The Relation Between the Cost of Capital and Economic Profit

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Abstract

This paper develops empirical estimates of the average cost of capital for 58 U.S. industries during 1990-2004. A simple, parsimonious theoretical relation between an industry's weighted average cost of capital (WACC) and the industry's economic profit is used to obtain empirical estimates of the WACC for these 58 industries. We show that our technique requires fewer data inputs for deriving WACC estimates than the conventional (or "textbook") cost of capital technique and are robust to alternative time periods. The method can also be applied to firm-level as well as industry data. The model's estimates perform better in out-of-sample forecasts of profitability than estimates based on the conventional method. Overall, the results suggest our technique can be a more expedient, descriptive, and less-subjective method of deriving estimates of an industry's (or firm's) weighted average cost of capital and economic profit. This new method can be used to complement or supplement the textbook approach to estimating the cost of capital.

Estimating a firm's weighted average cost of capital (WACC) is of critical importance to managers who evaluate investment projects for capital budgeting purposes as well as to investors who wish to assess the overall riskiness and expected return from a company's activities for valuation purposes.[1] For example, corporate finance textbooks typically devote several chapters to the problems of capital budgeting, cash flow estimation, and the determination of a firm's cost of capital. However, it can be difficult in practice to obtain reliable estimates of the inputs required to perform capital budgeting as recommended by the textbooks. As Fama and French (1997, 1999) point out, some of these practical difficulties exist because there is considerable uncertainty in estimating a firm's (or even an industry's) cost of capital. This uncertainty is similar to the risk faced by the firm when projecting a project's cash flow. In addition, surveys of corporate finance practitioners indicate there is wide variation in corporate WACC estimation methods, primarily due to managers' differences in estimating a firm's cost of equity capital (e.g., see Bruner, Eades, Harris, and Higgins, 1998). Thus, a simple, parsimonious, less-subjective, and accurate method of estimating the WACC for a firm or industry can be a useful tool to managers interested in capital budgeting problems and investment decision-making in general.[2] We present such a method and perform empirical tests based on this technique for 58 U.S. industries.

In addition, our method provides estimates of economic profit (also referred to as "economic value added" or EVA® by the Stern Stewart and Co. consulting firm). These estimates of economic profit can be useful for analysts who wish to study the long-term performance of corporations before and after an important financial event. For example, our model's economic profit estimates might be helpful in identifying (via an event study format) the long-term over- or under-performance of firms issuing new securities or merging with other firms.

The conventional approach to identifying a firm's WACC is based on estimating the costs of the individual components of the firm's sources of financing.[3] For example, computing the

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[1] As Lau (2000) notes, the cost of capital is also a critical component of computable inter-temporal general equilibrium macroeconomic models because the WACC ties together current and future investment, production, and consumption decisions.

[2] We can define a "simple" method as one that is less intensive in terms of the time and computations required to obtain a WACC estimate when compared to the conventional textbook method. Likewise, a "parsimonious, less-subjective" method can be defined as one that requires fewer inputs and/or calculations that are based on subjective judgments made by the analyst and / or the firm's management.

[3] See Ehrhardt (1994) for an in-depth discussion of the practical application of various methods of cost of capital estimation.

WACC for a company with debt and common equity in its capital structure entails estimating: 1) the relative weights of debt and equity in the capital structure, 2) the required after-tax return on the firm's debt securities, and 3) the required return on the company's common equity. One of the difficulties in implementing the above method is that it is sometimes hard to identify the correct weights of the capital structure components because the market values of many debt securities (e.g., bank loans, privately placed debt) might not be known. In addition, estimating the required returns on the debt securities can be problematic due to the general paucity of data related to corporate debt instruments.

Further, as Fama and French (1997, 2002) confirm, estimating the required return on common equity can be difficult due to the statistical "noise" inherent in estimating an asset pricing model's time-varying factor loadings and risk premiums. Using dividend and earnings growth models, Fama and French (2002) show that the expected equity premium for 1951-2000 is probably much lower than estimates based on realized stock returns (e.g., 2.55% – 4.32% versus the 7.43% estimate based on actual stock returns). This result is due to the statistical problems associated with the use of realized returns as proxies for expected returns. Results reported in Elton (1999) also suggest the use of historical returns as a proxy for *ex ante* returns is not appropriate when one examines the long-term performance of various securities such as U.S. government bonds and T-bills.

This study addresses the issues described above by proposing a method for estimating a firm's cost of capital that neither requires estimating the firm's capital structure nor the firm's required return on debt and equity securities. The approach is based on the microeconomic concept of "economic profit" first posited by Alfred Marshall (1890) over a century ago. Recent work on economic value added (EVA®) by Stewart (1991) has revived interest in estimating the economic profit of a firm or industry. Marshall described economic profit as the excess of an entity's marginal revenue over its marginal cost. Thus, a firm or industry that is generating returns greater than those required by investors is said to be earning economic profits or, in Stewart's terminology, adding economic value. Conversely, a firm or industry that yields returns less than those required by investors is destroying economic value or generating economic losses. We use the economic profit concept to derive an implicit relation between economic profit and the firm's weighted average cost of capital. This relation can then be used to estimate firm- or industry-level WACC estimates. These estimates can be obtained via regression analysis using relevant data from the firm's financial statements. To be more precise, the technique provides an ex post historical *average* of the firm's or industry's *marginal* cost of capital over the estimation period. By using this method, the analyst is freed from making several (potentially subjective) assumptions about the firm's capital structure and the costs of these capital components.[4] In turn, this historical average of the marginal WACC can also be used to formulate ex ante WACC estimates when the firm's or industry's WACC fluctuates fairly predictably over time. That is, even though EVA® and WACC vary over time, the time series method we employ can still lead to useful predictions of these variables, particularly for short-term forecasts in less-volatile industries. Our main hypothesis is that this technique can yield simpler, more parsimonious, less-subjective, and potentially more accurate WACC estimates than the conventional textbook method (subject to the caveats noted above).

We identify four main results from testing this new estimation method. First, we find that the average WACC across all 58 industries during 1990-2004 is 11.25% with a general increase in the cost of capital over sub-periods of 7 years and 8 years (i.e., 10.16% in 1990-1997 and 11.55% during 1998-2004). When the model's average economic profit is set to zero (i.e., the model's intercept equals zero), the model yields "required" WACC estimates which possess small standard errors (0.56% on average) and typically explain a large proportion of the variance in the industries' after-tax operating income (i.e., usually over 85% of the variation). These WACC estimates are statistically more precise than those reported in prior research and suggest that our approach can be used as an aid to practitioners in real-world capital budgeting / security valuation problems.

Second, the model's estimates are more effective in generating out-of-sample forecasts of future levels of industry profitability. This finding is based on a comparison of the model's estimates to WACC estimates published by Ibbotson Associates, which rely on the conventional textbook method. These latter estimates show no significant relation to realized industry stock returns and are poorer predictors of future industry profitability, thus suggesting that our model may be more descriptive of real-world returns to capital.

Third, we perform our analysis over sub-periods and show that our approach is robust to the choice of time period.[5] We also find evidence that WACC estimates vary over time in a predictable manner. Specifically, we report statistically significant mean-reversion in our WACC estimates during 1990-2004. This is particularly encouraging in terms of being able to use our ex post

[4] As Weaver (2001) notes, there is considerable cross-sectional variability in how real-world firms try to estimate their respective cost of capital and economic profit. Weaver finds that no two firms (out of a sample of 29) use the same method to estimate their firms' cost of capital and EVA®.

[5] Due to the limitations on the Compustat and Ibbotson Associates data available to us, we focus our analysis on the 1990-2004 time period. Clearly, more data for periods earlier than 1990 would be helpful to document the stability of the relations reported here. However, the main thrust of the paper (i.e., the use of the economic profit relation to estimate the weighted average cost of capital) can be demonstrated effectively with the 1990-2004 data.

averages of the industries' WACC in order to develop out-of-sample ex ante WACC estimates. Fourth, the technique proposed here also allows us to estimate a firm's or industry's average annual economic profit (or EVA®). We find that the average industry generated -$1.7 billion in annual economic losses during 1990-1997 and effectively zero EVA® during 1998-2004.

Although the approach presented here simplifies the amount of data required to estimate a firm's WACC, it typically requires reliance on financial accounting data that might not always reflect economic reality due to accounting conventions such as accruals and revenue/cost matching principles. However, the proposed methodology simplifies the estimation problem considerably and removes most of the potentially subjective decisions required by the conventional WACC estimation method. Thus, the gains in simplicity and objectivity appear to outweigh the potential drawbacks of using accounting data.[6] In sum, this paper contributes to the cost of capital literature by providing a new estimation method that can be used to complement or supplement the textbook approach.

The rest of the paper is organized as follows. Section I reviews some of the research relevant to our analysis. Section II develops the theoretical relations that are then tested using the data and methodology described in Section III. Section IV reports the results of our tests while Section V presents some concluding remarks and avenues for future research.

I. Relevant Research

There have been several attempts in recent years to estimate the cost of capital of U.S. companies at the industry level. Most notably, Poterba (1998), Fama and French (1997, 1999, 2002), and Gebhardt, Lee, and Swaminathan (2001) use different approaches to tackle the problems associated with estimating the cost of corporate capital. Using the Fama-French (1993) three-factor model, Fama and French (1997) estimated the cost of equity capital for 48 industries and found that, on average, the excess return on equity capital (i.e., the return above the risk-free rate) is 6.64% with a large degree of variability (e.g., standard errors of typically greater than 3.0%). Indeed, the authors claim that the large degree of imprecision in the excess returns makes these estimates

[6] For example, analysts frequently argue that accounting data might not reflect the true market value of a firm's activities. However, because we are looking at WACC as a *relative* measure based on the relation between net operating profits and firm capital, our accounting-based WACC can be as accurate as a market-based estimate when the biases inherent in accounting profits and capital are offsetting.

Given recent accounting scandals reported in the popular press, it is comforting to know that, for our methodology, most of management's accounting choices (including fraudulent ones) are naturally offsetting in terms of accounting profits and the book value of the firm's total capital. For example, if a company under-states its expenses by fraudulently capitalizing these costs, then both reported profits and total capital are inflated because over-stated profits also lead to over-stated common equity via the retained earnings account. Thus, our method is relatively insensitive to these potential problems.

useless in practice for corporate discounted cash flow analysis. In addition, economy-wide WACC estimates are also relatively imprecise with Fama and French (1999) reporting standard errors ranging from 1.67% to 2.21%. The authors admit that even these standard errors are probably *under-estimates* of the true standard errors.

Fama and French (2002) show that equity premiums based on fundamentals such as dividend and earnings growth can yield more precise estimates of equity premiums than those based on realized stock returns. For example, the standard error of dividend growth during 1951-2000 was 0.74% and is much smaller than the standard error of 2.43% for average stock returns during this time period. This evidence from Fama and French (2002) is consistent with our findings that using fundamental data can lead to more precise estimates of a firm's cost of capital.

Gebhardt et al. (2001) estimate the cost of equity capital but use a dividend discount model (DDM) methodology and I/B/E/S earnings estimates. They find that the cost of equity capital for large, U.S. publicly traded companies ranged between 10% and 12% during 1979-1995, depending on the assumptions used with the DDM approach. Interestingly, Myers and Borucki (1994) obtain the same range of estimates for the cost of equity capital of a limited sample of U.S. utility companies using a DDM-type method. Similar to Claus and Thomas (2001), Easton, Taylor, Shroff, and Sougiannis (2001) employ a less-restrictive version of the model used by Gebhardt et al. (2001) and find somewhat higher estimates of the industry-level cost of equity capital with an average value of around 13% during 1981-1998 for publicly traded stocks that are followed by the I/B/E/S information service. However, these papers rely upon analyst forecasts that Claus and Thomas (2001), among others, find to be biased upward (i.e., analysts typically over-estimate the actual growth rate of earnings).

Fama and French (1999) and Poterba (1998) are recent examples of research focused on estimating WACC rather than simply a firm's equity capital.[7] Poterba (1998) uses aggregate financial flow of funds data from 1959-1996 to estimate the annual inflation-adjusted WACC for the entire U.S. macroeconomy. He reports an inflation-adjusted WACC of 5.1% which translates to a nominal WACC estimate between 8% and 9%. Fama and French (1999) use *Compustat* data for 1950-1996 to estimate the annual WACC for large, publicly traded U.S. companies using the discounted cash flow technique. Their estimates of 7.1% - 7.3% for the inflation-adjusted WACC are somewhat higher than those reported by Poterba (1998). On a nominal basis, Fama and French (1999) show estimates that range from 10.7% to 11.8%. As Fama and French note, the difference

[7] These papers follow in the path of the seminal empirical work on cost of capital estimation presented in Miller and Modigliani (1966).

between the two sets of estimates could be driven by Fama-French's selective sample of larger, publicly traded U.S. companies when compared with Poterba's more comprehensive data set. In effect, Poterba's estimate captures smaller, private companies as well as the large, publicly traded companies analyzed in Fama and French (1999). If these small firms are less risky and less profitable than their larger, public peers, then one could explain the observed difference between the two sets of WACC estimates in terms of differences in the sample of companies employed.

As suggested in the previous section, there are several areas where the conventional textbook approach can force analysts to make subjective judgments. For example, Ehrhardt (1994) notes that choices related to the selection of asset pricing model, market factor proxy, periodicity of returns, and capital structure can all cause WACC estimates to vary widely. Bruner et al. (1998) and Weaver (2001) confirm these observations by surveying large corporations about their WACC methodologies. Both sets of authors find that significant differences exist in estimating the equity capital component of the firm, particularly via the use of the CAPM. Ideally, we desire a less-subjective WACC method that allows the results of actual firm-specific economic activities to "speak for themselves" and removes as many ad hoc judgments made by analysts and / or the firm's managers as possible from the estimation process. As will be described in greater detail in the following section, our approach proposes a solution to several of the problems that have confronted researchers in this area.

II. Theoretical Framework

As noted above, we can use the EVA framework first detailed in Stewart (1991) to derive a linear empirical relation that is useful for obtaining estimates of a firm's or an industry's WACC:

$$\mathrm{EVA}_{\mathrm{it}} = NOPAT_{it} - \mathrm{WACC}_{\mathrm{it}} \cdot TOTAL\ CAPITAL_{it-1} \qquad (1)$$

where, $\mathrm{EVA}_{\mathrm{it}}$ = economic value added for the *i*-th firm at time-*t*,

$NOPAT_{it}$ = net operating profit after taxes for the *i*-th firm at time-*t*,[8]

$\mathrm{WACC}_{\mathrm{it}}$ = weighted average cost of capital for the *i*-th firm at time-*t*, and

$TOTAL\ CAPITAL_{it}$ = book value of long-term debt, common stock, and preferred stock for the *i*-th firm at time-*(t-1)*.[9]

[8] The basic definition of NOPAT is defined as Earnings Before Interest but after Taxes (i.e., NOPAT = EBIT – Taxes) generated at time-*t*. NOPAT is defined as the quarterly Compustat data item, Operating Income after Depreciation, which is derived by subtracting Cost of Goods Sold (Q30), SG&A Expense (Q1), and Depreciation (Q5) from Sales (Q2). More details on the data definitions used in the model are reported in Appendix B.

[9] As Peterson and Peterson (1996) point out, the relevant estimate of a firm's total capital is based on *book* values, not market values, when the analyst is attempting to assess the *historical* performance of a firm in terms of EVA®. This is based on the notion that market values (particularly for equity) include forward-

Damodaran (1996) describes in detail how (1) can be viewed as an equilibrium relation for a value-maximizing firm that has established an optimal capital structure and generates sufficient perpetual, non-growing cash flows that satisfy investors' required returns on the firm's securities. If, for example, the return generated by the firm's equity does not meet investors' required return, then investors will exert selling pressure on the firm's common stock so that, in equilibrium, the firm's stock price falls to a level that equates the investors' required equity return with the expected return on the firm's stock.

Growth in NOPAT can be accommodated in (1) by assuming a constant growth rate, g, and including it within the WACC term. In this case, WACC = (NOPAT / TOTAL CAPITAL) + g. This is similar in spirit to Gordon's (1961) constant growth model for equity valuation. Non-constant growth can also be incorporated into the definition but this makes the WACC term more complicated and requires additional assumptions by the analyst. For the sake of simplicity, we use the perpetual, zero growth definition included in (1) for our analysis. To the extent that growth in NOPAT is large and variable, our estimates of WACC will differ from the "true" WACC figures.

It should also be noted that our WACC estimates based on (1) are unbiased when: a) growth is a constant (g) and b) the firm's dividend/profit retention policy is irrelevant for valuation purposes. For example, as shown in Damodaran's 2001 text on equity valuation, our WACC estimates will be *unchanged* if growth is constant and can be estimated via a conventional formula such as: g = (after-tax net operating profit retention ratio · WACC). Plugging this formula into a constant growth model of total firm valuation (i.e., firm value = [(1 – retention ratio) · NOPAT] / (WACC – g)) yields a relation between firm value and WACC that is *independent* of the growth rate. That is, using a conventional constant growth model and inserting the above assumptions about growth and WACC yields the relation that firm value = NOPAT / WACC. Thus, our simplified model presented in (1) might also be relatively accurate when the above conditions hold for a particular firm or industry with *non-zero* growth.[10]

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looking estimates of the value of future growth prospects. However, the NOPAT figure is based on historical accounting data that are derived from existing assets. Thus, using market value data for TOTAL CAPITAL will bias EVA® estimates downward because NOPAT will appear relatively low since it does not directly include future growth opportunities. This situation further simplifies our estimation process because market values for many debt instruments are frequently difficult to obtain. By using book values, the problem of finding market values for debt securities is avoided.

[10] Note that there is more than one way to demonstrate the irrelevance of the growth factor when specific assumptions are used to constrain a constant growth valuation model. As in Damodaran (2001), we use some standard textbook definitions of the dividend payout ratio and the growth rate to show the independence between growth and value. Other approaches can also arrive at the same conclusion using different definitions and the constancy of factors such as operating profitability, a capital requirement ratio, and the investment in capital. Since other approaches yield the same conclusion as ours, we prefer to use our original

Another perspective for interpreting (1) can be traced to Marshall (1890). As is well known from microeconomic theory, in a perfectly competitive industry, equilibrium occurs when marginal revenue equals marginal cost. In terms of Equation (1), we can view $NOPAT_{it}$ as the firm's marginal return on capital and $\text{WACC}_{it} \cdot TOTAL\ CAPITAL_{it}$ as the marginal cost of capital. Thus, in equilibrium, EVA_{it} should be zero. However, as Marshall (1890) noted, firms and/or industries might be in temporary disequilibrium because a new product or technological innovation can convey economic, or "abnormal," profits on a firm/industry that, ultimately, attracts competitors that, in turn, eventually erode these profits and force EVA_{it} back to zero. We can therefore view EVA_{it} in Equation (1) as an estimate of the Marshallian concept of economic profit.

As noted in the Introduction, our main hypothesis is that our proposed approach can yield simpler, more parsimonious, less-subjective, and potentially more accurate WACC estimates than the conventional textbook method. Thus, we can re-arrange (1) and include a stochastic disturbance term, e_{it}, to yield a more useful relation for the purposes of estimating WACC and testing our hypothesis:[11]

$$NOPAT_{it} = \text{EVA}_{i} + \text{WACC}_{i} \cdot TOTAL\ CAPITAL_{it-1} + e_{it} \qquad (2)$$

In the above specification, we can interpret EVA_i and WACC_i as parameters to be estimated via a bivariate regression analysis, where $NOPAT_{it}$ is the dependent variable and $TOTAL\ CAPITAL_{it-1}$ is the independent variable. To account for possible heteroskedasticity and autocorrelation in the residuals, we use the Newey-West (1984) generalized method of moments (GMM) estimator of the model's variance-covariance matrix.

Strictly speaking, a regression's parameter estimates of our model described above in Equation (2) are ex post *averages over time* of the marginal cost of capital and marginal economic profit related to a specific industry or firm. When the markets for physical and financial capital are efficient, investors can use the realized levels of NOPAT and TOTAL CAPITAL as reliable indicators of a firm's or industry's cash flows and invested capital. In this case, the regression parameter estimates from (2) can be interpreted as the average levels of EVA and WACC during the estimation period. That is, we can view the intercept and slope parameters of Equation (2) as measures of the average relationship between an industry's NOPAT and TOTAL CAPITAL over the sample period. In Equation (2), the estimated intercept is an *expected value* of the average level

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formulation because it is more closely aligned with the standard textbook definitions of the components of a constant growth valuation model.

[11] The stochastic disturbance term is included because unusual, non-recurring errors might be contained in the historical financial data. For example, a major revision in an accounting standard might significantly affect NOPAT and/or TOTAL CAPITAL for a specific quarter or year. Or, the firm/industry might have an unusually good or bad quarter due to a merger, strike, lawsuit, etc.

of EVA over the sample period that has a *standard error* associated with it. Likewise, the slope parameter estimate can be interpreted as the *expected* WACC over the sample period that also possesses a standard error. Therefore, the estimated intercept and slope parameter in Equation (2) should not be interpreted as being literally constant over the entire sample period. Instead, these parameter estimates should be viewed as accepted econometric theory defines them: that is, as measures of the *average* relationship between NOPAT and TOTAL CAPITAL that minimizes the sum of squared residuals. Viewed in this light, we can see that EVA and WACC do not have to be constant for every quarter within our sample period in order for us to obtain reliable parameter estimates via Equation (2).[12] Indeed, all we need for our analysis is to assume that the constant term in (2) is a reasonable proxy for the first moment of the distribution of EVA across the firms within an industry over a specified period of time.[13]

We can use time series accounting data for a firm or industry to estimate the parameters of Equation (2).[14] The slope parameter of this regression provides us with an estimate of the relevant firm's or industry's *average* WACC for the time period analyzed. For example, we can use quarterly accounting data for 1990-2004 to estimate the *15-year average* of the marginal WACC for an industry during the 1990s and early 21st century. This estimate is obtained simply (via

[12] While we agree that one needs to make certain assumptions in order to use the EVA relation for empirical estimation purposes as defined by Equation (2) (e.g., a constant growth framework and efficient markets), we also point out that, based on fundamental econometric theory, the intercept term of our bivariate regression, EVA, is equal to: EVA = average of *NOPAT* - (WACC parameter estimate * average of *TOTAL CAPITAL*). Thus, the intercept can be interpreted as follows: the average level of an industry's EVA is literally a function of the *average* levels of *NOPAT*, WACC, and *TOTAL CAPITAL* and does *not* have to be constrained to a constant value for all time periods within the sample period. So, our model is amenable to empirical testing because, based on the econometric relationship noted above, we do not require EVA (or WACC for that matter) to be constant for all time periods.

[13] That is, we do *not* need to make any assumptions about the distribution of EVA across individual companies within an industry because it is quite likely that some firms may have relatively wide distributions of EVA while other firms may have narrow EVA distributions. All that is required is that the distributions of different firms' EVA can be combined to form the first moment of an industry-wide distribution (i.e., we can view the intercept term as an average EVA for the industry). In addition, the inclusion of TOTAL CAPITAL in (2) allows us to control for different levels of investment across firms within an industry because a firm's investment expenditures are typically highly correlated with its level of TOTAL CAPITAL. Thus, our interpretation of the parameters in Equation (2) does not impose overly restrictive assumptions in terms of describing real-world levels of EVA and WACC.

[14] Equation (2) can also be estimated cross-sectionally at a point in time. For example, we could estimate the WACC for an industry during a specific quarter or year by using a cross-section of quarterly or annual financial statement data for firms within that industry. Similarly, one could also estimate an economy-wide WACC by using a cross-section of industry-level financial statement data. In either case, weighted least squares (WLS) would be appropriate for these cross-sectional analyses in order to account for differences in the size of firms within an industry or the size of industries within a macroeconomy. To conserve space, we focus on the time series application of Equation (2).

generalized method of moments, GMM) and less subjectively (because there is less room for analyst judgment in the choice of data inputs).[15] As noted earlier, Equation (2) shows that the intercept term of a bivariate regression yields an estimate of the firm's or industry's average EVA® over the estimation period. One can view this estimate as the 15-year average of the economic value added by the firm or industry. For example, if we use annual accounting data, then the EVA® estimate from (2) is an estimate of the average *annual marginal* economic profit generated by the firm or industry.[16]

Another relation implied by (2) also pertains to the intercept term, EVA_i. If we suppress the intercept term of the regression of (2), then we are, in effect, estimating a restricted form of (2) where the WACC slope parameter can be interpreted as an estimate of the "required" WACC for a firm/industry based on a rational expectations equilibrium. In addition, this required WACC approach ensures that the average NOPAT is equal to the expectation of NOPAT generated by the right hand side of Equation (2). As Muth (1961) first noted, market participants form rational expectations when, *on average*, their expectations are indeed realized over time and there are no systematic errors in their forecasts. Thus, according to Muth (1961), for an estimate to be a rational expectation it simply has to have no systematic biases. In effect, when the EVA_i parameter is suppressed in our regression, we are estimating a rational expectation of the return that, on average, investors *would have* required on the firm's/industry's assets in order to earn a "fair" return during the sample period (i.e., a return which yields an NPV of zero, which is equivalent to yielding an average EVA of zero over the period of analysis).[17]

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[15] In Equation (2), the "true" value of NOPAT may be measured with error whereas the TOTAL CAPITAL variable is more or less directly observable since it is based on book values (as theory suggests). As Greene (1993) notes, the measurement error of NOPAT is not a problem in terms of biasing our parameter estimates since NOPAT appears as the dependent variable in (2). Therefore, the effect of measurement error in our model is reflected in a more volatile error term rather than biased parameter estimates. As we will see in the Empirical Results section of the paper, the relatively tight fit of our model suggests that NOPAT's measurement error is not a significant problem in our sample.

[16] It should be noted that the model can expanded to accommodate increased complexity, such as time-varying interest rates, via explicit risk premiums for an industry's cost of debt and equity. However, we think that such a model departs from our original objective of constructing a simple, parsimonious model that does not require the analyst to choose a specific asset pricing model for the cost of debt and equity.

[17] As noted earlier, we do not need to impose restrictions on the distribution of individual firms within an industry. All that is required in this case is that we assume the first moment of the industry's distribution is zero on average over the sample period (and not necessarily zero for each quarter). In this way, we can interpret the resulting WACC estimate as one that is consistent with an estimate formed by a rational investor in equilibrium using all relevant available information. This does *not* mean that this estimate is the true, unobserved WACC but it is one that is consistent with one formed by an investor who forms rational expectations, as defined by Muth (1961).

It should also be noted that we are *not* claiming that the restricted form of our model will yield the "true" WACC for an industry or firm. Our objective in suppressing the intercept is to estimate a "required" WACC value for a given industry over a specified sample period, which might not be equal to the "true" unobserved WACC because of measurement error or other modeling problems. That is, when the intercept is suppressed, we are stating that EVA is, *on average*, zero over the sample period and that the resulting slope parameter estimate is consistent with a rational investor's unbiased expectation of an industry's WACC during this time period. Given the properties of the GMM estimators, our WACC estimates satisfy this requirement. When we suppress the intercept and estimate our "required" WACC values for each industry, we are *not* requiring EVA to be zero for all periods and we are not trying to estimate the unknowable "true" WACC. Our more modest goal is to show that the model can be used to uncover what WACC a rational expectations investor would require so that EVA would have been, on average, zero during the sample period. Note also that this does not require the investor to have perfect foreknowledge since there is an error term contained within our model. Thus, a rational investor can make forecasting errors, as long as there is no systematic bias in these errors. Accordingly, we can re-estimate (2) a second time without the intercept term in order to obtain estimates of the relevant WACCs required by investors within a rational expectations framework.

It is also important to note that suppressing the intercept in our model does *not* imply that one can estimate the firm's WACC by algebraically manipulating Equation (2). For example, one *cannot* calculate the firm's WACC by simply dividing the firm's average NOPAT by the firm's average TOTAL CAPITAL (i.e., WACC ≠ average NOPAT ÷ average TOTAL CAPITAL). As Greene (1993) and Kennedy (1998) demonstrate, the mean of a dependent variable in a bivariate regression (e.g., a random variable denoted as y) will *not* equal the product of the slope's parameter estimate and the mean of the random independent variable (denoted as x) when the intercept is set to zero. Both Greene and Kennedy show that the slope parameter is estimated in this case via the equation: slope = $\Sigma yx / \Sigma x^2$. Only by coincidence would this slope parameter estimate be equal to the ratio of the means of y and x. Thus, one must estimate the slope parameter (in our model, the WACC parameter) via regression and *cannot* be estimated by simply dividing the historical averages of NOPAT and TOTAL CAPITAL.

In theory, it is the above estimates of the *"Required"* WACC that should be used in corporate decision-making rather than ex post, unrestricted WACC estimates based on historical realizations of the firm's cash flows. To the extent that these required WACC estimates change slowly and predictably over time, these historical estimates can be useful to an analyst who wishes to forecast the future level of WACC for a firm or industry. In our discussion of the empirical results (Section IV), we report the results of this required WACC estimation process as well as the results based on the unrestricted form of Equation (2). Thus, we develop *two* estimates of WACC via Equation (2), an ex post required return (using the restricted equation) and an ex post realized return (based on the unrestricted equation).

Given (2), we can gather the relevant time series of accounting data for a set of companies and estimate the $WACC_i$ and EVA_i parameters. However, we must verify whether or not these estimates are realistic by comparing our WACC figures to WACC estimates derived from the conventional cost of capital approach. In the ideal case, our approach would be of great use to analysts and managers if it could generate reasonably accurate WACC estimates but without the need for subjective judgments and time-consuming data collection required by the conventional method. Thus, we can identify another set of WACC estimates using the conventional approach and then compare these estimates with the WACC figures derived from (2).

III. Data and Empirical Methodology

A. Data

The data used to estimate Equation (2) were obtained from the Standard & Poor's *Compustat* database. We use quarterly data for 1990-2004 to compute NOPAT and TOTAL CAPITAL for 58 U.S. industries (based on the primary two-digit SIC designations of individual firms).[18] The NOPAT and TOTAL CAPITAL figures for each company within an industry are summed to obtain quarterly industry-wide estimates of NOPAT and TOTAL CAPITAL.[19] We then use these data to estimate industry-specific WACCs for three time periods (1990-1997, 1998-2004, and 1990-2004). To create annual estimates of WACC and EVA®, we form four-quarter moving sums of the NOPAT variable.[20] In this way, the slope and intercept terms of (2) can be directly interpreted as annual estimates of the relevant industry's WACC and EVA®.[21] This approach also

[18] See Appendix A for the Standard Industry Classification (SIC) definitions of the 58 industries.

[19] To reduce survivorship bias, we do not require each company to have data for all years in the sample. A firm's data are included as long as it has data for any quarter during January 1990 – December 2004.

[20] According to the EVA® proponents at Stern Stewart and Co., there are numerous alternative definitions of NOPAT that can be used. Yook (1999) attempts to estimate NOPAT and TOTAL CAPITAL using five of the most common adjustments recommended by Stern Stewart and Co. We find a very high correlation between our simple definitions of NOPAT and TOTAL CAPITAL noted earlier and those computed using Yook's method. For example, our simple definitions of NOPAT and TOTAL CAPITAL have statistically significant correlations of 0.94 and 0.86 with Yook's method of calculating these variables.

[21] It should be noted that some of our WACC and EVA® estimates could be biased *downward* if there are numerous small, young firms within an industry. This type of firm typically has low or negative NOPAT yet can have relatively high levels of TOTAL CAPITAL. This problem is mitigated by the fact that we use 2-

has the advantage of smoothing out some of the quarter-to-quarter volatility present in NOPAT, thus reducing the potential distortionary effects of cyclical/seasonal variations in NOPAT.

To develop a benchmark WACC estimate for each industry to compare with our estimates, we use the annual editions of the Ibbotson Associates' *Cost of Capital Quarterly* (CCQ) starting with the inception of this publication in 1995. This source provides five different estimates of WACC for the 58 two-digit SIC industries employed in our analysis. The CCQ estimates are all calculated using the textbook approach described earlier on annual basis during 1995-2004. The five WACC estimates correspond to different methods of estimating an industry's cost of equity capital.[22] For example, CCQ publishes WACC estimates based on the conventional CAPM, a "size-adjusted" CAPM, Fama and French's (1993) three-factor model, as well as two estimates based on discounted cash flow techniques (see Ibbotson Associates, 1999, or their web site, www.ibbotson.com for more details on these estimation methods).[23]

The firms included in our 58 industry estimates are matched with the firms included in Ibbotson's CCQ reports on an annual basis. We then form 10-year averages of these annual WACC estimates for the 1995-2004 period and across Ibbotson's five estimation methods. As noted earlier, firms are allowed to enter and leave the industry groups over our sample's time horizon, thus minimizing potential survivorship bias. The above matching procedure yields a total of 3,653 companies across the 58 industries. However, our sample is limited to publicly traded firms and therefore our results are not directly applicable to privately held companies that might operate in these industries.

B. Empirical Methodology

B. 1) Estimating the Cost of Capital

To estimate Equation (2), we first use quarterly *Compustat* data for 1990-2004 for each company within a two-digit SIC industry to compute aggregate, industry-wide values for NOPAT and TOTAL CAPITAL. Therefore, we have 58 quarterly values for these two variables for each of

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digit SIC codes (rather than 3- or 4-digit SICs) and thus our industry categories are rather broad and contain, on average, over 60 firms in each industry group. Thus, the 2-digit SIC groups are much more likely to include a mix of large and medium-sized, established firms rather than be dominated by small, young start-ups.

[22] Similar to our model's WACC estimates, Ibbotson's estimates are value-weighted within each industry to ensure comparability between our method and theirs.

[23] The analysts at Ibbotson Associates also adjust their estimates based on "reality checks". For example, WACC estimates less than the yield on a 20-year U.S. Treasury bond or greater than 100% are omitted altogether.

the 20 quarters that comprise the January, 1990 – December, 2004 time period. In effect, we form 58 time series (one for each industry) where each series comprises 60 quarters of data. We then perform separate regression analyses based on (2) to obtain WACC estimates for each of the 58 industries. These WACC estimates are the 15-year average of marginal WACCs for the relevant industries during the 1990-2004.[24] For corporate managers, this historical estimate can be of use in determining how their firm's WACC compares with its relevant industry.

B. 2) Two Robustness Tests

One way to test the robustness of our model is by re-estimating (2) for sub-periods within the 1990-2004 sample period. For example, we examine required WACCs for each of the 58 industries during an earlier time period (e.g., 1990-1997). We can compare these estimates to the 1998-2004 WACC estimates to see if there are substantial differences over the two time periods. This approach can also be useful for comparing these sub-period estimates to the model's overall 1990-2004 results and to study the dynamics of how WACC estimates change over time.

We have also developed an out-of-sample test of our model's validity by using the following relation to estimate NOPAT quarter-by-quarter via one-quarter-ahead forecasts over the entire 40-quarter 1995-2004 period:

$$NOPAT_{i,t} = \mathrm{EVA}_i + (\mathrm{WACC}_i * TOTAL\ CAPITAL_{i,t-1}) \qquad (3)$$

Where the right-hand-side estimates of EVA_i and WACC_i are based on an "expanding" data set using 1990-1994 quarterly data for the i-th industry as the starting point. We then use *actual* quarterly data for *TOTAL CAPITAL* during the 1995-2004 period to estimate *NOPAT* for each quarter (and each industry) of this out-of-sample period.[25] For example, we use the actual *TOTAL CAPITAL* at the end of the fourth quarter of 1994, along with our model's parameter estimates for EVA_i and WACC_i (estimated using data for 1990 Q1 – 1994 Q4), to forecast *NOPAT* for the first quarter of 1995. (We can use the actual *TOTAL CAPITAL* level for the previous quarter because the above relation specifies that *TOTAL CAPITAL* is lagged one quarter.) We then use the actual *TOTAL CAPITAL* for the first quarter of 1995 (along with the *updated* parameter estimates for EVA_i and WACC_i based on the expanded data set for the 1990 Q1 – 1995 Q1 period) to forecast *NOPAT* for the second quarter of 1995, and so on. We can compare these forecasts of *NOPAT* with the

[24] As described in the previous section, we can re-estimate (2) a second time without an intercept term in order to derive estimates of the Required WACC.

[25] This forecasting approach is most likely to mimic the method a practitioner would use to assess our model's effectiveness using real-world data.

actual values of *NOPAT* to compute the statistics reported later in Table 4 of the Empirical Results section.[26]

For the Ibbotson WACC estimates, we compute the forecast statistics using the most relevant data available to us (i.e., the annual values of the Average and Median estimates during 1995-2004). Thus, we are stacking the test further *in favor* of Ibbotson's estimates because these estimates are based on data contained *within* the out-of-sample test period of 1995-2004. Given that more up-to-date information is better than less information in terms of generating accurate forecasts, our model's forecasts are at a disadvantage when compared to Ibbotson's.

B. 3) Comparing the Cost of Capital Estimates with Ibboton's Estimates

Once the 1995-2004 WACC estimates are computed according to Equation (2), we can compare them to the Ibbotson CCQ estimates for the corresponding period to determine whether or not our methodology yields estimates that are consistent with those derived via the textbook approach. However, we cannot compare our results to Ibbotson's figures for the full 15-year period because Ibbotson Associates did not begin publishing the CCQ report until 1995. The non-parametric Wilcoxon test can therefore be performed for 1995-2004 in order to make these comparisons (and are reported later in Table 5 of Section IV).

IV. Empirical Results

A. The Cost of Capital Estimates

Before discussing the results of the various tests described in the previous section, it should be noted that diagnostic tests were performed on the two key variables found in Equation (2). Namely, we performed unit root and cointegration tests for each of the 58 industry-specific time series of NOPAT and TOTAL CAPITAL. These tests are based on Phillips and Perron (1988) and Phillips and Ouliaris (1990), respectively. None of the 58 pairs of NOPAT and TOTAL CAPITAL variables are cointegrated or non-stationary.[27] Thus, we can proceed with our tests knowing that these potential econometric problems are not biasing our results.

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[26] Note that in the above process, we re-estimate our model's parameters using additional information contained in the quarterly data within the 1995-2004 period. We also ran a stricter test where the model's parameters are effectively "frozen" at the end of 1994 and are *not* allowed the benefit of, for example, the additional information contained in the first quarter of 1995 to forecast *NOPAT* for the second quarter of 1995, and so on. This latter test is a particularly strict one that works *against* our model's estimates in terms of developing accurate out-of-sample forecasts. Even in this more stringent case, our model out-performs the Ibbotson estimates in terms of generating out-of-sample quarterly forecasts of NOPAT. To conserve space, we do not include these results but are available upon request.

[27] Results are available upon request.

Table 1 provides summary statistics of the industry WACC estimates based on Equation (2) and the textbook approach. This table shows that the average WACC for the entire set of 58 industries during the 1990-2004 time period was 12.04% based on estimating (2) in its unrestricted form (referred to as the *Ex Post WACC*).[28] However, the estimates based on this form are relatively noisy with a large average standard error of 5.03%. This wide variation is consistent with the notion that the estimates are essentially realized return estimates which, by their nature, will typically be more volatile than investors' ex ante returns. Despite the noisiness of the Ex Post WACC figures, the unrestricted form of (2) has the side-benefit of providing an estimate of the average annual EVA® generated by the firms that comprise the 58 industries used in our analysis. As Table 1 reports, the average annual economic value destroyed was -$1.801 billion during 1990-2004. However, this figure is statistically insignificant.

We also show in Table 1 that, based on the restricted form of (2), the average required WACC required by investors was 11.25% (referred to as the *Required WACC* in the table). In effect, this is the return that would have set the average EVA® equal to zero during the 1990-2004 period for our sample of 58 industries. Despite the Required WACC's more precise parameter estimates (e.g., a standard deviation of 3.2% versus 5.03% for the Ex Post WACC), the WACCs themselves exhibit considerable cross-sectional dispersion. Figure 1 plots the distribution of Required WACC estimates for our sample. This graph shows substantial variation in WACCs across industries, with most estimates clustered between 8% and 18%.

Table 1 also reports the median and average Ibbotson WACC estimates for the aggregate set of five estimation techniques (referred to as *Ibbotson Average* and *Ibbotson Median* in the table) as well as the median and average WACC estimates for each of the five asset pricing approaches (referred to as: *CAPM* for the WACC estimates based on equity capital estimates derived from the Capital Asset Pricing Model, *Adjusted CAPM* for the size-adjusted CAPM, *Fama-French* for the 3-factor Fama-French model, *Discounted CF* for the 1-stage discounted cash flow model, and *3-Stage DCF* for the 3-stage discounted cash flow model).

Although there is some modest variation in the Ibbotson models' WACC estimates, their dispersion is noticeably smaller than that reported for estimates based on Equation (2). For example, the Ibbotson average of all five techniques is 12.56% with a standard deviation of 1.58% (the median estimates are quite similar to the average with values of 12.49% and 1.23%,

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[28] We refer to the unrestricted form's WACC estimate as the "Ex Post WACC" because this estimate is based on realized values of NOPAT and TOTAL CAPITAL and therefore represents an estimate of the actual cost of capital realized by investors rather than a "required" return on invested capital.

respectively). These estimates are somewhat higher than our model's estimates as well as those reported in other studies (e.g., 10.7-11.8% in Fama and French, 1999, and 8-9% in Poterba, 1998). As Figure 1 demonstrates, the Ibbotson estimates are also more tightly clustered between 10% and 16% than our model's estimates, which range more widely between 6% and 20%. This result might be due to the "reality checks" performed by Ibbotson Associates to remove high and low WACC estimates from their reports. It is possible the less-disperse results shown in Figure 1 are due also to analysts' conservatism and subjectivity when estimating the components of WACC via the conventional textbook method.

Table 2 displays various WACC estimates and their standard errors for each of the 58 industries. The first six columns of results contain estimates based on the restricted and unrestricted forms of (2), while columns 7-10 show the average and median Ibbotson estimates. Columns 3 and 6 report the adjusted "raw" R^2 statistics for the two forms of our model. The final two columns of Table 2 present the EVA® estimates and their standard errors based on the unrestricted form of (2). The average and standard deviation for each column is presented at the bottom of the table to summarize the results across all 58 industries.

What is most striking about Table 2 are the relatively low standard errors and high explanatory power of the Required WACC estimates. For example, the Required WACC standard errors are comparable in magnitude to those reported for the Ibbotson estimates (0.56% versus 0.38-0.45%).[29] The average *t*-statistic for these parameter estimates is also quite large at 25.40 when compared to the average *t*-statistics for the Ex Post WACC (3.92) estimates. Further, the average level of the Required WACC estimates are consistent with those published in other studies such as Fama and French (1999) and Poterba (1998). However, the standard errors for the Required WACC estimates are quite small when compared to the estimates reported in Fama and French (1999). For example, Table 2 shows that the 0.56% average standard error of the Required WACC provides a much tighter confidence interval compared to Fama-French's (1999) standard errors of 1.67-2.21%. In addition, the explanatory power of our model, measured by what Aigner (1971) calls "raw" R^2, is remarkably good.[30] Table 2 indicates that the average adjusted R^2 for the restricted form of (2) is

[29] The standard errors reported for the Ibbotson estimates are probably *under*-estimated because these standard errors are based on five different WACC estimates that have standard errors themselves. However, Ibbotson does not publish the standard errors for each of the five WACC estimates. In addition, as noted earlier, Ibbotson analysts will omit unusually high or low WACC estimates in their "reality checks", thus further exacerbating the under-estimation of standard errors.

[30] When the intercept is suppressed, the regular definition of R^2 ($\sum(\hat{y}-\bar{\hat{y}})^2/\sum(y-\bar{y})^2$) loses its interpretation as a measure of the explained variance of the dependent variable. However, Aigner (1971) shows that the "raw" R^2 (defined as $\sum \hat{y}^2/\sum y^2$) *does* represent the proportion of the dependent

.8966 while the unrestricted form's average adjusted R^2 is .7759. Thus, our method appears to provide a more precise set of WACC estimates when compared to other academic studies.

Overall, the table indicates that our model's WACC estimates are generally lower and more widely dispersed than the Ibbotson estimates. For example, the average difference between the Required WACC and Ibbotson estimates is 1.24-1.31% (and is statistically significant at the 1% level according to a conventional *t*-test). In addition, an inspection of the industry-specific WACC estimates suggests the average figures might be masking greater variation at the industry/SIC level, which we will examine in more detail later in Section IV. C.

B. The Results of the Robustness Tests

We continue our investigation of the model described in Equation (2) by performing our first robustness test based on industry data for 1990-2004. Table 3 displays the Required WACC estimates for the 58 industries based on three time periods (1990-1997, 1998-2004, and the full 15-year period, 1990-2004). The results show that the average Required WACC is lower during 1990-1997 (10.16% versus 11.55% for 1995-2004) but this difference is not significant at the 1% level. In addition, the variability in WACC estimates is higher for the second sub-period (2.9% vs. 3.8%).[31] Further, a paired *t*-test confirms that the two sets of WACC estimates are not statistically different from each other at the 1% level (not reported here to conserve space). Thus, the earlier period's results replicate those obtained for 1998-2004 and suggest that our model's findings are not a statistical artifact of a specific sub-sample. Lastly, the WACC estimates for the full 15-year period yield a similar average cost of capital figure of 11.25%.

The estimates presented in Table 3 also indicate that industry-specific WACCs might vary over time in a predictable fashion. For example, WACCs might exhibit mean-reverting behavior similar to that observed by Blume (1975) for empirical estimates of market betas. Thus, we run a Blume-type cross-sectional regression of the 1998-2004 WACCs on the 1990-1997 WACC estimates to determine whether or not the earlier period's estimates can explain the future period's cost of capital. To conserve space, we report the results of this regression at the bottom of Table 3. The statistically significant slope parameter estimate of 0.248 is consistent with the hypothesis that our WACC estimates exhibit mean-reverting behavior because this parameter, as in Blume (1975),

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variable's variance that is explained by the model. Consequently, we report the raw R^2 statistics for the restricted and unrestricted forms of (2) in order to present a proper comparison of the two forms of the model. We adjust these statistics for degrees of freedom to create adjusted raw R^2 statistics.

[31] Interestingly, the EVA estimate for 1990-1997 of –\$1.70 billion is similar in magnitude to the 1998-2004 EVA estimate of -\$1.86 billion. However, the 1998-2004 EVA figure is effectively zero because this parameter estimate is not statistically significant.

is significantly lower than 1.0. Overall, the robustness tests reported in Table 3 provide further evidence of the validity of our model. In addition, the tests have identified mean-reverting, predictable variations in the cost of capital over time. This information, coupled with the technique described by (2), might be able to help practitioners develop more accurate ex ante forecasts of a firm's or industry's cost of capital.

For our second robustness test, we report in Table 4 the out-of-sample forecasting ability of our model in terms of predicting future industry profitability, as measured by quarter-by-quarter values of NOPAT. Table 4 reports the root mean squared error (RMSE), mean absolute error (MAE), Theil's U-statistic (U), along with four other measures of forecast reliability suggested by Theil (the R^2, UM, UR, and UD statistics of the model's forecasts). Ideally, we would like to see values close to zero for all of these measures except the R^2 and UD statistics (which are ideally close to 1).[32] These seven standard measures of forecast accuracy are presented for four sets of WACC estimates. In panel A of Table 4, the first two rows of the table display the forecast statistics based on our model using the restricted and unrestricted forms, respectively. The next two rows of Panel A of Table 4 show the forecast statistics based on using Ibbotson's annual Average and Median WACC estimates during 1995-2004, respectively. Panel B repeats the same rows as in panel A in order to report the percentage improvements in the forecast statistics when our restricted model's WACC estimates are used to forecast NOPAT for the 1995-2004 period. For example, the RMSE of the restricted model's estimates are typically between 4% and 8% smaller than those reported for the Ibbotson forecasts.

Despite the aforementioned advantage Ibbotson's estimates have in this out-of-sample test, we find that our restricted, or "required", WACC model's estimates of NOPAT are moderately better than Ibbotson's estimates across all measures of forecast accuracy. In addition to the restricted model's lower RMSE forecast errors, the other forecast statistics such as the MAE and Theil's U-statistic show similar (and many times, greater) levels of improvement in panel B of the table. Interestingly, the UM statistic indicates that our restricted model's systematic bias is virtually negligible (0.01-0.02 in Panel A). This lack of bias confirms our earlier claim that the Required

[32] Theil's (1971) method showed that any model's RMSE can be decomposed into three components (UM, UR, and UD) that sum to 1. The UM statistic indicates the percentage of the RMSE that is associated with any systematic bias in the mean of the quarterly NOPAT forecasts. The UR and UD figures represent the model's ability to replicate NOPAT's actual variability around the mean and the model's random error, respectively. As noted above, a "good" model is one where UM and UD are near zero (indicating no systematic bias and an exact replication of NOPAT's variability around its mean) and UR is near one (suggesting that all forecast errors are simply caused by random fluctuations). The R^2 statistic suggested by Theil is based on a regression of actual and forecasted values of NOPAT and, ideally, should be equal to 1 in order to show that the model's forecasts closely fit the actual out-of-sample data.

WACC estimates can be interpreted as WACC estimates based on a rational expectations framework. Interestingly, our unrestricted model's NOPAT forecasts perform better than our restricted model's forecasts. In sum, Table 4's results in favor of our method provide further evidence that both of our models can be useful in terms of developing out-of-sample forecasts and generating more accurate estimates than Ibbotson's conventional approach.

C. Cross-Sectional Comparisons of the Model's and Ibbotson's Cost of Capital Estimates

Despite Table 2's confirmation that the average estimates of Equation (2) and Ibbotson's CCQ report are relatively close, we still find that less than half of the industry-specific Required WACC estimates are within +/- 200 basis points of either Ibbotson's average estimates (i.e., 23 estimates or 40% of the total). Thus, there appear to be a significant number of large deviations between our model's and Ibbotson's industry-specific estimates. Table 5 confirms this observation by reporting the results of non-parametric Wilcoxon tests comparing the Required WACC industry estimates with the average and median Ibbotson figures. Both tests indicate that the industry-specific WACC estimates are significantly different at the 1% confidence level.

In sum, Tables 3-5 report several results that support our inference that the restricted form of Equation (2) can generate WACC estimates that are robust, unbiased, and can provide better out-of-sample forecasting of NOPAT than estimates derived from the conventional textbook approach. Since we do not observe the "true" WACC for the industries in our sample, we cannot be certain that our model presents a more accurate picture of real-world cost of capital figures. However, the indirect evidence reported here indicates that Equation (2) can provide statistically significant and economically reliable WACC estimates.

V. Conclusion

We present a model that can provide estimates of an industry's weighted average cost of capital (WACC) in a simple, parsimonious, less-subjective (and potentially more accurate) fashion than the conventional textbook approach. This new method can be used to complement or supplement the textbook approach to estimating the cost of capital. The tests presented here indicate that our economic profit-based approach summarized by Equation (2) provides estimates of industry-level WACCs for the 1990-2004 period that are robust to different time periods and yield better out-of-sample forecasts of an industry's future profitability than the conventional WACC estimates published by Ibbotson Associates. Our WACC estimates exhibit mean-reverting behavior over time similar to the dynamics in market betas observed by Blume (1975) and thus provide a potential means for using our model to develop out-of-sample, forward-looking WACC estimates.

It should be noted that follow-on research related to this topic is feasible in at least three areas. First, additional cross-sectional tests *within* an industry would be helpful to develop shorter-term industry-specific WACC estimates. For example, one can estimate our model for one industry on a cross-sectional basis at a point in time (e.g., during one quarter or one year). A weighted least squares approach (with the weights equal to the relative size of each firm within the industry) might be preferable for these tests.

Second, there are potentially several straightforward applications of our model to event studies in corporate finance and market microstructure. For example, one can study the impact of a change in capital structure or dividend policy on the firm's cost of capital and economic profit in a more direct way because Equation (2) provides a method for estimating a firm's WACC for both the pre- and post-event periods. In addition, a change in the microstructure of a securities exchange might enhance liquidity that, in turn, could lower the liquidity premium associated with a firm's securities. This effect can be measured by estimating the firm's WACC before and after the microstructure change (and, obviously, controlling for other potential confounding factors).

Third, asset pricing tests might also benefit from our proposed methodology because, in theory, one could infer the implied cost of equity capital from our WACC estimates if the researcher had a reasonably good estimate of the firm's capital structure and the costs of debt/preferred stock. This would enable the analyst to identify the cost of equity capital without having to specify an explicit asset pricing model.

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Appendix A. **(The SIC Code is followed by the Industry Title)**

01	Agriculture Production Crops
10	Metal Mining
13	Oil and Gas Extraction
15	Building Construction-General Contractors and Operative Builders
16	Heavy Construction Other Than Building Construction-Contractors
17	Construction-Special Trade Contractors
20	Food and Kindred Spirits
22	Textile Mill Products
23	Apparel and Other Finished Products Made from Fabrics
24	Lumber and Wood Products, Except Furniture
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing, Publishing, and Allied Industries
28	Chemicals and Allied Products
29	Petroleum Refining and Related Industries
30	Rubber and Miscellaneous Plastic Products
31	Leather and Leather Products
32	Stone, Clay, Glass, and Concrete Products
33	Primarily Metal Industries
34	Fabricated Metal Products, Except Machinery and Transportation Equipment
35	Industrial and Commercial Machinery and Computer Equipment
36	Electronic and Other Electrical Equipment
37	Transportation Equipment
38	Measuring, Analyzing and Controlling Equipment
39	Miscellaneous Manufacturing Industries
40	Railroad Transportation
42	Motor Freight Transportation and Warehousing
44	Water Transportation
45	Transportation by Air
47	Transportation Services
48	Communications
49	Electric, Gas, and Sanitary Services
50	Wholesale Trade-Durable Goods
51	Wholesale Trade-Nondurable Goods
52	Building Materials, Hardware, Garden Supply and Mobile Home Dealers
53	General Merchandise Stores
54	Food Stores
55	Automotive Dealers and Gasoline Service Stations
56	Apparel and Accessories Stores
57	Home Furniture, Furnishings, and Equipment Stores
58	Eating and Drinking Places
59	Miscellaneous Retail
60	Depository Institutions
61	Non-depository Credit Institutions
62	Security and Commodity Brokers, Dealers, Exchanges, and Services
63	Insurance Carriers
64	Insurance Agents, Brokers, and Service
65	Real Estate
67	Holding and Other Investment Offices
70	Hotels, Rooming Houses, and Other Lodging Places
72	Personal Services
73	Business Services (including Software Development)
75	Automotive Repair, Services and Parking
78	Motion Pictures
79	Amusement and Recreation Services
80	Health Services
82	Educational Services
87	Engineering, Accounting, Research, Management, and Related Services

Appendix B. Additional Data Definitions for Variables used in the Model

In addition to the data definitions described in Section II, we define Taxes as the difference between Pretax Income (Q23) and Net Income (Q69). For simplicity, we follow the typical financial convention and assume that this flow variable is received at one point in time (i.e., at time-*t*) even though, in reality, NOPAT is most likely generated over the entire period between time-*t-1* and time-*t*. As Stewart (1991) discusses, adjustments to the NOPAT definition can be used to tailor the NOPAT figure to a specific firm or industry.

In our analysis, Depreciation Expense is not added back to EBIT to obtain NOPAT. This is because depreciation is viewed as a true economic cost that represents the amount of money that the firm must spend to maintain its existing set of assets. See Peterson and Peterson (1996) and Stewart (1991) for a detailed discussion of how to estimate NOPAT, as well as TOTAL CAPITAL. Depending on the company, Peterson and Peterson note that numerous adjustments can be made to the basic NOPAT formula. In our case, data on most of these adjustments are not available on a quarterly basis. Consequently, we focus our analysis on the basic definition of NOPAT.

The TOTAL CAPITAL variable is lagged one period in Equation (1) to avoid counting the current portion of Retained Earnings as part of the firm's capital at the beginning of the current period. The quarterly Compustat data items used for long-term debt, preferred stock, and common equity are Q51, Q55, and Q59, respectively.

We do not include short-term debt (Q45) in our specification because many textbooks, as well as most practitioners, focus on the long-term sources of corporate financing (long-term debt, preferred stock, common stock) when estimating a firm's cost of capital. For example, Gitman and Vandenberg (2000) find in a survey of large U.S. firms that most practitioners focus on the long-term debt and common equity components of the capital structure when estimating their firms' respective WACC.

Table 1. Descriptive Statistics (1990-2004)

The table displays summary statistics for the 58-industry cross-section of cost of capital estimates and selected financial variables, NOPAT, EVA, and Total Capital, based on Equation (2) during 1990-2004.

	Cost of Capital Estimates				
Variable	N	Mean	Std. Dev.	Minimum	Maximum
Required WACC	58	11.25	3.21	6.81	20.26
Ex Post WACC	58	12.04	5.03	3.70	29.74
NOPAT ($ Mil.)	3,389	13,390.5	35,747.9	-22,486.7	375,834.5
Total Capital ($ Mil.)	3,389	131,964.6	328,689.0	167.8	3,016,712.2
EVA ($ Mil.)	58	-1,801.2	7,892.6	-46,746.1	6,477.3
Ibbotson Average	58	12.56	1.58	8.60	15.63
Ibbotson Median	58	12.49	1.23	8.56	15.56
Median CAPM	58	10.66	1.18	7.79	13.65
Median Adjusted CAPM	58	12.07	1.35	8.49	15.78
Median Fama-French	58	13.37	1.61	8.90	16.76
Median Discounted CF	58	13.83	2.23	8.58	19.43
Median 3-Stage DCF	57	12.58	1.36	9.36	17.43
Average CAPM	58	11.59	1.63	8.05	16.25
Average Adjusted CAPM	58	12.23	1.77	7.96	16.71
Average Fama-French	58	13.33	2.28	9.20	18.62
Average Discounted CF	58	14.07	3.07	8.16	21.28
Average 3-Stage DCF	56	11.27	1.47	7.74	16.00
Adjusted R^2 - Required WACC	58	0.8966	0.1006	0.4956	0.9934
Adjusted R^2 – Ex Post WACC	58	0.7759	0.2083	0.1211	0.9891

Table 2. Industry-Specific Cost of Capital Estimates (1990 – 2004)

The column labeled, *Required WACC*, contains cost of capital estimates for 58 industries (referred to as *SIC* in the table) based on the restricted form of Equation (2). The columns labeled, *S.E.* and *Adj.* R^2, report the standard error of the corresponding WACC estimate and the regression equation's adjusted coefficient of determination, respectively. The column labeled, *Ex Post WACC*, reports cost of capital estimates based on the unrestricted form of Equation (2). The intercept from this model's regression is reported below in the column labeled *EVA*. The WACC estimates based on the average and median of Ibbotson Associates' five cost of capital estimation techniques are reported in the columns labeled, *Ibbotson Average* and *Ibbotson Median*. Summary statistics are presented at the bottom of the table (*Average* and *Std. Dev.*). *No. of Firms* denotes the average number of firms used to estimate the *Required* and *Ex Post WACC* figures.

SIC	No. of Firms	Required WACC	S.E.	Adj. R^2	Ex Post WACC	S.E.	Adj. R^2	Ibbotson Average	S.E.	Ibbotson Median	S.E.	EVA	S.E.
1	9	9.61	0.360	0.9476	5.18	1.340	0.1211	11.26	0.380	11.79	0.422	217.4	62.7
10	16	11.89	0.988	0.8038	18.01	3.000	0.7399	12.89	0.547	13.96	0.759	-968.1	420.3
13	118	10.35	0.905	0.8939	12.68	1.140	0.8238	13.07	0.553	12.80	0.425	-2368.3	490.0
15	24	11.59	0.613	0.9404	15.40	0.602	0.9488	13.29	0.538	12.03	0.408	-991.8	101.6
16	10	9.48	0.433	0.7373	8.36	2.300	0.5083	13.86	0.488	12.99	0.471	46.5	97.9
17	7	7.83	0.576	0.9221	7.47	0.689	0.8718	12.86	0.457	11.93	0.336	4.9	5.1
20	83	17.06	0.890	0.9023	22.29	2.350	0.7884	11.15	0.484	11.06	0.360	-4848.4	1725.7
22	26	9.47	0.256	0.9515	6.38	1.530	0.3674	12.10	0.288	11.81	0.359	336.4	161.8
23	35	13.04	0.499	0.8432	19.23	2.940	0.7137	13.64	0.387	12.70	0.309	-593.8	253.8
24	17	10.00	0.736	0.8523	9.13	1.170	0.7511	14.00	0.278	13.83	0.509	86.6	89.1
25	21	16.82	0.351	0.9796	18.23	0.649	0.9559	13.60	0.315	13.22	0.268	-264.2	102.7
26	32	10.24	0.428	0.9666	11.26	0.645	0.9340	11.24	0.244	11.52	0.284	-680.6	303.8
27	48	11.31	0.502	0.9473	9.20	0.749	0.8338	12.01	0.410	11.99	0.359	1041.9	266.3
28	253	17.27	0.285	0.9888	18.15	0.479	0.9728	11.89	0.395	13.39	0.326	-3942.3	1319.3
29	18	20.19	1.570	0.8493	29.74	2.670	0.8186	10.11	0.283	10.99	0.267	-30577.7	4112.7
30	42	12.68	0.567	0.9243	12.59	1.260	0.7555	13.16	0.420	12.37	0.304	17.3	204.3
31	14	9.83	0.688	0.5625	10.14	3.060	0.3213	14.64	0.524	13.50	0.521	-5.1	49.2
32	16	15.83	0.986	0.8862	18.11	1.990	0.7800	12.56	0.529	12.47	0.367	-253.3	184.8
33	49	9.14	0.816	0.7202	8.87	2.180	0.5106	13.54	0.284	13.36	0.213	84.7	620.3
34	46	13.91	0.371	0.9657	16.22	1.130	0.8617	12.10	0.400	12.59	0.413	-452.9	191.1
35	228	10.44	0.569	0.8953	9.21	1.280	0.7186	14.69	0.590	14.53	0.319	1746.7	1613.2
36	259	10.47	0.892	0.7195	6.72	1.650	0.4880	15.63	0.509	15.56	0.251	5011.0	1634.4
37	62	7.97	0.570	0.8355	8.69	1.710	0.5542	9.98	0.291	12.18	0.188	-3225.9	7035.3
38	232	11.65	0.370	0.9701	11.31	0.707	0.9079	12.48	0.193	13.99	0.329	273.8	480.3
39	37	14.02	0.415	0.9597	16.65	1.270	0.8912	12.79	0.508	12.28	0.312	-192.0	86.3

Table 2. Industry-Specific WACC Estimates (continued)

SIC	No. of Firms	Required WACC	S.E.	Adj. R^2	Ex Post WACC	S.E.	Adj. R^2	Ibbotson Average	S.E.	Ibbotson Median	S.E.	EVA	S.E.
40	9	7.93	0.081	0.9856	7.47	0.178	0.9563	10.78	0.432	11.35	0.386	485.9	172.3
42	27	20.26	1.320	0.9025	21.90	1.420	0.8515	13.05	0.273	12.16	0.269	-403.7	61.1
44	10	9.23	0.560	0.9356	10.58	0.971	0.9035	14.24	0.487	12.89	0.613	-158.4	88.1
45	24	8.40	0.754	0.8471	3.70	1.680	0.2799	12.27	0.234	13.33	0.365	3261.6	3,261.6
47	7	8.16	0.225	0.9861	7.09	0.182	0.9678	13.46	1.016	13.13	0.511	50.9	15.1
48	70	8.06	0.477	0.8800	6.49	0.800	0.7655	11.22	0.319	11.94	0.277	6477.3	2368.7
49	149	8.93	0.142	0.9934	9.61	0.231	0.9848	8.60	0.300	8.56	0.300	-5411.4	1332.0
50	97	8.55	0.362	0.4956	9.97	3.080	0.2622	13.04	0.346	12.56	0.262	-277.2	600.3
51	51	9.88	0.298	0.7760	10.60	2.290	0.4828	11.34	0.290	11.82	0.240	-170.5	536.2
52	10	16.24	0.386	0.9904	18.28	0.406	0.9891	14.59	0.389	13.13	0.442	-395.3	50.8
53	24	11.30	0.210	0.9851	13.71	0.681	0.9049	12.53	0.316	11.87	0.429	-3071.5	820.8
54	24	12.61	0.423	0.8893	8.46	1.330	0.6273	10.20	0.283	10.71	0.274	1378.1	386.6
55	12	12.34	0.327	0.9856	13.05	0.431	0.9734	13.69	0.662	11.97	0.247	-49.6	18.8
56	36	15.18	0.619	0.9544	16.70	1.150	0.8354	14.73	0.432	14.34	0.411	-275.7	159.4
57	18	11.96	0.510	0.9507	15.27	0.910	0.9026	15.01	0.673	13.70	0.565	-361.3	65.3
58	66	13.45	0.307	0.9695	16.92	0.884	0.9211	12.22	0.470	12.00	0.362	-823.3	183.3
59	63	8.72	0.507	0.8401	10.51	1.670	0.6423	12.80	0.265	12.92	0.241	-367.2	329.1
60	383	11.03	0.508	0.9319	13.45	0.506	0.9117	9.64	0.394	9.81	0.400	-46746.1	7630.1
61	32	10.68	0.593	0.9467	11.03	0.640	0.9119	9.93	0.662	10.52	0.560	-5277.0	2524.9
62	45	11.45	1.140	0.8150	14.99	1.370	0.6566	10.16	0.765	13.29	0.423	-19286.3	3838.2
63	96	9.36	0.591	0.9207	8.78	0.603	0.8452	11.82	0.475	12.40	0.448	3555.7	1627.4
64	19	16.59	0.322	0.9917	16.39	0.478	0.9865	13.38	0.505	12.57	0.645	6.1	10.3
65	32	6.88	0.304	0.9415	11.00	0.425	0.9633	11.13	0.572	10.65	0.446	-379.6	53.9
67	74	7.99	0.185	0.9915	8.07	0.207	0.9857	9.99	0.474	11.25	0.403	-102.3	109.3
70	13	6.87	0.326	0.9557	6.68	0.403	0.9216	13.15	0.574	12.16	0.361	24.7	31.4
72	7	11.93	0.565	0.9323	10.55	0.822	0.8898	13.07	0.641	13.18	0.558	26.0	9.8
73	300	9.51	1.150	0.7982	6.19	1.950	0.6457	15.33	0.450	14.99	0.266	4812.5	1590.7

Table 2. Industry-Specific WACC Estimates (continued)

SIC	No. of Firms	Required WACC	S.E.	Adj. R^2	Ex Post WACC	S.E.	Adj. R^2	Ibbotson Average	S.E.	Ibbotson Median	S.E.	EVA	S.E.
75	7	6.81	0.430	0.9169	5.48	0.618	0.8140	10.99	0.519	11.45	0.548	142.6	43.1
78	22	7.70	0.712	0.8163	8.08	2.390	0.7748	13.56	0.516	13.31	0.401	-8.5	44.4
79	36	8.25	0.165	0.9918	8.18	0.203	0.9838	13.80	0.790	12.85	0.400	24.2	38.5
80	69	10.36	0.465	0.9448	12.34	0.718	0.8471	12.35	0.451	12.38	0.299	-548.6	164.9
82	8	12.80	1.580	0.8441	15.53	1.890	0.7834	14.04	0.421	12.84	0.403	-25.7	9.8
87	58	10.76	0.682	0.9323	12.26	0.876	0.8905	13.94	0.484	13.71	0.357	-79.0	23.4
Average		**11.25**	**0.560**	**0.8966**	**12.04**	**1.220**	**0.7759**	**12.56**	**0.450**	**12.49**	**0.380**	**-1,801.2**	**858.8**
Std. Dev.		**3.21**	**0.325**	**0.1006**	**5.03**	**0.807**	**0.2083**	**1.58**	**0.150**	**1.23**	**0.120**	**7,892.9**	**1563.4**

Table 3. Required WACC Estimates

The WACC estimates based on the restricted form of Equation (2) for three time periods, and related summary statistics, are presented below. At the bottom of the table, a Blume-style (1975) cross-sectional regression is presented using the 1998-2004 WACC estimates reported below as the dependent variable and the 1990-1997 WACC estimates as the independent variable. Parameter estimates and *t*-statistics displayed in bold face are statistically significant at the .01 level.

SIC	1990-97 WACC	1998-04 WACC	1990-04 WACC	SIC	1990-97 WACC	1998-04 WACC	1990-04 WACC
1	**8.23**	**10.30**	**9.61**	47	**8.38**	**7.49**	**8.17**
10	**8.72**	**12.99**	**11.89**	48	**8.40**	**7.60**	**8.06**
13	**6.14**	**11.71**	**10.35**	49	**8.50**	**9.15**	**8.93**
15	**5.33**	**12.72**	**11.59**	50	**9.52**	**7.05**	**8.55**
16	**8.99**	**10.39**	**9.49**	51	**9.96**	**10.07**	**9.88**
17	**6.93**	**7.74**	**7.83**	52	**12.87**	**16.80**	**16.24**
20	**15.34**	**19.90**	**17.06**	53	**10.40**	**11.78**	**11.30**
22	**8.98**	**9.54**	**9.47**	54	**13.24**	**11.34**	**12.61**
23	**11.45**	**14.60**	**13.04**	55	**12.15**	**12.63**	**12.34**
24	**10.44**	**9.65**	**10.00**	56	**12.39**	**16.04**	**15.18**
25	**11.30**	**17.07**	**16.82**	57	**8.31**	**13.02**	**11.96**
26	**8.45**	**10.50**	**10.24**	58	**12.88**	**14.17**	**13.45**
27	**13.74**	**10.58**	**11.31**	59	**9.33**	**8.47**	**8.72**
28	**15.44**	**17.42**	**17.27**	60	**5.74**	**12.05**	**11.03**
29	**7.62**	**23.06**	**20.19**	61	**6.24**	**10.72**	**10.68**
30	**14.44**	**12.24**	**12.68**	62	**6.87**	**13.52**	**11.45**
31	**8.70**	**11.59**	**9.83**	63	**8.91**	**8.78**	**9.36**
32	**12.29**	**18.25**	**15.83**	64	**18.41**	**16.20**	**16.59**
33	**11.53**	**7.32**	**9.14**	65	**6.33**	**8.57**	**6.88**
34	**13.83**	**14.73**	**13.91**	67	**7.89**	**8.03**	**7.99**
35	**13.08**	**9.86**	**10.44**	70	**7.53**	**7.04**	**6.87**
36	**13.33**	**8.56**	**10.47**	72	**13.81**	**11.21**	**11.93**
37	**7.76**	**9.16**	**7.97**	73	**15.38**	**7.95**	**9.51**
38	**11.58**	**11.75**	**11.65**	75	**7.87**	**6.24**	**6.81**
39	**14.38**	**14.44**	**14.02**	78	**8.60**	**5.38**	**7.70**
40	**10.12**	**8.00**	**7.93**	79	**9.78**	**8.18**	**8.25**
42	**8.90**	**20.96**	**20.26**	80	**9.79**	**12.34**	**10.36**
44	**5.32**	**10.16**	**9.23**	82	**9.50**	**14.00**	**12.80**
45	**10.29**	**6.87**	**8.40**	87	**7.85**	**12.03**	**10.76**
Average					10.16	11.55	11.25
Std. Deviation					2.93	3.82	3.21
Minimum					5.32	5.38	6.81
Maximum					18.41	23.06	20.26

OLS Regression: *1998-2004 WACC$_i$* = a + b (*1990-1997 WACC$_i$*) + e_i

	Parameter	S.E.	t-statistic		
Constant	**7.304**	1.181	**6.19**	No. Observ.	58
1990-97 WACC	**0.248**	0.097	**2.55**	Adjusted R^2	0.088

Table 4. Out-of-Sample NOPAT Forecasting Ability

Using the WACC estimates based on both the restricted and unrestricted forms of Equation (2), as well as Ibbotson Associates' Average and Median WACC estimates, out-of-sample forecasts of NOPAT are computed via Equation (3) for the 40-quarter period during 1995-2004. From these quarterly NOPAT forecasts, seven measures of forecast accuracy are presented below for the restricted (*Required WACC*) and unrestricted (*Ex Post WACC*) models, as well as for the two sets of Ibbotson estimates (*Ibbotson Average* and *Ibbotson Median*). The seven measures are the forecasts' Root Mean Squared Error (*RMSE*), and Mean Absolute Error (*MAE*), as well as Theil's R^2 statistic (R^2) corresponding to a regression of the actual NOPAT values on the forecasted values of NOPAT for each industry, Theil's U-statistic (*U*), and Theil's decomposition of the RMSE into *UM, UR and UD* in order to measure the unbiasedness of the forecasts. These latter three statistics sum to 1 with *UD* ideally equal to 1 and the remaining two statistics equal to zero. Panel A reports the forecast statistics based on Equation (2). Panels B repeats the same rows as in Panel A in order to report the percentage improvements (positive values) or decreases (negative values) in the forecast statistics when the Required WACC estimates are used to forecast NOPAT.

Forecast Method	RMSE	MAE	R^2	U	UM	UR	UD
Panel A. Conventional Forecasts							
Required WACC	19,733.9	7,779.5	.8807	.308	.01	.01	.98
Ex Post WACC	18,633.2	7,400.1	.8935	.291	.00	.02	.98
Ibbotson Average	20,693.5	8,092.9	.8782	.323	.02	.04	.94
Ibbotson Median	21,333.3	8,168.4	.8706	.333	.02	.04	.94
Panel B. Percentage Improvement of Required WACC via Conventional Forecasts							
Required WACC	--	--	--	--	--	--	--
Ex Post WACC	-5.6	-4.9	-1.5	-5.5	-100.0	100.0	0.0
Ibbotson Average	4.9	4.0	0.3	4.8	100.0	300.0	4.1
Ibbotson Median	8.1	5.0	1.2	8.1	100.0	300.0	4.1

Table 5. Non-Parametric Wilcoxon Tests of the Cost of Capital Estimates

The first two rows of the table report results of a Wilcoxon test of the differences between the Required WACC and Ibbotson Average WACC estimates reported in Table 2. The last two rows of the table report results of a Wilcoxon test of the differences between the Required WACC and Ibbotson Median WACC estimates reported in Table 2. The *z*-statistic and corresponding *p*-value are reported in the last two columns.

Variable	N	Sum of Scores	Expected Sum Under Null	Mean Score	*z*-statistic	*p*-value
Required WACC	58	2719.0	3,393.0	46.879310	-3.7188	0.0002
Ibbotson Average	58	4067.0	3,393.0	70.120690	-	-
Required WACC	58	2683.0	3393.0	46.258621	-3.9176	0.0001
Ibbotson Median	58	4103.0	3393.0	70.741379	-	-

Figure 1. Distribution of Restricted Model and Ibbotson WACC Estimates

This figure plots the distribution of WACC estimates based on the restricted form of Equation (2), as well as the average estimates published by Ibbotson Associates for five different estimation techniques. The distribution is derived from 5-year average Required WACC and Ibbotson average estimates of 58 two-digit SIC industries during 1995-2004.