by investors who invest in common stocks primarily for dividends, rather than by those mainly interested in changes in market prices of stocks. The Dividend Yield can be computed using the following formula:

$$\text{Dividend Yield} = \frac{\text{Annual dividend per share}}{\text{Market price per share}}$$

A high Dividend Yield ratio may indicate that investors either expect low dividend growth or stock's risk merits a high expected return (Brealey and Myers, 1984: 577). It should be emphasized that the Dividend Yield is closely connected to the Earnings Yield. The numeratoros of these two ratios differ by the amount of retained earnings by the firm, while the denominators are exactly the same.

1.3 Purpose and structure of the study

In this article, the two most important assumptions concerning the form and distributional properties of security ratios are considered. Firstly, the distributional properties of security ratios are examined. This is done because when we are constructing parametric tests in security ratio analysis, we have to assume some underlying distribution for the security ratio data. Typically this distribution has been assumed to follow the normal distribution.

Secondly, the proportionality of the security ratios is examined. If this assumption does not hold true, it has several essential implications for financial analysts and other decision makers. In this case, the security ratios cannot be used normatively, i.e. the industry-averages cannot be used as a norm or objective by which a firm is evaluated. Furthermore, it is impossible to know what is expected or even what is usual in the context of the behavior of the security ratio. For example, we may regard certain relationships as unstable in practice, when a proper model between the items of the ratio would show that these relationships were in fact stable in nature (see Barnes, 1986, 179–180).

The remainder of this article is organized as follows. In Chapter 2, the basic assumptions and alternative functional specifications of financial ratios are discussed. The empirical analysis is carried out in Chapter 3. Firstly, the normality of security ratio distributions is tested applying the Shapiro-Wilk's W-test and the potential outliers are removed from the data. In addition, we study if some transformations are needed in order to obtain normality in ratio distributions. Secondly, the proportionality of security ratios is studied by forming and testing a functional specification between the items of the security ratios.

2. *Distributional characteristics and proportionality of financial ratios*

2.1 On the distributional characteristics of financial ratios

The distributional characteristics of financial (accounting) ratios have been studied widely during recent years. A representative study from this field was presented by Deakin (1976). His basic idea was to test for the normality of the ratios and transformations of the ratios on a cross-sectional level. From more recent studies one can mention e.g. those made by Frecka and Hopwood (1983), and Barnes (1983). On Finnish data the ratio distributions have been studied by Virtanen and Yli-Olli (1989), and Martikainen (1990).

The main reason for studying the distributional properties has been that if the financial ratios are normally distributed, we can characterize the whole distribution with only two parameters, the mean and the standard deviation. This is an essential aspect when constructing parametric hypotheses tests for financial ratio data. Unfortunately, there are many reasons why the financial ratio distributions may be non-normal and contain some extreme observations. These might be due to firm-specific effects (such as drastic changes in production technology, acquisitions and divestitures, and other remarkable financing, operating or financial reporting decisions) as well as economy-wide effects (significant changes in competitiveness of the companies, and tax or other legal deregulations etc.). In addition, it should be noted that the ratio form itself may cause some extreme observations and non-normality to the ratio distributions. Virtanen and Yli-Olli (1989) present three main reasons why the distributions of the financial ratios cannot be expected to be normal or even symmetrical (see also Foster, 1986, Frecka and Hopwood, 1983, and Buijink and Jegers, 1986):

— technical limits in values of certain ratios
— unit decrease in the denominator produces a larger absolute change in the ratio value than an equal increase in the numerator does
— firm's management pressure to keep the ratios within certain acceptable limits

All of these three aspects are highly relevant concerning the security ratios, too. Firstly, since the dividend per share cannot be less than zero, the Dividend Yield ratio has technical limit to zero. It has been suggested (see Frecka and Hopwood, 1983) that these kinds of ratios typically belong to the gamma distribution family. The most interesting aspect in this sense is that by applying square root transformation to the gamma distributed ratio, we can obtain an approximately normally distributed transformed ratio. The Earnings Yield ratio, however, has no technical limit of this kind.

The second reason above is the problem of proportionality, which will be discussed below. The third reason, why financial ratios are not expected to be normally distributed, is also relevant in the context of security ratios. For example, conerning the Dividend Yield ratio, firm's management obviously makes strong efforts to keep this ratio in acceptable limits and by this way makes the firm interesting from an investor's point of view.

2.2 Proportionality of financial ratios

Even if the basic statistical properties of the financial ratios have been studied widely, the critique concerning the ratio form itself has not been studied properly in empirical means. (for the theoretical discussion of the ratio form see Kuh and Meyer, 1955). Especially, the proportionality of security ratios has received little attention in literature.

McDonald and Morris (1984, 1985) used different types of regression models in order to study the connection between the numerator and the denominator of the ratio on an intra-industry sample as well as on a cross-industry sample. For the four ratios investigated (current assets / sales, current assets / current liabilities, total debt / total assets, and cash flow / total debt) the proportionality assumption did not hold on an intra-industry sample. However, for the cross-industry sample, the conclusions were significantly different, and McDonald and Morris concluded that their empirical evidence supported the ratio form.

The empirical results obtained by McDonald and Morris have been criticized by several more recent studies. Lee (1985) studying the distributional properties of financial ratios reported significant size and sector effects in ratio behavior. Similarly, McLeay and Fieldsend (1987) found industry as well as size effects in financial ratios. They also concluded that these effects vary significantly from one ratio to another. Fieldsend, Longford and McLeay (1987) studied ratio proportionality and industry effects on UK data using variance component analysis. They concluded that a substantial part of the departure from proportionality can be explained by the size effect. On Finnish data Perttunen and Martikainen (1989) studied the proportionality of six financial ratios representing profitability, liquidity and capital structure. They reported that the ratio proportionality concerning these ratios of Finnish firms seemed usually to hold true.

As stated above, certain deviations from proportionality of the traditional financial ratios have been found in recent empirical studies. This is true even if in a traditional financial ratio the numerator as well as the denominator are determined by the same accounting process. When the items in a security ratio are determined by two different processes (accounting process and security pricing process), it is even more difficult to assume the ratio proportionality.

2.3 Functional specification of financial ratios

The ratio of two financial variables y_i and x_i can be generally stated as:

$$(1)\quad \frac{y_i}{x_i} = \beta + u_i$$

where β is the industry norm and u_i is the measure of conformity to the industry norm (McDonald and Morris, 1985). In equation (1) it is assumed that $u_i \sim N(0, \sigma_u^2)$. If (1) is a valid representation of the behavior of the ratio, then all that is needed is a knowledge of β and σ_u^2 to produce a range of values for the ratio that can be considered to be acceptable (Ezzamel, Mar-Molinero and Beecher, 1987).

In the context of financial ratio analysis, however, it has been suggested that a simple bivariate regression of financial items y_i and x_i would represent a more appropriate description than the ratio model above does (see e.g. McLeay and Fieldsend, 1987). This regression model is stated as follows:

$$(2)\quad y_i = \alpha + \beta x_i + \varepsilon_i$$

where

$$(3)\quad \varepsilon_i \sim N(0, \sigma^2)$$

The assumption regarding the variance of residuals is called homoskedasticity and if it is violated this is called heteroskedasticity. However, while the classical regression model in equation (2) is homoskedastic by assumption, the ratio model in equation (4) is heteroskedastic by presumption.

$$(4)\quad \frac{y_i}{x_i} = \frac{\alpha}{x_i} + \beta + \frac{\varepsilon_i}{x_i}$$

where

$$(5)\quad \frac{\varepsilon_i}{x_i} \sim N(0, (\frac{\sigma}{x_i})^2)$$

Barnes (1986), however, notes that if the original data is cross-sectional, it is expected that residuals in regression model (2) are heteroskedastic. Assuming the heteroskedasticity in the regression model (2) to be of the form:

$$(6)\quad var(\varepsilon_i) = (x_i\sigma)^2$$

then the variance of the residuals in ratio model (4) is

$$(7)\quad var(\frac{\varepsilon_i}{x_i}) = \sigma^2$$

In this case the ratio transformation would tend to cancel out the heteroskedasticity of the original functional form. In other words, the residuals in the cross-sectional data are likely to be heteroskedastic tending to make the residuals in the ratio form homoskedastic. (Barnes, 1986)

Assuming now that the dependence between two financial variables is of the form:

$$(8)\quad y_i = \alpha + \beta x_i + \varepsilon_i$$

where

$$(9)\quad var(\varepsilon_i) = (x_i\sigma)^2$$

the proportionality assumption can be tested by testing the significance of the intercept in equation (8). The heteroskedasticity, however, makes it impossible to test that directly from equation (8). Transforming equation (8) to the ratio form, however gives us the following homoskedastic model:

$$(10) \quad \frac{y_i}{x_i} = \beta + \frac{\alpha}{x_i} + \frac{\varepsilon_i}{x_i}$$

where

$$(11) \quad \mathrm{var}\left(\frac{\varepsilon_i}{x_i}\right) = \sigma^2$$

The equation above enables us to study the possible existence of a constant or intercept term in model (8). The existence of non-zero regression coefficient α in model (10) leads to non-zero intercept α in model (8). This would mean rejecting the proportionality assumption in the ratio analysis and making the bivariate regression (2) a more appropriate specification than the ratio method. If the regression coefficient α in model (10), however, does not significantly differ from zero, the ratio form successfully eliminates the size-effect from the financial data.

3. *Empirical results*

3.1 Data and statistical models

The data used in this research effort is collected from two information sources: the financial statements of the firms and the stock prices of the stocks listed in the Helsinki Stock Exchange. The financial statement numbers have been computed exploiting the Tilpana data base constructed in the University of Vaasa. Our data consists of all the Finnish firms which have had their ordinary shares listed in the Helsinki Stock Exchange for the whole period of 1974 – 1986, i.e. 28 firms are included in the study. The ratios are computed separately for each year from 1980 to 1986.

The ratios are computed using the absolute values of earnings, dividends, and market values of the firms. The earnings have been determined as annual net incomes computed according to the recommendations by Credit Analysis Commission (1983). Thus, net incomes have been determined applying the maximum level depreciations allowed by the Finnish government. This adjustment of earnings is commonly applied in Finland in order to make financial statement numbers comparable over firms (on the effect of different depreciation methods on corporate earnings in Finland see e.g. Martikainen and Ankelo, 1989). The dividends represent the absolute annual dividends paid to shareholders. Finally, the market values have been computed determining the market value for equity at the balance sheet date.

The normality of the ratio distributions is tested applying the Shapiro-Wilk test, which is extremely effective for normality particularly in connection with small samples. This test outperforms the well-known Kolmogorov-Smirnov test, and is therefore selected to be used in this study. The null hypothesis of the test is that the variable of interest is normally distributed. For further details of the Shapiro Wilk test see e.g. Shapiro and Wilk (1965).

In order to test the ratio proportionality the simple bivariate regression of the items of financial ratio y_i/x_i is tested by estimating the parameters of the following regression model:

$$(12) \quad \frac{y_i}{x_i} = \alpha + \frac{\beta}{x_i} + \varepsilon_i$$

The analysis is carried out for each particular ratio and for each year. The heteroskedasticity of the model above is then tested using the Park-Glejser test described later in this chapter. If the homoskedasticity assumption is valid, we are able to test the proportionality assumption by testing the significance of the intercept term α of the model. If the intercept term does not significantly differ from zero, this proportionality assumption holds true.

The Park-Glejser test of heteroskedasticity regresses the natural logarithm of the square of the residuals of the original model of the natural logarithm of the independent variable of the original model.

$$(13) \quad \ln\hat{\varepsilon}_i^2 = \gamma_1 + \gamma_2 \ln x_i + \mu_i$$

If the regression coefficient γ_2 of this model significantly differs from zero, we assume that the residuals of the original model are heteroskedastic. (Pindyck and Rubinfeld, 1981: 150 – 152)

3.2 Distributional characteristics of security ratios

In the first empirical phase of the study we focus on the distributional properties of the selected security ratios. Table 1 presents the descriptive statistics of the cross-sectional distributions of the Earnings Yield in each particular year.

The mean values of the Earnings Yield in Table 1 are very low. This is due to the fact that the depreciation method applied in this paper leads to strongly negative earnings for unprofitable firms in the long run. This can also be seen from the high standard deviation numbers. The Shapiro-Wilk test rejects the normality hypothesis on .05 level in four years. While the distributions are negatively skewed in those years, the potential reason for non-normality are possible outliers on the left tail of the distribution. In order to examine the effect of these extreme observations we removed from the sample the firms with the most negative Earnings Yield. This process was continued until the normality hypothesis could not be rejected on .05 level any more. Thus, we apply a procedure similar to the one used by Virtanen and Yli-Olli (1989) in the context of traditional financial ratios. Table 2 presents the descriptive statistics of the distributions after removing outliers from the data.

In three years we were able the obtain the normality after removing 1 – 4 firms from the left tail of the distribution. Typically, these observations were forest industry firms which were very unprofitable during those years. The earnings figures of these firms were so extreme that these firms can be classified as 'true' outliers. This kind of a conclusion would have been drawn whatever depreciation method would have been applied.

Table 1. Earnings Yield.

Obs	Year	Mean	Std-dev	Skew	Kurt	S-W (prob)
n = 28	1980	0.025	0.039	1.013	1.678	0.929 (0.064)
n = 28	1981	0.019	0.028	−0.290	−0.076	0.966 (0.500)
n = 28	1982	−0.006	0.061	−0.657	2.348	0.908 (0.019)
n = 28	1983	−0.014	0.071	−4.403	21.373	0.479 (0.000)
n = 28	1984	0.001	0.047	−3.361	13.736	0.623 (0.000)
n = 28	1985	0.000	0.022	−1.061	1.053	0.916 (0.034)
n = 28	1986	0.002	0.013	−0.431	2.045	0.934 (0.086)

Table 2. Earnings Yield. Reduced sample.

Obs	Year	Mean	Std-dev	Skew	Kurt	S-W (prob)
n = 24	1982	0.003	0.034	−0.969	1.202	0.927 (0.083)
n = 25	1983	0.003	0.018	−0.775	1.896	0.938 (0.142)
n = 26	1984	0.012	0.018	0.420	1.603	0.943 (0.168)
n = 27	1985	0.002	0.019	−0.739	0.290	0.931 (0.078)

In the next phase we examine the distributional properties of the Dividend Yield ratio. It should be emphasized that firms paying zero dividends have been excluded from the sample. The mean values of the ratio indicate a clear decreasing trend in the Dividend Yield of the Finnish firms over the research period. This is because of the fact that the absolute dividends of the Finnish firms have been rather stable while the market values of the listed firms have increased rapidly. The results in Table 3 indicate that the normality of this ratio can be rejected in three years.

Since the results of this ratio indicate systematic positive skewness in the distributions, we applied square root transformation in order to examine if the normality of this ratio could be improved. This was done because of the fact that the absolute dividends cannot be less than zero. Thus, the Dividend Yield ratio has a technical limit to zero. As stated above, it has been suggested (see Frecka and Hopwood, 1983) that ratios of these kinds typically belong to the gamma distribution

Table 3. Dividend Yield.

Obs	Year	Mean	Std-dev	Skew	Kurt	S-W (prob)
n = 27	1980	0.057	0.020	0.152	−0.939	0.941 (0.144)
n = 27	1981	0.059	0.020	0.515	−0.178	0.968 (0.574)
n = 27	1982	0.045	0.019	1.099	0.591	0.897 (0.011)
n = 26	1983	0.032	0.015	0.951	0.662	0.932 (0.093)
n = 27	1984	0.040	0.023	1.577	3.291	0.863 (0.002)
n = 27	1985	0.037	0.016	0.297	−0.950	0.941 (0.142)
n = 25	1986	0.024	0.017	1.585	1.980	0.817 (0.000)

Table 4. Dividend Yield. Square root transformation.

Obs	Year	Mean	Std-dev	Skew	Kurt	S-W (prob)
n = 27	1980	0.236	0.042	−0.111	−0.016	0.941 (0.144)
n = 27	1981	0.240	0.041	0.126	−0.312	0.984 (0.935)
n = 27	1982	0.209	0.042	0.733	−0.030	0.944 (0.168)
n = 26	1983	0.175	0.041	0.398	0.021	0.975 (0.770)
n = 27	1984	0.193	0.054	0.829	0.778	0.936 (0.108)
n = 27	1985	0.188	0.043	−0.020	−1.099	0.949 (0.225)
n = 25	1986	0.146	0.050	0.976	0.599	0.917 (0.044)
n = 24	1986	0.141	0.044	0.865	0.650	0.931 (0.107)

family. Applying square root transformation to a gamma distributed ratio, we can obtain an approximately normally distributed transformed ratio.

As can be seen from Table 4, the square root transformation clearly improved the normality of the Dividend Yield ratio. The Shapiro-Wilk test rejects the normality only in one year (1986) on .05 level. When one outlier from the right tail of the distribution was removed, the normality was obtained also in that year.

3.3 Proportionality of security ratios

In order to test the ratio proportionality we estimated regression model (12) using the reduced samples presented in the previous subchapter. Thus in the context of the Earnings Yield we removed the previously identified outliers from the data, and instead of the raw Dividend Yield ratio we used a square root transformation of the original ratio. In the year 1986 we also removed one outlier from the Dividend Yield distribution. Table 5 presents the results obtained from the Earnings Yield ratio.

It can be noticed that the Park-Glejser test does not reject the homoskedasticity assumption in any of the years examined. Thus, we are able to test the ratio proportionality using this model. The regression coefficient β of the model does not significantly differ from zero in any of the years examined. This tells us that the ratio proportionality holds true in the context of the Earnings Yield.

The test of the proportionality of the Dividend Yield ratio brought results similar to those above (see Table 6). Again the models proved to be homoskedastic with a non-significant regression coefficient β. Thus, after the clear outliers had been removed and an appropriate transformation applied, both of these ratios seemed to follow the assumptions of normality and proportionality.

4. Summary and conclusions

In this paper, the distributional characteristics and proportionality of two security ratios, Earnings Yield and Dividend Yield, were considered. The selection of these ratios was based on two criteria. Firstly, these ratios are probably the two most popular security ratios exploited in finance literature. Secondly, even if these two ratios are closely connected, there are certain reasons that make them different in nature.

Table 5. Proportionality of Earnings Yield.

$$\frac{E_i}{P_i} = \alpha + \frac{\beta}{P_i} + \varepsilon_i$$

Year	α (t-stat)	β (t-stat)	P-G t-stat	S-W (prob)
1980	0.030	−341756	−0.032	0.938
	(3.093)**	(−0.821)		(0.111)
1981	0.019	−15136	−0.122	0.966
	(2.765)*	(−0.043)		(0.502)
1982	0.007	−584691	1.397	0.931
	(0.680)	(−0.540)		(0.105)
1983	0.008	−877650	1.611	0.942
	(1.668)	(−1.438)		(0.171)
1984	0.015**	−524325	−1.506	0.942
	(3.430)	(−1.069)		(0.161)
1985	0.004	−394500	−0.621	0.911
	(0.928)	(−0.746)		(0.026)
1986	0.002	−136641	−0.254	0.934
	(0.828)	(−0.248)		(0.087)

significance levels: * .05 ** .01 *** .001

Table 6. Proportionality of Dividend Yield.

$$\sqrt{\frac{D_i}{P_i}} = \alpha + \frac{\beta}{\sqrt{P_i}} + \varepsilon_i$$

Year	α (t-stat)	β (t-stat)	P-G t-stat	S-W (prob)
1980	0.227)	2.618	−0.549	0.950
	(13.522)***	(0.604)		(0.239)
1981	0.238	0.851	−0.233	0.984
	(14.225)***	(0.178)		(0.940)
1982	0.216	−2.760	−1.782	0.954
	(11.758)***	(−0.427)		(0.286)
1983	0.150	12.082	0.061	0.950
	(9.157)***	(1.699)		(0.249)
1984	0.163	15.040	0.755	0.924
	(8.314)***	(1.760)		(0.054)
1985	0.172	8.488	−0.691	0.954
	(10.934)***	(1.151)		(0.288)
1986	0.125	13.458	−0.112	0.925
	(5.983)***	(0.829)		(0.079)

significance levels: * .05 ** .01 *** .001

In the first empirical phase the distributional characteristics of the two security ratios were examined. Having technical limit to zero, the Dividend Yield ratio appeared to be positively skewed. However, a substantial part of that skewness disappeared when a square root transformation was applied to this ratio. In the context of the Earnings Yield, the ratio distributions were found to follow the normal distribution. To achieve normality, however, certain extreme observations, interpreted as outliers, had to be removed. In the second empirical phase the proportionality of the ratios was investigated. The results of this examination indicate that the proportionality of these ratios holds true surprisingly well.

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