The Estimation of Fundamental Equity Betas Using Accounting Information

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August 2004
ABSTRACT

The estimation of equity betas is important due to the applications of beta in portfolio selection and evaluation and project valuation. However, the most commonly used estimation procedure, that being an Ordinary Least Squares (OLS) regression of security returns against market returns, is inadequate, due to the various estimation errors it introduces, which cause the estimated betas to be biased. Numerous studies conducted during the 1970’s and early 1980’s suggested that accounting variables could provide estimates of systematic risk that are superior to ordinary betas, by reducing some of the sources of estimation error. This research builds upon this literature by employing the most appropriate estimation procedure, developed by Rosenberg and McKibben (1973), and using accounting variables consistent with a relatively simple and intuitive theoretical model, presented by Mandelker and Rhee (1984), to estimate a fundamental equity beta for a selection of US firms between 1996 and 2002. The usefulness of these betas will then be evaluated by comparing their ability to forecast future period returns with ordinary estimates of beta.
INTRODUCTION

The estimation of the systematic risk of a stock (also known as beta), that is the portion of total variation in returns that can be explained by movements in the overall market, is an important process. The importance of beta is due to its relationship with the expected return on a stock. That is, Sharpe (1964) and Lintner (1965) showed that the expected return on equity is a function of the expected returns on a market portfolio, a risk-free rate of return, and the stock’s beta (a model known as the Capital Asset Pricing Model, or CAPM). The expected return on equity is widely used in both portfolio management and corporate finance. Consequently, beta is important because of its numerous applications.

Beta is used when establishing an investment portfolio with certain risk and return characteristics. Beta is also used when evaluating the past return performance of a stock or portfolio, as the expected return is used as a performance benchmark. Investors looking to value the equity of a firm can use the expected return on equity, of which beta is an input, to discount future cash flows to that equity. Finally, beta is useful to a firm’s management in making investment decisions. When new projects are valued, managers use a combination of the expected return on equity and the return on debt to discount anticipated cash flows associated with each project. Therefore, the estimation of beta is important.

The traditional method used to estimate beta, which is still widely accepted, and employed by both researchers and practitioners, is relatively simple. An ordinary least squares (OLS) regression is run with the returns on the stock as the dependent variable and the returns on a stock market index as the independent variable. The estimated beta is the regression coefficient on the independent variable. This regression equation is known as the market model, and is an implementation of the CAPM. Betas estimated in this manner contain various errors, which cause them to deviate substantially from true systematic risk. Obviously, erroneous betas can cause poor investment decisions, and thus the removal of these errors has been examined thoroughly. Numerous researchers have attempted to reduce particular sources of errors using techniques which adjust the estimated market beta. However, these methods are arguably inadequate. This is evident from anecdotal observations which see estimated betas, even after an adjustment for errors, varying substantially period to period, without a change in any fundamental aspect of the business. An alternative approach to the removal of estimation errors from betas is to use a different estimation technique. That is, to employ a model other than the market model. A substantial amount of literature during the 1970’s and 1980’s examined the association between accounting variables and systematic risk, and found that several accounting variables could be empirically and theoretically linked to beta. Some research also used accounting variables to estimate systematic risk, and found these betas to be superior at forecasting subsequent period betas and returns relative to ordinary market betas. It was suggested in several of these studies that the relative success of this alternative beta was due to its lower level of estimation error.

Few studies have examined this area since the early 1980’s, which is somewhat surprising given the importance of estimating betas and the inadequacies inherent in existing estimation procedures. Consequently, several researchers, such as Ryan (1997), have suggested that there is a need to update and extend this research.

This study revisits this area of literature, and approaches it with a pragmatic objective: to develop a beta estimation procedure that overcomes some of the problems with the ordinary estimation process. The success of this alternative beta, which will be called a fundamental

1 ‘Market beta’ will be used in this paper to describe an estimate of systematic risk derived from an OLS estimation of the market model.
beta, will be measured by its ability to predict future returns relative to an ordinary beta. This paper adopts the most appropriate empirical model developed by Rosenberg and McKibben (1973), as well as a simple and intuitive theoretical model, developed by Mandelker and Rhee (1984), to provide a comprehensive study of the usefulness of accounting data in calculating betas.

PROBLEMS WITH OLS BETAS

There are a number of errors which cause betas estimated via the market model to deviate significantly from their true value. This problem is known as bias, which is where the expected value of the estimated parameter differs from the true parameter. A few of these errors cannot be avoided. However, some of the problems relate specifically to betas derived through an OLS estimation of the market model, and thus could potentially be reduced or overcome by changing the estimation procedure. The sources of both of these types of errors will be described below.

The Market Portfolio

A potential source of error in estimated betas relates to the definition of the market portfolio. In CAPM, it is defined as the return on a value weighted portfolio of all risky assets. However, as noted by Roll (1977), this is unobservable. Consequently, in implementing the market model, a proxy for the market portfolio must be found, and a value-weighted stock market index is usually used. However, this proxy ignores several important classes of assets, such as cash, bonds and property. Consequently, movements in a stock market index may not accurately reflect movements in all risky assets. As a result, the estimated beta may be biased.

Structural Changes to Business

Under the assumptions of OLS regression, the parameters of the market model, of which beta is one, must be constant over time. If this assumption is breached, the estimated beta will be biased. Many companies operate in a dynamic environment where external factors which influence the risk of the firm’s shares, such as competition, product lines and target markets, are constantly changing. Further, factors within the firm, such as operating and financial leverage, which can be shown to effect beta, would be expected to change frequently. Consequently, the true systematic risk of these firms will also change frequently. The OLS estimation technique does not account for structural changes to businesses which occur during the estimation period. Hence, a market beta estimated for a firm experiencing change over the estimation period will be biased.

A possible solution to this problem is the use of comparable firms. That is, where a company’s historical data is not an accurate reflection of the current status of the firm, the market betas of companies which are similar to the firm’s current profile can be used to estimate its systematic risk. A number of problems with using comparables to estimate beta are discussed at the end of this section.

Fundamental Change to the Market

A structural change to the market as a whole over the estimation period can also cause the estimated beta to be substantially different from the true beta. Some examples of structural changes would be the imposition or relaxation of capital controls, a change in the company tax regime, a change in the personal tax regime in relation to equity securities (such as the introduction of an imputation system) and a change in superannuation laws (such as the introduction of compulsory superannuation).
A fundamental change in the market which occurs during the estimation period can cause errors in the estimated beta in at least two ways. It can affect the returns on the market index, as well as the relationship between those returns and individual stock returns.

A possible approach to estimating betas after a structural shift occurs is to examine betas of comparable firms from another jurisdiction (i.e. from another market where a structural shift has not occurred). However, there are problems associated with this, which are discussed at the end of this section.

**Cyclicality**

Some companies have characteristics which cause the relationship between the returns on their equity and market returns to be different in a recession compared to a boom. That is, a beta computed over one time period, which consists only of a recession, may be different to a beta computed for the same firm during a boom.

A potential solution to this problem is to compute the beta over a longer time horizon to ensure that both a boom and recession are captured. However, a longer estimation window can lead to significant weight being placed on older and therefore less relevant data. It also increases the chance that a structural change to the business or market occurred during the estimation period. Finally, the estimated beta for the current period should take into account the type of market that exists at the moment, and not be an average over a boom and recession. Consequently, using a longer estimation period also produces biased estimates of beta, and thus is an inadequate solution to the cyclicality issue.

**Statistical Issues**

There is substantial evidence, most notably that of Blume (1971, 1975), to suggest that beta is mean reverting. Mean reversion is an observation that estimated betas tend toward the mean beta of one over time. This trait leads to the conclusion that the OLS beta is biased.

A study by Vasicek (1973) provides a correction technique for the mean reversion property of betas using a Bayesian smoothing formula. He argued that the estimated beta should be some weighted average of the OLS beta and the market average of OLS betas, with the weightings to be determined by the variance of those two estimates. His formula has the effect of adjusting estimated betas toward one, which helps to address the problem of mean reversion.

A further statistical issue which introduces error into estimated betas is that of non-synchronous trading, which was recognised by Scholes and Williams (1977), Dimson (1979) and Fowler and Rorke (1983). These studies showed that differences in frequency of trading can cause the estimated beta to be biased. The estimated betas for stocks which trade very frequently or very infrequently are underestimated, and stocks which trade with average frequency are over estimated. These papers presented techniques to correct for non-synchronous trading.

However, anecdotal evidence suggests that beta can vary dramatically from period to period even after these adjustments are implemented.

**Unlisted Firms and Initial Public Offerings**

The traditional methodology for estimating betas cannot be applied to companies which are unlisted or have recently listed, as historical price data is not available. The usual solution to this problem is to use information from comparable entities. However, there are several problems with this solution, which are discussed below.
Problems with Using Comparables

The use of betas from comparable entities is a common solution to several of the problems outlined above. However, there are some issues with estimating company betas using comparable firms. For example, the comparable firms often have a different capital structure to the firm of interest. Hamada (1972) has demonstrated that there is a direct relationship between financial leverage and systematic risk. Consequently, as adjustment must be made to account for differences in leverage. Generally, the adjustment made is a de-lever/re-lever calculation, using a formula developed by Hamada (1972) and Rubenstein (1973).

However, there are problems associated with implementing this de-lever/re-lever process. The market value of debt is required, which is difficult to estimate, and thus the book value is used as a surrogate. However, book values can be inappropriate where the comparable firms are subject to different accounting standards. Further, book values are based on past events, whereas market values should relate to anticipated future events. The tax rate, another input into the calculation, can also be difficult to estimate. Theoretically, the tax rate that should be used in the calculation is the actual tax rate of each company. However, as this involves forecasting cash flows, it can be difficult to estimate accurately, particularly without access to the management of the company. Consequently, the statutory tax rate is often used as a proxy.

A number of other differences can exist between the firm of interest and a group of comparables which causes a beta estimated from comparables to be inaccurate. There may be disparities in size, which is likely to be the case where the beta of an unlisted firm is being estimated. Size can cause differences in true systematic risk because of the existence of a control premium and differences in liquidity. Further, the comparables may be trading in a different jurisdiction, where risk is priced differently, and there are different political risks and regulatory environments. There may also be differences between the intangible qualities of the firms, such as quality of management, loyalty of employees and reputation. Finally, it may be difficult to find a group of comparables which operate only in the industry in which the firm of interest operates.

Hence, betas estimated via comparable firms are also subject to numerous sources of error.

ERROR REDUCTION USING ACCOUNTING VARIABLES

It is possible to use methods other than an implementation of the market model to estimate systematic risk, in an attempt to overcome some of these sources of error. This research examines one of these alternatives – the use of accounting variables, and shows that several estimation errors can be reduced or avoided.

The estimation technique employed in this study will allow the beta to vary every quarter, as the accounting variables change, and will therefore reduce bias caused by a violation of the OLS assumption of stationarity. Further, this trait may also deal with problems which arise when there is a structural change to the firm. That is, if the structural change is reflected in one of the accounting variables used in the calculation of fundamental betas, and these variables are allowed to vary over the estimation period, this problem will be reduced. Similarly, betas which fluctuate with the business cycle will also be more accurately estimated, as long as this fluctuation is captured by the accounting data. The problem of non-synchronous trading will not affect betas estimated in this study, as stock prices are not used as an input. Further, the estimation procedure can be applied to unlisted and newly listed companies, reducing the need to resort to comparables.
EXISTING LITERATURE/CONTRIBUTION

Numerous studies during the 1970’s and early 1980’s examined the relationship between accounting data and systematic risk. Most of the early research investigated the empirical association between accounting variables and market betas. This association was generally examined by running a regression of the accounting data against the market betas. A few of these studies used this model to forecast subsequent period market betas, and found them to be superior forecasters compared to current period market betas. This methodology can be criticized in that it assumes that the market beta is a true measure of systematic risk. That is, if market betas are known to contain estimation errors, as explained above, then developing an estimation model to forecast these erroneous betas is not worthwhile. Rosenberg and McKibben (1973) developed an estimation technique where the returns on the security were the dependent variable in the regression. They then used this beta to forecast subsequent period stock returns, rather than market betas. This procedure does not assume market betas are error-free, and provides a meaningful evaluation of the accounting based betas. Despite this advantage, their methodology has not been employed in any subsequent research. This study employs the Rosenberg and McKibben (1973) methodology.

A further criticism that can be made in relation to the early research is that the accounting variables were often derived by trial and error, or intuition. Very few used sound theory or economic arguments as the basis for their investigation. Consequently, the models used in these papers were potentially mis-specified, and the relationships discovered potentially sample specific. There were, however, a few later studies, such as Mandelker and Rhee (1984) which developed a theoretical decomposition of systematic risk into components that could be approximated with accounting variables. This study builds its estimation model around the theory proposed by Mandelker and Rhee (1984).

Therefore, the key contribution of this paper is to estimate fundamental betas using accounting data employing variables grounded in sound economic theory and the best available methodology.

METHODOLOGY

Variable Construction

The fundamental betas estimated in this study will be derived following the expression developed by Mandelker and Rhee (1984), which presented systematic risk as a function of financial leverage, operating leverage, and a measure of intrinsic risk. Their model is shown below.

\[ \beta_i = (DOL)(DFL)\beta_i^0 \]

Where

- \( DOL \) = degree of operating leverage.
- \( DFL \) = degree of financial leverage.
- \( \beta_i^0 \) = the covariance between, the product of net profit margin and the turnover of common equity, and the return on the market portfolio, divided by the variance of returns on the market portfolio.

DOL was defined to be the percentage change in pre-tax earnings that resulted from a given change in the quantity sold. Similarly, DFL was defined as the percentage change in net income that was derived from a given change in pre-tax earnings. In several studies, these variables were estimated by running a time series regression of pre-tax earnings (dependent variable) against sales, and net income (dependent variable) against pre-tax earnings, and taking the estimated coefficient on the independent variables as the estimates of DOL and DFL respectively. However, this requires an assumption that a company’s leverage is
constant over the estimation period, which is undesirable. That is, it would be expected that leverage would change reasonably frequently, and thus the two variables should be defined such that they can vary. Consequently, Ferri and Jones (1979), using a measure of operating leverage in a different context, suggested the following definition for DOL:

\[
DOL = \frac{\frac{EBIT_t - EBIT_{t-1}}{EBIT_{t-1}}}{\frac{Sales_t - Sales_{t-1}}{Sales_{t-1}}}
\]

This definition allows DOL to vary each quarter, which is desirable. Their definition will be used in this study. A similar definition, which was not suggested in the Ferri and Jones study, will be employed for DFL:

\[
DFL = \frac{\frac{NI_t - NI_{t-1}}{NI_{t-1}}}{\frac{EBIT_t - EBIT_{t-1}}{EBIT_{t-1}}}
\]

The final variable included in the Mandelker and Rhee (1984) model which must be given an operational definition is intrinsic business risk. An estimation of the actual variable defined in the model would require a regression of an accounting based return on equity against market returns. This is likely to introduce many of the estimation errors that are present in the ordinary estimation process for beta, which this accounting based procedure is seeking to avoid. Consequently, an alternative measure of intrinsic business risk will be employed. Ferri and Jones (1979) suggested that this type of risk is reflected in variability in sales. Therefore, the measure of business risk used in this paper will be the variance in sales, calculated over the previous 16 quarters.

**Data and Estimation Procedure**

The research will employ US data, due to the greater volume and frequency available. The three variables defined above, which will be combined to estimate each company’s fundamental beta, will require quarterly data from Compustat. The sample period is from the first quarter 1980 to the fourth quarter 2002. However, the period from first quarter 1980 to first quarter 1984 is simply required for the purposes of estimating variables (e.g. variance of sales). The second quarter 1984 to first quarter 1996 will be the estimation period for the first fundamental beta, to be calculated for first quarter 1996. That is, the fundamental beta will be based on the previous 48 quarters of accounting data. This estimation period will then roll forward each quarter. Thus, the fundamental beta for first quarter 1997 will be based on an estimation period from second quarter 1985 to first quarter 1997. In order to be included in the sample for any one quarter, the company will be required to have a DOL, DFL and sales variance figure for the current quarter. Further, as the fundamental beta will be compared to an ordinary market beta, the company will be required to have 48 consecutive monthly price figures in the CRSP database.

Once a firm qualifies to be included in the sample for a particular quarter, a fundamental beta and market beta must be calculated. The market beta, derived via an OLS estimation of the market model, is calculated based on 48 months of data, using the Standard and Poor’s 500 index as the proxy for the market portfolio, and the implied yield on the US 10 year Treasury Bond as the risk-free rate of return. The following model is then estimated.
\[ R_{it} = \alpha + \beta_x [X_{it}] + \beta_y [Y_{it}] + \beta_z [Z_{it}] \]

Where

- \( R_{it} \) = an i x t matrix of excess stock returns, where i represents stocks and t represents time.
- \( \alpha \) = an intercept term (i.e., a scalar).
- \( X_{it} \) = an i x t matrix of the product of DOL and excess market returns.
- \( Y_{it} \) = an i x t matrix of the product of DFL and excess market returns.
- \( Z_{it} \) = an i x t matrix of the product of sales variance and excess market returns.
- \( \beta_x, \beta_y, \beta_z \) = the sensitivity of all stock returns to each accounting variable (i.e., each scalars)

This regression is run for the first estimation period, from the second quarter 1984 to the first quarter 1996. This produces three estimated coefficients, one for each accounting variable. These coefficients are identical across all firms for the estimation period. The fundamental betas for all stocks for the first quarter 1996 can then be calculated. The fundamental beta will be the sum of the product of each accounting variable multiplied by the relevant coefficient, as shown below.

\[ \beta_{it} = \beta_x DOL_{it} + \beta_y DFL_{it} + \beta_z (Var(Sales))_{it} \]

The above regression will then be re-run from the third quarter 1984 to the second quarter 1996, and the fundamental betas calculated. At the end of this estimation process, the data set is comprised of a number of firms each with a market beta and a fundamental beta for quarters between the first quarter 1996 and the fourth quarter 2002.

**Comparison of Betas**

The usefulness of the fundamental betas will then be assessed by comparing their ability to forecast subsequent period returns with market betas. The forecasting model adopted will be based on CAPM. The estimated return for a firm in a particular quarter will be the product of the estimated beta and the market risk premium, plus the risk-free rate. Given the purpose of comparing forecasting ability, the beta used will be that calculated for the period prior to the forecast quarter. Therefore, the first forecast period will be the second quarter 1996, where the beta employed will be that calculated for the first quarter 1996. The forecast returns will then be compared to the actual returns via a calculation of a mean square error.

**ANTICIPATED RESULTS**

Prior literature suggests that the fundamental beta should outperform an ordinary market beta. Several studies, most notably Beaver, Kettler and Scholes (1970) showed that accounting based betas were superior in predicting subsequent period market betas. However, as noted above, this study uses a more appropriate comparison, by examining the ability of the betas to predict subsequent period returns. Thus, it does not assume that market betas are a true measure of systematic risk. Rosenberg and McKibben (1973) adopted this method for comparison and also found the accounting based beta to outperform. However, their market beta was only based on annual data, and therefore may not have provided an accurate representation of the usefulness of the market beta. Nonetheless, it is still anticipated that the fundamental beta will outperform the market beta. This is because the model presented in this study is superior to that of Rosenberg and McKibben (1973). That is, the accounting variables employed are based on sound theory, and the variables are constructed such that
they are allowed to vary every quarter. Consequently, the fundamental betas are expected to produce a consistently lower mean square forecast error.
References


