

THE ANALYSIS AND USE OF FINANCIAL RATIOS: A REVIEW ARTICLE

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INTRODUCTION

Financial ratios are used for all kinds of purposes. These include the assessment of the ability of a firm to pay its debts, the evaluation of business and managerial success and even the statutory regulation of a firm's performance. Not surprisingly they become norms and actually affect performance.¹ The traditional textbooks of financial analysis also emphasise the need for a firm to use industry-wide averages as targets (Foulke, 1968), and there is evidence that firms do adjust their financial ratios to such targets.²

Whittington (1980) identified two principal uses of financial ratios. The traditional, normative use of the measurement of a firm's ratio compared with a standard, and the positive use in estimating empirical relationships, usually for predictive purposes. The former dates back to the late nineteenth century and the increase in US bank credit given as a result of the Civil War when current and non-current items were segregated and the ratio of current assets to current liabilities was developed (Horrigan, 1968; and Dev, 1974). From then the use of ratios both for credit purposes and managerial analysis, focusing on profitability measures soon began. Around 1919 the du Pont Company began to use its famous ratio 'triangle' system to evaluate its operating results, underpinning the modern interfirm comparison scheme introduced in the UK by the British Institute of Management and the British Productivity Council in 1959.

The positive use of financial ratios has been of two types: by accountants and analysts to forecast future financial variables, e.g. estimated future profit by multiplying predicted sales by the profit margin (the profit/sales ratio), and, more recently, by researchers in statistical models for mainly predictive purposes such as corporate failure, credit rating, the assessment of risk, and the testing of economic hypotheses in which inputs are financial ratios. These will be reviewed in the section on predictive studies.

The reason ratios are used, as opposed to absolute values, is a mathematical one, and is basically in order to facilitate comparison by adjusting for size. However, this assumes that ratios possess the appropriate statistical properties for handling and summarising the data. Also, the statistical models assume,

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and depend on, the nature of the distribution of the input data. These matters will be examined in the next section.

METHODOLOGICAL ASPECTS

The Reasons For Using Ratios

There are two principal reasons for using ratios. They are:

a) To control for the effect of size on the financial variables being examined. Although Lev (1974) touched on these matters, it was not until Lev and Sunder (1979) that the full ramifications were examined. They said the use of ratios was 'necessarily based on a hypothesis (either explicitly specified or implicitly assumed) about the relationship between the numerator variable (e.g., income) and the denominator size variable (e.g., equity).' Control for size by ratio was only satisfactory in certain restricted conditions, and elsewhere important biases resulted. Lev and Sunder concluded 'surprisingly, despite the extensive use of ratios by practitioners and researchers, the conditions under which such use is appropriate and the consequences of using ratios when these conditions are not met are never thoroughly discussed in the accounting and finance literature'.

Size is only properly controlled when the two financial variables (x and y , where x is a measure of size) are strictly proportional. That is, $y = bx$, and the ratio $y/x = b$. The strict assumption of proportionality is violated if (i) there is an intercept term, a , and $a \neq 0$, (ii) where there is an error term, e ; in which cases $y = a + bx + e$. Clearly in the case of (i), the ratio does not satisfactorily control for size as $y/x = b + a/x$. In the case of (ii), this depends on the behaviour of e , which will be discussed later. Whittington (1980) and Barnes (1982) identified the nature and likelihood of misinformation arising from (i) above, and suggested that regression analysis should be used.³ That is, for the functional relationship to be properly estimated, it is necessary for the intercept to be estimated. For an assessment of the performance of individual firms, the residuals would be inspected.

Is the proportionality assumption usually violated? Barnes (1982) cited previous empirical studies concerning the cross-sectional distribution of financial ratios which revealed skewness as evidence for a non-zero intercept. There have also been a number of recent empirical studies testing the proportionality assumption. McLeay and Fieldsend (1987) concluded that it 'remained tenable' allowing for size and sector effects identified by Lee (1985) and Buijink and Jegars (1986). Also McDonald and Morris (1984 and 1985) have presented evidence that the proportionality assumption was not violated and the ratio model was to be preferred, although Barnes (1986) argued that such an inference was not warranted from their statistical study, rather the opposite.

b) To control for industry-wide factors. Ratios aid comparisons between a sub-

ject firm and its industry. In practical ratio analysis a firm's ratios will be compared with industry norms which may be location measures, such as the industry mean and median ratios, and inferences about the firm's performance are based on the difference between the firm's ratios and the industry norm. In empirical research, control for size effects is done by, for example, dividing the examined ratio by industry mean ratios. (Lev and Sunder, p.202) While location measures may be unanimous in normal distributions, they will not be in the case of skewed distributions, rendering the choice of location variable problematic. However, as Lev and Sunder noted, there are no guiding criteria as yet in the accounting and finance area.

The Cross-Sectional Distribution of Financial Ratios

Bird and McHugh in Australia (1977), Bougen and Drury in the UK (1980), Deakin (1976), Horrigan (1965), Mecimore (1968) and O'Connor (1973), all in the USA, and Ricketts and Stover (1978) and Bedingfield et al. (1985) in the US commercial banking industry, tested the basic hypothesis of normality in financial ratios. Deakin concluded that the normality assumption was untenable for eleven well-known ratios, except for the debt/total asset ratio. While square root and logarithmic transformations sometimes produced normality, no general guidelines could be given.

Most of those early empirical studies noted skewness but did not inquire into the reasons. Nor was it clear why non-normality mattered. However, the recent advances in this area have clarified the matter. Firstly, the importance of the knowledge of the distribution of financial ratios is established. It is required (i) in order to use ratios themselves (for reasons referred to in the previous section), (ii) their effects on location measures, and (iii) in order to facilitate the use of financial ratios in statistical models that assume multivariate normality.

There are two alternatives. Either they can be forced into a normal distribution or a more suitable ratio model could be sought. Concerning the former, the traditional approach was to transform the data in such a way so that it eventually conformed. Deakin attempted square root and logarithmic transformations which resulted in normality in his data in some cases. However, no guidelines were offered or principles established as to which transformation was appropriate in a particular instance. Also, transformation may change the interrelationships among the variables and affect the relative positions of the observations of the group (Eisenbeis, 1977).

More recently, trimming the data by segregating 'outliers' by reference to a prescribed and well-known distribution (such as the normal)⁴ and 'Windsorising' (changing an outlier's value to that of the closest non-outlier, and then attempting to fit the distribution with a known one) have been suggested. Frecka and Hopwood (1983) used Deakin's original ratios for a later time period and found that by deleting outliers normality could be achieved for most ratios

using a population of manufacturing firms and specific industry groupings. This also greatly reduced variances and increased their stability over time. Square-root transformations and other statistical techniques were used to identify outliers.

As financial ratios are constructed from two accounting variables, the joint distribution will depend on the behaviour of both the numerator and the denominator and on the relationship between these two co-ordinates. If there is non-proportionality as mentioned in the previous section, then the distribution will be skewed (Barnes, 1982). Ezzamel, Mar-Molinero and Beecher (1987) conducted a similar test on the same eleven ratios used in the Deakin study but used the non-normal stable asymmetric Paretian distribution. After removing the outliers, many of the distributions were found to be still non-normally and asymmetrically distributed. They concluded that non-proportionality probably explained why even after eliminating outliers normality could still not be achieved. Similar inferences may be made from Lee (1985) who tested various cross-sectional models, not simple ratios, for normality when systematic factors were taken into account. While the ratio distribution was non-normal, non-ratio models which took into account size and industrial classification were found to be distributed normally.

Concerning the other alternative (retaining their information by using a suitable ratio model), advances have been made by McLeay (1986a). McLeay looked at theoretical models of distribution, and making certain assumptions found that they fitted his data from French companies. These assumptions were: (i) that stochastic growth processes adhering to Gibrat's law generate a lognormal size distribution, (ii) that accounting data comprise two broad classes, those which are sums and bounded at zero [Σ] and those which are differences [Δ], so that there are three types of financial ratio, Σ/Σ , Δ/Σ and Δ/Δ . Σ/Σ has a lognormal distribution, Δ/Σ a t -distribution, and Δ/Δ a Cauchy distribution. The hypothesis concerning Δ/Σ ratios was further verified by McLeay (1986b) on UK profitability ratios which demonstrated the importance of using the appropriate distribution model for 'fractile estimation'. That is, when making inferences concerning corporate performance relative to the industry as a whole was demonstrated there was a larger proportion of the population classified incorrectly compared with a better fitting t^2 approximation.

THE USE OF FINANCIAL RATIOS

Which Ratios Are Most Useful?

There has been considerable debate in the traditional literature as to which ratios are most useful, and in particular, for assessing the likelihood of failure. The focus originated on liquidity as an indication of both current and future cash inflows and outflows. Merwin (1942) and Tamari (1966) found that,

generally, current ratios of failed firms were less than those of the industry as a whole. Beaver (1966) used the concept of cash flow (net profit plus depreciation) and found that its ratio to total debt was the best classifier amongst fourteen ratios, followed by debt to total assets and the 'no credit interval' [(defensive assets - actual liabilities)/projected daily expenditure]. This ratio was also shown by Lev (1973) using his balance sheet decomposition measure, to outperform other static balance sheet ratios in the prediction of failure. Fadel and Parkinson (1978) also found cash flow ratios good predictors of future returns on capital employed.

The notion of treating liquidity as a function of the flow of funds as opposed to a stock of funds is amplified by Sorter and Benston (1960) who advocate liquidity evaluation by a collection of interval measures, which are the ratios between certain defensive assets (cash and near-cash) and various measures of future expenditure and are expressed as a number of days. Davidson, Sorter and Kalle (1964) found firms' liquidity rankings, using these defensive interval ratios, were substantially different to the current ratio. However, the notion of 'defensive assets' has been criticised as being 'static' and should be replaced by cash inflows from trading; for example, Bierman (1960) related net cash inflows to various measures of working capital as an indicator of liquidity.

The Use of Financial Ratios for Predictive Purposes

Financial ratios have been used as inputs for advanced statistical models to forecast many kinds of business event and to identify financial and other characteristics. Notable studies include Ingram and Copeland (1984) who used regression analysis to measure the relationship between differences in financial ratios across municipalities and the risk premiums on their bonds. Horrigan (1966) used correlation analysis, while Pinches and Mingo (1973) used MDA to predict published corporate bond ratings by means of individual ratios. Rege (1984) and Belkaoui (1978) are recent studies which have used financial ratios to identify characteristics of takeover targets.

But the main focus has been on testing (mainly multivariate) statistical models which use financial ratios to predict business failure. These were based on the original work of Beaver (1966) and Altman (1968). Beaver matched a sample of failed firms with a sample of non-failed firms and studied their financial ratios for a period of up to five years before failure and found that they had high predictive ability. Each ratio was analysed separately and the cut-off point selected so as to maximise the number of accurate classifications for a particular sample. This technique was to become known as classification analysis and was essentially univariate. Altman used a well known multivariate statistical technique in the social sciences called multiple discriminant analysis (MDA). This was popularised as the Z-score model and was successfully marketed for credit analysis, investment analysis and going-concern evaluation. MDA finds that combination of variables which best discriminates between two or more

classification groups (here failed and non-failed firms) by means of a statistical technique which estimates the coefficients which are attached to the ratios used as discriminating variables. Since then the technique has been applied to different countries and industries, and in particular the US banking industry. Statistical models using financial ratios have been used to identify the financial characteristics of problem banks (Sinkey, 1975; and Pettway and Sinkey, 1980), lending decisions, and capital adequacy (Dince and Fortson, 1972).

There have been other approaches. Altman et al. (1977) developed and marketed a 'second-generation' model called 'Zeta analysis' which is essentially the same as the Z-score model, but takes into account changes in financial reporting standards such as capitalisation of leases (Elam, 1975). An alternative to using discriminant analysis is to use a conditional probability model, usually using logit or probit, to estimate the probability of occurrence of a particular outcome (Santomero and Vinso, 1977; Ohlson, 1980; and Zavgren, 1985). This may be preferable in bankruptcy prediction where it is not mere classification that is usually required but rather the probability of failure. Another bankruptcy prediction model is based on the gambler's ruin model in probability theory (Wilcox, 1971, 1973 and 1976). In this model the firm is the gambler and bankruptcy occurs when its net worth falls to zero. However, applications of the model have been disappointing as it assumes that periodic cash flows are independent of each other. In fact Wilcox (1976) discarded the functional form as suggested in the model and used the variables it suggested for an operationally predictive model.

It is not possible here to review in detail the enormous number of empirical studies. In fact this is unnecessary as there have been a number of recent national and international surveys and reviews.⁵ There have also been a number of methodological criticisms of the MDA studies. Both Pinches (1980) and Eisenbeis (1977) identified a number of difficulties arising from the statistical assumptions made in the application of the technique which researchers did not usually address. These include: the assumptions of multivariate normality in the distribution of the sample groups, the equality of the group dispersion (variance-covariance) matrices, addressing the problems of determining the relative importance of individual variables, reducing the number of variables that do not significantly contribute to the overall discriminating model, the selection of prior probabilities and costs of misclassification, and the classification error rates. Zmijewski (1984) debated sample bias, particularly that which arises from 'oversampling' failed firms due to the relatively low frequency rate of firm failures (many studies have used a 1:1 ratio in their samples of failed and non-failed firms). Joy and Tollefson (1975), using Altman (1968) to illustrate their points, argued that the predictive ability was often exaggerated. This was because researchers had confused predictive success with discrimination success. The former means foretelling the future and testing the model on a later period, while the latter involves testing the classifying ability of the model on another sample set from the same time period as the sample from

which the model was estimated. Also, ratios by themselves cannot describe a dynamic system of corporate collapse. These studies may demonstrate that failed and non-failed firms have different ratios, but not that ratios have predictive power. For inference in the reverse direction (from ratios to failures) it is necessary to establish that certain ratios' values imply failure or non-failure, which requires a model to link given ratio values to these two groups (Johnson, 1970).

There are certain other points concerning predictive ability particularly relevant to this review. A model is only useful for predictive purposes if the underlying relationships and parameters are stable over time. Otherwise it will only be valid for the sample period and it cannot be extrapolated into a subsequent period with the same expected performance (Altman and Eisenbeis, 1978). This raises the question of the stationarity of the model and ratios over time. Dombolena and Khoury (1980) found a substantial amount of instability in the financial ratios (as measured by their standard deviations and their coefficients of variation) in the ratios of firms which went bankrupt compared with those that did not. This instability increased over time as the firm neared failure. There is also evidence that the relationships among the variables are also unstable over time. In fact these variables change. Consider for example, the case of Taffler's Z-score model, which has been operational in the UK for many years. His first model, which was completed in 1974, comprised five ratios: earnings before interest and tax/opening total assets, total liabilities/net capital employed, quick assets/total assets, working capital/net worth and stockturn (Taffler, 1982). This compares with his later model updated to 1976, a quite different model containing different variables, namely four ratios: profit before tax/average current liabilities, current assets/total liabilities, current liabilities/total assets, and the no-credit interval (Taffler, 1983). It is also necessary that the discriminating coefficients are stationary. However, for proprietary reasons these are not usually disclosed.

Which are the useful ratios for bankruptcy prediction and are there certain ratios that consistently show up in the discriminant studies? The published studies usually identify particularly significant ratios. However, there is no absolute test for the importance of variables and the significance of particular variables and the pros and cons of various statistics are debated.⁶ Nevertheless Dev (1974) and Chen and Shimerda (1981) have analysed the main studies and tabulated the frequency of individual ratios and the main factors involved. However, the way in which variables are selected needs to be considered. Ratios are usually selected on the basis of their popularity in the literature together with a few new ones initiated by the researcher. The theoretical importance of the results is therefore restricted as those variables which figure in the final discriminant model are chosen according to their ability to improve its discriminating power. Zavgren (1983) writes 'This power relates to the characteristics of a particular sample and not to any rationale regarding the actual importance of particular characteristics in general. As Edminster

recognised, "It should be noted that other functions of almost the same quality are possible using variables excluded because they are highly correlated with those included" (1972, p. 1487). Thus, while such a function may have predictive ability it will not provide unique information' (p. 17).

Ratio selection is a contentious matter because information overlaps individual ratios. On the one hand if all ratios were used the decision model would contain repetitive-redundant data (for example if both ratios A/B and B/A were included), while on the other hand if only fully independent ratios were included the information content of the semi-independent ratios would be lost (Benishay, 1971). To identify those ratios which contain complete information about a firm whilst minimising duplication cannot be achieved purely by logic; in fact it is largely an empirical matter in which correlational independence is used as a statistical criterion. Accordingly, Pinches, Mingo and Carruthers (1973) used factor analysis to determine the long term stability/change patterns during 1951-1969 in financial ratio patterns in the USA. The results yielded seven financial ratio factor patterns: return on investment, capital turnover, inventory turnover, financial leverage, receivables turnover, short term liquidity and the cash position and that these groups were reasonably stable over time. By selecting one ratio from each classification analysts may use just seven financial ratios which are essentially independent but represent those seven different empirical aspects of a firm's operations as identified in the study. Building on this, Johnson (1978) conducted a similar study involving retail and primary manufacturing firms and found that financial ratio factor patterns common to both involved those seven plus decomposition measures. Elsewhere, Laurent (1979) found ten factors in his study of Hong Kong, and Mear and Firth (1986) added growth in size and growth in profitability from their study of New Zealand data. Gombola and Ketz (1983) found that cash flow measures also represented a separate dimension of firm performance, although general price-level adjusted financial ratios did not. They showed factor patterns very similar to those of historical cost ratios, including the cash flow factor. Pinches, Eubank, Mingo and Carruthers (1975) further examined short-term stability in order to empirically establish a hierarchical classification. They studied interrelationships among the seven first-order classifications and identified higher order factors which were return on invested capital, overall liquidity and short term capital turnover.

Are financial ratios and prediction models sensitive to the use of alternative accounting methods? Norton and Smith (1979) compared the performance of a MDA bankruptcy prediction model using traditional historical cost data and using data adjusted for changes in general price-levels (GPL). They found these were similar, although Solomon and Beck (1980) showed how the model was biased against a finding of predictive GPL data, and Ketz (1978) found that GPL data slightly improved performance. Mensah (1983) came to a similar conclusion as Norton and Smith concerning specific price-level data, and Bazley (1976), using a simulation approach, found that both were slightly inferior to

historical cost. Short (1980) used factor analysis to test whether empirical classifications were similar under historical and price-level accounting. He found that they were unaffected, suggesting that the meaning of a ratio is not altered by a price-level adjustment.

Financial ratios have been used to assess and forecast company risk in other contexts. Falk and Heintz (1975) used industry financial ratios in what is called a partial order scalogram technique to scale industries according to their degree of risk. To a similar end, Gupta and Huefner (1972) used cluster analysis to relate ratios to established economic characteristics of the industries involved.⁷ However, the biggest development has been the prediction of betas as measures of risk using financial ratios. Early work was by Thompson (1976) and Bildersee (1975) who examined such correlations, and now commercial services are available for practitioners (see Foster, 1986, p. 352–355). There have also been studies investigating the statistical relationship between financial ratios and rates of return on common stocks (such as O'Connor, 1973 and Roenfeldt and Cooley, 1978), in which the inference is that ratios are useful in forecasting future rates of return.

CONCLUDING REMARKS

Financial ratios are almost always used predictively, either implicitly or explicitly. It is axiomatic from the research reviewed that it is assumed that they are good indicators of a firm's financial and business performance and characteristics and that they may be used to forecast future performance and characteristics. It is also axiomatic that there have been considerable advances in this work: in their statistical nature and in their statistical use and in these respects we are much nearer the 'theory of financial ratios' to which Horrigan (1968) referred. However, there are at least four aspects in which there has been little advance. Firstly, the recent advances made on the methodological aspects have not yet been picked up in the applied work, certainly not by researchers and probably not by analysts. The second concerns predictive ability of accounting numbers in the context of the use of financial ratios. It is left as a mere empirical question and, as has been shown, even then, not examined rigorously. Thirdly, as the company failure studies blatantly demonstrate, accounting ratios are rarely used in the financial literature to test hypotheses and theories of economic and financial behaviour. Rather, they are testing the (strange) hypothesis that, without a theory, an event, be it a company failure, a takeover or an earnings figure, may be forecast from data simply selected statistically. Fourthly, there has been little advance in behavioural insights into the use of financial ratios — especially given the advances in the methodological analysis and the behavioural assumptions on which it is based.

NOTES

- 1 See, for example, the law regulating banks, building societies and insurance companies in the UK.
- 2 Lev (1969). However, his use of a log-linear partial adjustment model has recently been criticised by Frecka and Lee (1983) and Lee (1984) whose evidence, using more sophisticated adjustment models, is not so conclusive. In a different type of test, Peles and Schneller (1979) found evidence to suggest that firms' relative levels of current assets could be explained by a firm's size and its labour intensity in addition to the industry effect.
- 3 It should not be thought that they were the first. See, for example, Tummins and Watson (1975).
- 4 Without knowing the shape of the distribution (or the correct transformation to be used) it is not possible to classify a point as an outlier.
- 5 See Altman (1983); Scott (1981) and Zavgren (1983) and a special edition of the *Journal of Banking and Finance* (June 1984).
- 6 See for example, Joy and Tollefson (1975) who cite the case of the sales/total assets ratio being stated by Altman (1968) as the second most important discriminator in his study. According to Joy and Tollefson a more appropriate statistic would indicate that it was the least important. See Altman and Eisenbeis (1978) for a rebuttal and further discussion.
- 7 A similar study was conducted by Jensen (1971). The interested reader is also referred to the related bodies of literature concerning the association between a company's earnings, its industry and the economy such as Brown and Ball (1967).

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