Accounting for Estimation Risk in CAPM-generated Forecasts of Firm Earnings Growth

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Abstract:

The objective of the present study is twofold: 1) To increase the information content, and thus the accuracy of CAPM-generated forecasts of firm-earnings growth; and 2) To improve the accuracy of the combined CAPM-generated and financial analysts' consensus forecasts of firm-earnings growth.

This dual objective is achieved by modifying the index of systematic risk (beta) in the CAPM to account for estimation risk, represented by the dispersion of financial analysts' forecasts.

The findings indicate that in all three of the test-periods, the CAPM forecasting mechanism employing the modified beta had a lower mean absolute forecast error, than the CAPM forecasting mechanism employing the traditional beta measure. The findings also indicate that in 21 of the 27 possible test cases, the most successful combination-forecast employed the modified beta in the CAPM forecasting mechanism. (In only 2 of the 27 possible cases did the most successful combination-forecast employ the traditional beta measure in the CAPM forecasting mechanism.)

Apparently, accounting for estimation risk (as captured by the modified beta) generally leads to better forecasting results by the CAPM forecasting mechanism, and in turn, also by the combining model.

Introduction:

A previous study concerning the Capital Asset Pricing Model (CAPM) has demonstrated two things: 1) There appears to be an independent-information content in the CAPM that financial analysts are not using when forecasting firm-earnings growth; 2) Combining CAPM-generated forecasts with financial analysts' consensus forecasts of firm-earnings growth appears to result in superior forecast accuracy. [i]

The objective of the present study is twofold: 1) To increase the information content and thus the accuracy of CAPM generated forecasts of firm-earnings growth; and 2) To improve the accuracy of the combined CAPM-generated and financial analysts' consensus forecasts of firm-earnings growth. This dual objective is achieved by modifying the index of systematic (beta) in the CAPM to account for estimation risk.

When estimating the CAPM, the traditional or conventional approach in the measurement of beta (an index of systematic risk) has been to use historical security- and market-return information to estimate a security's future level of covariance-of-return with the market portfolio.

However, the traditional index of systematic risk (beta) in the CAPM may be an incomplete proxy for ex ante investor risk, since beta makes no allowance for estimation risk. Specifically, the beta measure makes no allowance for information contained in analysts' forecasts.

Thus, an obvious criticism of the CAPM is that it is backward looking, since practical use of the CAPM requires the use of historical data to estimate expectations of current and future levels of systematic risk.

The present study modifies the CAPM to make it more forward-looking, by accounting for estimation risk.

The current study then investigates if accounting for estimation risk when estimating the CAPM leads to better CAPM-generated forecasts of earnings growth, and thus to more accurate combinations of CAPM-generated and financial analysts' consensus forecasts of firm-earnings growth.

The technique employed is to make an adjustment in the measurement of a firm's beta that incorporates forward-looking information regarding a firm's systematic-volatility of return. Specifically, estimation risk is represented by the dispersion (standard deviation) of financial analysts' forecasts, which has been found over time to be a highly significant and most important explanatory risk variable with respect to security returns and prices.[ii]

In fact some researchers maintain that dispersion of analysts' forecasts may be a more reliable and accurate index of a security's systematic risk, than the traditional beta measure. [iii]

The (consensus) reasoning is that dispersion of analysts' forecasts may indirectly measure the sensitivity of securities to underlying macroeconomic factors (such as movements in the general stock markets, in economic activity, and in the inflation rate). Thus, dispersion of analysts' forecasts may serve as an effective proxy for systematic risk.

Incorporating this forward-looking systematic risk measure into beta estimation enhances the use of the CAPM as a valuation/forecasting model in the present study: The findings indicate that in all three test periods the CAPM-based forecasting model employing the modified beta (accounting for estimation risk) on average outperformed the CAPM-based forecasting model employing the traditional beta. Further, in a large majority (78%) of possible test cases, the most successful combination-forecast technique employed the modified beta in the CAPM forecasting mechanism.

Methodology:

An implicit forecast of the five-year average annual growth rate of earnings-per-share (EPS) for each firm in a given sample is obtained from the CAPM, using a technique introduced by Rozeff (1983) and modified in a later study[iv].

Combinations of financial analysts' consensus forecasts (IBES) and implicit CAPM forecasts of five-year average annual earnings growth (for each firm in a given sample) are then formed, which can be expressed as:

$$F_{ci} = W_A(IBESforecast_i) + W_B(CAPMforecast_i)$$

Combination weights (W_A;W_B) are generated using cross-sectional regressions, thus incorporating information from all firms in a given sample. Actual values are regressed on predicted values of the five-year average annual growth rate of earnings-per-share (EPS), for all firms in a given sample, in the following manner:

$$a_{it} = \alpha + \beta({}_{t\text{-}5}g_{iAt}) + \gamma({}_{t\text{-}5}g_{iBt}) + \mu \qquad \text{EQ1}$$

where,

a_{it} = actual five-year average annual growth rate of EPS of firm i over the 60 months preceding time t ;

${}_{t\text{-}5}g_{iAt}$ = consensus forecast of the five-year average annual EPS growth-rate of firm i, made by financial analysts (Model A) in period t-5, taken from the IBES data-source;

$_{t-5}g_{iBt}$ = forecast of the five-year average annual EPS growth rate of firm i, generated from the CAPM-based forecasting method (Model B), using only information available at time t-5 and using the model's estimation procedure and forecasting method each period;

μ_t = error term;

α = constant term.

The regression model is estimated four ways:
With constrained OLS, alternately with and without a constant, and alternately employing the CAPM-based forecasts that reflect the traditional beta and the modified beta (accounting for estimation risk), respectively. [v]

Each of the four sets of estimated regression coefficients is then alternately used as weights for out-of-sample combination forecasts of five-year average annual EPS growth for each firm in a cross-sectional sample for a given time period.

Combinations are also formed using five different weighted-averages:
.50/.50; .75/.25; .80/.20; .85/.15; .90/.10. The financial analysts' forecasts are ***a priori*** assigned the greater weights in the asymmetric averages, since these forecasts can reasonably be expected to embody a greater informational content than the CAPM-generated forecasts. One set of these simple average forecasts uses the CAPM-based forecasts that employ the traditional beta; the other set employs the modified beta (accounting for estimation risk).

Thus overall, fourteen different combinations are formed for each firm in a given sample, for a given time period.

Deriving $E(R_i)$ from the CAPM and accounting for estimation risk:

The Capital Asset Pricing Model states that, in equilibrium, an individual security's expected return is a linear function of it covariance of return with the market portfolio. This relationship is depicted in ex-ante form by the equation:

$$E(R_i) = R_f + B_i[E(R_m) - R_f] \qquad \text{EQ 2}$$

A firm's expected return, $E(R_i)$, is calculated via the CAPM in the following manner:

First, a characteristic line is generated to manufacture a conventional (traditional) estimate of a firm's index of systematic risk (beta), B_{Ti}. Actual, monthly security returns, $R_{i,t}$, (thirty-day geometric mean) are regressed against actual, monthly market returns, $R_{m,t}$, (thirty-day geometric mean) over the 60-month period prior to a forecast horizon. This regression in equation form is:

$$R_{i,t} = B_{Ti} (R_{m,t}) \qquad \text{EQ 3}$$

The monthly market return, $R_{m,t}$, is a value-weighted measure of the returns of all stocks on the Centre for Research of Security Prices (CRSP) tape, a relatively broad measure of the market portfolio. All returns (firm and market) include both dividends and price changes.

Once a firm's traditional beta (B_{Ti}) is estimated, it is then inserted into equation 2 to solve for the firm's expected rate of return, $E(R_i)$. In equation 2 the risk-free rate, R_f, is taken as the yield-to-maturity on a five-year U.S. government security prevailing at the beginning of a forecast horizon. The data source is Moody's Municipal and Government Manual. The mean market return, $E(R_m)$, is estimated as the average of the monthly market returns over the 60-month period prior to a forecast horizon. This measure is a value-weighted index of all stocks on the CRSP tape.

An earnings growth forecast for firm i is then generated by the CAPM forecasting mechanism, employing the traditional beta.

The traditional beta (B_{Ti}) is then modified with the dispersion (standard-deviation) of analysts' earnings forecasts to form a more forward-looking measure of a firm's ex ante systematic risk, B_{Ni}, as follows[vi]:

$$B_{Ni} = (B_{Ti}^2 + B_{Ei}^2)^{0.5}, \text{ where}$$

B_{Ti} = traditional or conventional beta estimated from a characteristic line based on historical information (as shown in equation 3);

$B_{Ei} = \sigma_{im}(\sigma_a/\sigma_m)$;

σ_{im} = historical correlation coefficient between the return of security i and the return of the market portfolio;

σ_a = standard deviation in analysts' forecasts;

σ_m = historical standard deviation in the return of the market portfolio;

σ_i = historical standard deviation in the return of security i.

σ_{im}, σ_i, and σ_m values are obtained from the conventional beta (B_T) regressions. σ_a is obtained from the IBES data source.

This forward-looking proxy of ex ante systematic risk, B_{Ni}, is then inserted into equation 2 (in place of B_i) to solve for the firm's expected rate of return, $E(R_i)$. An earnings growth forecast for firm i is then generated by the CAPM forecasting mechanism, employing the modified-beta (and thus accounting for estimation risk).

Samples and test procedures:

A. Samples[vii]:

The first in-sample coefficient-estimation period is the five-year period from January 1982 to January 1987. Using only information available prior to January 1982, and employing the CAPM-based forecasting model, a simulated ex-ante forecast of the average annual earnings-per-share (EPS) growth rate over the January 1982 - January 1987 period is made, for each firm in the sample. The actual average annual EPS growth rates over this period are then regressed against financial analysts' (IBES) consensus forecasts and CAPM-generated forecasts for this period, to generate the four sets of regression coefficients to be used as weights for the out-of-sample combination forecasts for each firm in a sample.

The first out-of-sample forecast horizon is the adjacent five-year period from January 1983 to January 1988. For each firm in the sample, employing the CAPM-based forecasting model, a simulated ex-ante forecast for the January 1983 - January 1988 period is then made. For each firm in the sample, combinations of CAPM-generated forecasts and financial analysts' (IBES) consensus forecasts for this period are then formed, using in turn the four different sets of regression coefficients as weights for the combination forecasts.

The four sets of estimated regression coefficients generated from the January 1982 - January 1987 in-sample coefficient-estimation period are also used to manufacture out-of-sample combination forecasts for the five-year period from January 1984 to January 1989; and also for the five-year period from January 1985 to January 1990. Thus, the temporal stability of a given set of forecast weights is tested.

The experiment is replicated twice more: The second coefficient-estimation period is from January 1983 to January 1988, generating four sets of weights for out-of-sample combination forecasts for the adjacent five-year period from January 1984 to January 1989; and also for the five-year period from January 1985 to January 1990.

The third coefficient-estimation period is from January 1984 to January 1989, leading to out-of-sample combination forecasts for the adjacent five-year period from January 1985 to January 1990 (the last year of the available data set).

As explained above the present study also forms combinations using simple averages (equally weighted and asymmetric).

B. Test procedures:

Let

a_i = actual five-year average annual growth rate of earnings per-share (EPS) for firm i ;

and

g_{ij} = forecasted five-year average annual growth rate of EPS for firm i by method j.

In each test period a vector of forecast errors,

$$|a_i - g_{ij}| = e_{ij} \qquad \text{EQ 4}$$

is calculated for each method j. e_{ij} is the absolute value of the difference between the forecasted and realised growth rates. The mean absolute forecast error (MABE), defined as the sample average of $|a_i - g_{ij}|$, is then computed. This measure best reflects the overall forecasting performance of a given forecasting model since it takes into account the average error size.

Empirical results:

The findings of the present study indicate that in all three of the test-periods the CAPM forecasting mechanism employing the modified beta (accounting for estimation risk) has a lower mean absolute forecast error, than the CAPM forecasting mechanism employing the traditional beta measure. (See table 1A.)

The findings also indicate that in 12 out of the 15 trials in which estimated in-sample regression coefficients were used as forecast weights, the combination-model employing the CAPM-generated forecast that accounts for estimation risk performs best, on average. (See table 1A, 1B, and 1C.)

And in 9 out of the 12 trials in which combinations of equal and asymmetric proportions were formed, the combination-model employing the CAPM-generated forecast that accounts for estimation risk again performs best, on average. (See table 2.)

Thus in 21 of the 27 possible test cases, the most successful combination-forecast technique employed the modified beta in the CAPM forecasting mechanism. (In only 2 of the 27 possible test cases did the most successful combination-forecast technique employ the traditional beta measure in the CAPM forecasting mechanism.) (See table 1A, 1B, 1C, and 2.)

Summary and conclusion:

The present study finds that accounting for estimation risk (as represented by the dispersion of analysts' forecasts) leads to better CAPM-generated forecasts of earnings growth, and in turn, generally improved combinations of financial analysts' consensus forecasts and CAPM-generated forecasts of earnings growth. And although in most cases the improvement in forecasting performance is slight, small differences in compound earnings-growth can translate into large differences in the absolute level of future earnings. Stock price is of course a direct function of the absolute level of current and future earnings.

The present study also indicates a temporal consistency regarding the combination-forecast that uses ordinary-least- squares (OLS) in-sample regression coefficients as weights: In 12 out of 15 possible test cases the combination that uses the modified beta in the CAPM-forecasting mechanism and employs no constant, performed best on average.

Note that in only one test case did the best combination (formed with in-sample regression coefficients as weights) include a constant term. In this case the modified-beta was again employed in the CAPM forecasting mechanism. (See table 1A, 1B, and 1C.)

The combinations formed with in-sample regression-coefficients as weights may be considered out-of-sample in the sense that some portion of a combination-forecast horizon is outside the in-sample estimation period.

The combinations formed of asymmetric proportions, with the analysts' forecasts assigned the greater weight, may be considered to be simulated ex-ante forecasts in the sense that, *a priori*, an earnings forecaster could reasonably be expected to assign the analysts' forecast a larger weight on the grounds that the analysts' forecast embodies a broader information set.

In conclusion, in a large majority of test cases (78%), the most successful combination forecast employed the modified beta in the CAPM forecasting mechanism. Apparently, accounting for estimation risk (as captured by dispersion of analysts' forecasts) leads to greater informational content of and better forecasting results by the CAPM-forecasting mechanism; and in turn, more accurate combinations of CAPM-generated forecasts with financial analysts' consensus forecasts of firm-earnings growth.

Table 1A

Mean Absolute Forecast Error (MABE) Summary Table

(In Percentages)

(Note: all out-of-sample combination forecasts formed with forecast-weights generated from the 1982-1987 coefficient-estimation period.)

Forecast horizon:	1983-88	1984-89	1985-90
Model A (IBES)	10.2015	10.9918	13.0300
Model B (CAPM; B_T)	13.4298	14.2684	17.4012
Model C (CAPM; B_N)	13.4275	14.2644	17.3989
Model 1 (B_T; WC)	9.9405	10.7954	12.8764
Model 2 (B_N; WC)	9.9406	10.7954	12.8763
Model 3 (B_T; NC)	9.9204	10.7622	12.8736
Model 4 (B_N; NC)	9.9204	10.7621	12.8735

Notes:
Model A represents the financial analysts' forecasting mechanism (IBES).
Model B is the CAPM-based statistical forecasting model employing the traditional beta, B_T.
Model C is the CAPM-based statistical forecasting model employing the modified beta, B_N.
Model 1 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the traditional beta, B_T.
Model 2 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the modified beta, B_N.
Model 3 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the traditional beta, B_T..
Model 4 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the modified beta, B_N.

Table 1B

Mean Absolute Forecast Error (MABE) Summary Table

(In Percentages)

(Note: all out-of-sample combination forecasts formed with forecast-weights generated from the 1983-1988 coefficient-estimation period.)

Forecast horizon:	1984-89	1985-90
Model A (IBES)	10.9918	13.0300
Model B (CAPM; B_T)	14.2684	17.4012
Model C (CAPM; B_N)	14.2644	17.3989
Model 1 (B_T; WC)	11.0010	12.9212
Model 2 (B_N; WC)	11.0009	12.9210
Model 3 (B_T; NC)	10.7541	12.8710
Model 4 (B_N; NC)	10.7540	12.8709

Notes:
Model A represents the financial analysts' forecasting mechanism (IBES).
Model B is the CAPM-based statistical forecasting model employing the traditional beta, B_T.
Model C is the CAPM-based statistical forecasting model employing the modified beta, B_N.
Model 1 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the traditional beta, B_T.
Model 2 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the modified beta, B_N.
Model 3 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the traditional beta, B_T..
Model 4 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the modified beta, B_N.

Table 1C

Mean Absolute Forecast Error (MABE) Summary Table

(In Percentages)

(Note: all out-of-sample combination forecasts formed with forecast-weights generated from the 1984-1989 coefficient-estimation period.)

Forecast horizon:	1985-90
Model A (IBES)	13.0300
Model B (CAPM; B_T)	17.4012
Model C (CAPM; B_N)	17.3989
Model 1 (B_T; WC)	12.9205
Model 2 (B_N; WC)	12.9012
Model 3 (B_T; NC)	12.9248
Model 4 (B_N; NC)	12.9245

Notes:
Model A represents the financial analysts' forecasting mechanism (IBES).
Model B is the CAPM-based statistical forecasting model employing the traditional beta, B_T.
Model C is the CAPM-based statistical forecasting model employing the modified beta, B_N.
Model 1 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the traditional beta, B_T.
Model 2 is the combination model with weights generated by constrained OLS with a constant and employing the CAPM forecast using the modified beta, B_N.
Model 3 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the traditional beta, B_T..
Model 4 is the combination model with weights generated by constrained OLS with the constant suppressed and employing the CAPM forecast using the modified beta, B_N.

Table 2

Mean Absolute Forecast Error (MABE) Summary Table

(In Percentages)

(Note: all combination forecasts are simple weighted-averages, with the analysts' forecasts assigned the greater weight in the asymmetric averages.)

Forecast horizon:	1983-88	1984-89	1985-90
Model A (IBES)	10.2015	10.9918	13.0300
Model B (CAPM; B_T)	13.4298	14.2684	17.4012
Model C (CAPM; B_N)	13.4275	14.2644	17.3989
Model 5 (.50/.50; B_T)	10.3406	11.3192	13.7952
Model 6 (.50/.50; B_N)	10.3399	11.3183	13.7945
Model 7 (.75/.25; B_T)	9.8656	10.7321	12.9735
Model 8 (.75/.25; B_N)	9.8654	10.7319	12.9732
Model 9 (.80/.20; B_T)	9.8565	10.7106	12.8997
Model 10 (.80/.20; B_N)	9.8564	10.7105	12.8995
Model 11 (.85/.15; B_T)	9.8838	10.7355	12.8704
Model 12 (.85/.15; B_N)	9.8838	10.7354	12.8702
Model 13 (.90/.10; B_T)	9.9617	10.7901	12.8873
Model 14 (.90/.10; B_N)	9.9618	10.7901	12.8872

Notes:

Model 5 is the (.50/.50) combination model employing the CAPM forecast using the traditional beta, B_T.

Model 6 is the (.50/.50) combination model employing the CAPM forecast using the modified beta, B_N.

Model 7 is the (.75/.25) combination model employing the CAPM forecast using the traditional beta, B_T.

Model 8 is the (.75/.25) combination model employing the CAPM forecast using the modified beta, B_N.

Model 9 is the (.80/.20) combination model employing the CAPM forecast using the traditional beta, B_T.

Model 10 is the (.80/.20) combination model employing the CAPM forecast using the modified beta, B_N.

Model 11 is the (.85/.15) combination model employing the CAPM forecast using the traditional beta, B_T.

Model 12 is the (.85/.15) combination model employing the CAPM forecast using the modified beta, B_N.

Model 13 is the (.90/.10) combination model employing the CAPM forecast using the traditional beta, B_T.

Model 14 is the (.90/.10) combination model employing the CAPM forecast using the modified beta, B_N.

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Footnotes:

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[i] See Terregrossa (1999).

[ii] See Malkiel and Cragg (1982) and Friend, Westerfield and Granito (1978).

[iii] See Malkiel (1981), and Carvell and Strebel (1984), Harris (1986) and Conroy and Harris (1987).

[iv] See Terregrossa (1999) for a detailed description and explanation of the CAPM based forecasting model that is employed in the present study to generate the statistical component-forecast of EPS growth.

[v] Constrained OLS is employed in the present study to generate forecast weights because using constrained OLS coefficients as forecast weights has been shown to generate more accurate out-of-sample combination-forecasts than using unconstrained OLS coefficients. (See Terregrossa (2003)).

[vi] See Carvell and Strebel (1984) for an explanation and derivation of the modified beta used in the present study to account for estimation risk.

[vii] For a detailed list and explanation of the criteria each firm must satisfy to be included in a given sample of firms, chosen from the Centre for Research of Security Prices (CRSP) tape, see Terregrossa (1999). The same criterion is exactly applicable in the present study.