Understanding Weighted Average Cost of Capital: A Pedagogical Application

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We offer a pedagogical application of the capital structure decision-making process. The application consists of a two-stage interactive spreadsheet model by which the student assumes the role of financial manager. The student first performs construction and analysis of six traditional capital structure scenarios to find the optimal debt level - the level that minimizes weighted average cost of capital (WACC) and maximizes firm value - then applies Monte Carlo simulation to those scenarios. During their investigation of alternative capital structure scenarios, students must deal with the reality that WACC components, thus WACC itself, are stochastic variables. The capital structure model has proven very helpful for students to investigate and better understand the relationship between debt and equity capital components in their relative effects on WACC and firm value, and also to appreciate the impact on estimated WACC of uncertainty and variability in its components.

INTRODUCTION

> *In truth, not even the chairman of the Federal Reserve Board knows how to identify a firm's precise optimal capital structure or how to measure the effects of capital structure changes on stock prices and the cost of capital. In practice, capital structure decisions must be made using a combination of judgment and numerical analysis*. (Brigham and Houston, 2010. p.486).

The weighted average cost of capital (WACC) is an invaluable tool for use by financial managers in capital budgeting and business valuation analyses, and consequently, is a key topic in financial management courses. A continuing need exists for improved methods of teaching and learning this important topic. In a survey of 392 CFOs Graham and Harvey (2001) find that financial executives readily use business school techniques like net present value (NPV) and the capital asset pricing model (CAPM), but are much less likely to follow capital structure guidance from academia. Graham and Harvey (2001) suggest an explanation for this behavior might be that business schools are better at teaching capital budgeting and the cost of capital than at teaching capital structure. Citing this need for better capital structure teaching methods, Hull (2008) offers a pedagogical spreadsheet application of the capital structure decision-making process for a firm issuing debt to retire equity. Continuing the effort to produce improved teaching methods for capital structure, our purpose in this paper is to describe pedagogy that includes an experiential process for students to explore alternative mixes of debt and equity in the firm's capital structure and to observe the impact of their choices upon WACC and common stock price.

The traditional approach to estimating the cost of invested capital is to compute a WACC using point estimates of each input (Keown, Martin, and Petty, 2011; Van Horne and Wachowicz, 2001; and Welch, 2010). In reality however, there is uncertainty associated with these inputs. Some of the parameters in the WACC, such as the unlevered beta and market risk premium, are not known with certainty due to their stochastic nature or because they are not under the firm's control. These variable inputs can add to the variability of WACC results. An approach to estimating WACC that explicitly addresses this uncertainty is to identify and quantify the uncertainty in individual WACC parameter estimates, then describe the uncertainty around the expected WACC via Monte Carlo simulation. This paper describes use of both the traditional and Monte Carlo approaches as a means for students to (a) investigate and better understand the relationship between debt and equity in the capital structure, WACC, and firm value and (b) appreciate the impact on estimated WACC of uncertainty and variability in its components.

The remainder of this paper is organized as follows: The next section describes the basic spreadsheet model as used by students. Input and output variables are defined, terminology is given, and key relationships among variables are explained. The following section describes the use of Monte Carlo simulation to help students understand the effects of uncertainty on the calculated WACC and how the effect is influenced by the degree of leverage used. The penultimate section discusses student learning objectives and assessment, and the final section offers some concluding remarks.

THE WACC SPREADSHEET MODEL

In this section we present a student-friendly spreadsheet model based on relatively simple scenario analysis. The spreadsheet can be used in class to introduce students to the calculation of weighted average cost of capital, and to help them better understand how changes in the mix of debt and equity affect the firm's cost of capital and overall corporate valuation. Scenarios are descriptions of different future states of an organization's environment (Brauers and Weber, 1988). Scenario analysis has long been used in the business world (Bradfield, Wright, Burt, Cairns and Van Der Heijden, 2005) and by 1980 the technique was being applied by half of Fortune 1000 companies (Linneman and Klein, 1983). Its use has continued to grow with the increased uncertainty, globalization, and complexity in the business environment (Schoemaker, 1993).

Terminology

WACC is determined by the following equation:

$$WACC = w_d r_d (1 - T) + w_{ps} r_{ps} + w_s r_s \quad (1)$$

Where,

w_s = the proportion of total capital represented by common equity.
r_s = rate on common equity.
w_{ps} = the proportion of total capital represented by preferred stock.
$r_{ps} = D_{ps} / P_{ps}$ = rate on preferred stock.
w_d = the proportion of total capital represented by debt.
r_d = interest rate on new debt (before tax)
$r_d (1\text{-}T) = r_L$ = after-tax interest rate on new debt, where T = firm's marginal tax rate.

Model Inputs and Assumptions

The base spreadsheet model[2] appears in Figure 1. This model is one that assumes addition of debt occurs within a context of company recapitalization, that is, the exchange of one form of financing for another. An example would be removing common shares from the company's capital structure and replacing them with bonds. A reverse example would be when a company issues stock in order to buy back debt securities, thus increasing its proportion of equity capital compared to its debt capital. The model maintains total initial capital (book value) constant - additional debt is taken on through several alternative scenarios in which common equity is proportionally decreased. This approach isolates and emphasizes the risk/return tradeoffs inherent in placing additional debt in the capital structure. Students begin in Scenario 1 (column C) by creating a capital structure of their choosing. They enter values for the amount of debt, the amount of preferred stock equity, the firm's unlevered beta, and other inputs. Since total capital remains constant, the amount of common stock equity (book value) is calculated as TOTAL CAPITAL less the sum of Long Term Debt and Preferred Stock. Of course the market value of equity will be different in each scenario and will depend on the WACC and the Firm Value. Upon entering values for debt a student can immediately see the effect on the WACC and firm's stock price. Students can create up to six capital structure combinations (scenarios). In Scenarios 2 through 6 students test each of those alternatives with increasingly larger amounts of debt, and investigate the effect of that increased leverage on WACC and firm value. The firm value is measured by the present value of future Free Cash Flows to the Firm (FCFF).

Figure 1. Base Spreadsheet Model

	Tax Rate (T)	40%					
	Real Risk Free Rate r_{RF^*}	3.00%				Input cells	
	Inflation Premium (IP) = $r_{RF} - r_{RF^*}$	2.00%					
	Weighted Average Cost of Capital (WACC) Model						
Cost of…	Scenario	1	2	3	4	5	6
Long Term Debt	r_d	5.9000%	6.0214%	6.9002%	7.8541%	9.2739%	11.2518%
r_L	Amount	**$400,000**	**$800,000**	**$1,200,000**	**$1,400,000**	**$1,600,000**	**$1,800,000**
	r_L	3.540%	3.613%	4.140%	4.712%	5.564%	6.751%
$r_L=r_d(1-T)$	**Weight**	0.160	0.320	0.480	0.560	0.640	0.720
	Weighted Cost	**0.566%**	**1.156%**	**1.987%**	**2.639%**	**3.561%**	**4.861%**
Preferred Stock	D_{ps}	**$5.00**	$5.00	$5.00	$5.00	$5.00	$5.00
r_{ps}	P_{ps}	$61.56	$58.80	$53.97	$50.49	$46.41	$41.94
	Amount	**$300,000**	$300,000	$300,000	$300,000	$300,000	$300,000
$r_{PS}=D_{ps}/P_{ps}$	r_{PS}	8.12%	8.50%	9.26%	9.90%	10.77%	11.92%
	Weight	0.120	0.120	0.120	0.120	0.120	0.120
	Weighted Cost	**0.975%**	**1.020%**	**1.112%**	**1.188%**	**1.293%**	**1.431%**
Common Stock Equity	$r_M - r_{RF}$	**4.70%**	4.700%	4.700%	4.700%	4.700%	4.700%
r_S	r_M	9.70%	9.70%	9.70%	9.70%	9.70%	9.70%
	$b_{s\ Unlevered}$	**1.00**	1.00	1.00	1.00	1.00	1.00
	$b_{s\ Levered}$	1.10	1.19	1.29	1.34	1.38	1.43
	Amount	$1,800,000	$1,400,000	$1,000,000	$800,000	$600,000	$400,000
$r_S = r_{RF}+(r_M-r_{RF})b_s$	r_s	10.343%	10.986%	11.630%	11.951%	12.273%	12.594%
	Weight	0.7200	0.5600	0.4000	0.3200	0.2400	0.1600
	Weighted Cost	**7.447%**	**6.152%**	**4.652%**	**3.824%**	**2.945%**	**2.015%**
TOTAL CAPITAL		**$2,500,000**	**$2,500,000**	**$2,500,000**	**$2,500,000**	**$2,500,000**	**$2,500,000**
WACC		**8.988%**	**8.329%**	**7.751%**	**7.652%**	**7.799%**	**8.307%**
Free Cash Flow to Firm (FCFF)		**$200,000**	$200,000	$200,000	$200,000	$200,000	$200,000
Common Stock Price	Number of Shares	180000	137678	103419	85947	64138	32433
	P_0 =(FCFF/(WACC)-Debt-Preferred)/shares	**$8.47**	**$9.45**	**$10.45**	**$10.63**	**$10.36**	**$9.49**

Cells having shadded background are user inputs. More specifically, students can enter their estimates for:

1. The applicable effective tax rate - cell C3.
2. The real Risk-Free interest rate – cell C4.
3. The inflation premium - cell C5.
4. The dollar amount of debt the company takes on – cells C9-H9.
5. The dividend paid by the preferred stock – cell C13.
6. The dollar amount financed by the use of preferred stock – cell C15.
7. The market risk-premium – cell C19.
8. The unlevered company beta – cell C21.
9. The Free Cash Flow to the Firm – cell C29.

Most inputs are common for all scenarios (1-6). Only the amounts financed by debt are allowed to vary by scenario since the purpose of this exercise is for students to see how different capital structure combinations can affect WACC. The rest of the numbers that appear on the spreadsheet are calculated results, based on user inputs. The large number of inputs provides the student with considerable flexibilities and adds increased realism to the learning experience.

The Cost of debt (row 8) is calculated in a way that reflects the fact that higher financial leverage leads to an increased probability of default, higher bond interest rates and multiple symptoms of financial distress. The issue of financial distress cost as related to WACC is summarized well by Almeida and Philippon (2008):

> *The risk of bankruptcy for highly-levered companies will rise precisely when it is most disadvantageous: when it is harder to liquidate assets and more costly to raise new capital. Bond investors seem to be aware of these risks, and have usually demanded significant risk premia to hold debt securities issued by highly-levered firms. But since standard valuations of bankruptcy costs ignore these economy-wide risks, corporate managers who follow this practice will underestimate the actual expected costs of debt and may end up with excessive leverage in their capital structure.* (p. 110)

The formulas in cells C8:H8 calculate the cost of debt as the risk free rate of interest plus the model's built-in yield spread. The spread depends on the company's bond rating (AAA, BB, etc.), and reflects the higher risk associated with higher debt levels. Table 1 shows the bond rating criteria of Standard &Poor's Rating Services.

The Cost of Debt and Financial Distress

A company's bond rating depends on its business and financial risk. For a given level of business risk, bond ratings vary depending on financial risk - and one of the measures of financial risk is the debt ratio.

Table 1. Risk Profile for Bond Ratings

Business Risk Profile	Financial Risk Profile				
	Minimal	Modest	Intermediate	Aggressive	Highly Leveraged
Excellent	AAA	AA	A	BBB	BB
Strong	AA	A	A-	BBB-	BB-
Satisfactory	A-	BBB+	BBB	BB+	B+
Weak	BBB	BBB-	BB+	BB-	B
Vulnerable	BB	B+	B+	B	B-
Financial Risk Indicative Ratios (Corporates)					
	Minimal	Modest	Intermediate	Aggressive	Highly Leveraged
Funds From Operations/Debt (%)	over 60	45-60	30-45	15-30	below 15
Debt/Capital (%)	below 25	25-35	35-45	45-55	over 55
Debt/EBITDA (x)	less than 1.4	1.4-2.0	2.0-3.0	3.0-4.5	over 4.5

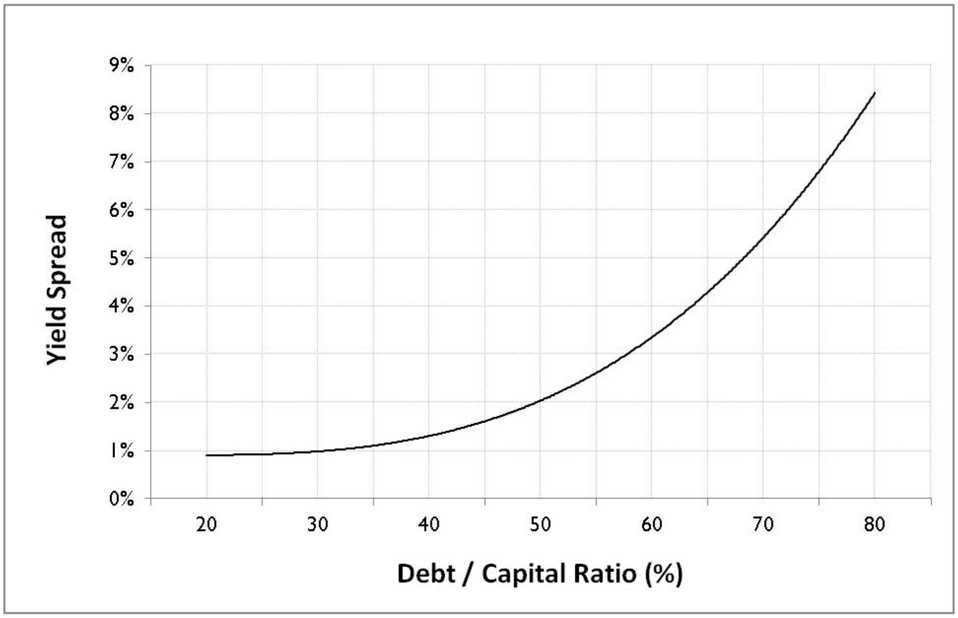
Table 2. Leverage, Ratings, and Yield Spreads for a Firm with *Satisfactory* Risk Profile

Debt/Capital (%)	below 25	25-35	35-45	45-55	over 55
Bond Rating	A-	BBB+	BBB	BB+	B+
Yield Spread	0.89%	1.04%	1.22%	2.10%	3.35%

In the model, it is assumed that the company is one with a satisfactory business risk profile and it is assigned a debt rating based on its leverage ratio (debt to total capital, cells C11 to H11 in the spreadsheet).[3]

For each debt level there is assigned a corresponding yield spread to be added to the Risk-Free Rate (Real Risk-Free rate plus Inflation Premium). Yield spreads may be obtained for industrial firms from www.bondsonline.com and typical values appear in table 2. For purposes of this student exercise, the values in Table 2 are used, with the step function implicit there converted and extended into a best-fit continuous function that permits representative yield spreads to be identified at any level of debt up to a maximum of 80% debt to capital. The resulting curve for Yield Spread as a function of Debt/Capital Ratio appears in Figure 2.

Figure 2. Yield Spread as a Function of Debt Ratio



The yield spread corresponding to a given debt level is applied automatically, based upon the amount of debt the student enters. For example, in Scenario 2 the company's debt to capital ratio is 32%, falling in the upper portion of the BBB+ bond rating range in Table 2. Based on the relationship shown in Figure 2, the yield spread corresponding to that specific debt level is 1.0214%. Thus, we assign the company a total cost of debt equal to a risk-free rate of 5% plus a yield spread of 1.0214% for a total of 6.0214%. Similarly, in Scenario 3 where the debt ratio is equal to 48% the company has a cost of debt equal to 5% plus 1.90% for a total of 6.90%. Students can readily see that choosing a higher leverage ratio will lead to a higher cost of debt.

The Cost of Equity

For the cost of equity a similar process was developed that reflects the additional risk of leverage. The students enter the unlevered company beta. Levered betas are calculated based on the company capital structure using the Hamada equation.

$$b_{s\ Lvered} = b_{b\ Unlevered}\left[1+(1-T)\left(\frac{D}{E}\right)\right] \qquad (2)$$

In equation (2) D is the amount of debt, E the total equity, T the tax rate, $b_{s\_Levered}$ the levered beta, and $b_{s\_Unlevered}$ the unlevered beta.

Higher degrees of leverage commensurately lead to higher levered betas and thus a higher cost of equity. Using the levered betas we calculate the cost of equity using the Capital Asset Pricing Model (CAPM) equation:

$$r_s = r_{RF} + b_{s\ Levered}(r_M - r_{RF}) \tag{3}$$

In equation (3) r_s is the cost of equity, r_{RF} the risk-free rate, r_M the required market rate of return, and $b_{s\_Levered}$ the levered beta.

The Cost of Preferred Stock

Finally, the required return on preferred stock is calculated as the average of cost of debt and cost of common equity. Preferred shares have risk due to price fluctuations; preferred stock is a perpetuity and as such is sensitive to changes in interest rates. If interest rates rise, the price of the preferred falls, and although dividends may continue, an investor could be stuck with lower-valued stock that could be sold only at a substantial loss. With the cost of preferred stock and the preferred stock dividend, the price of preferred stock is calculated as:

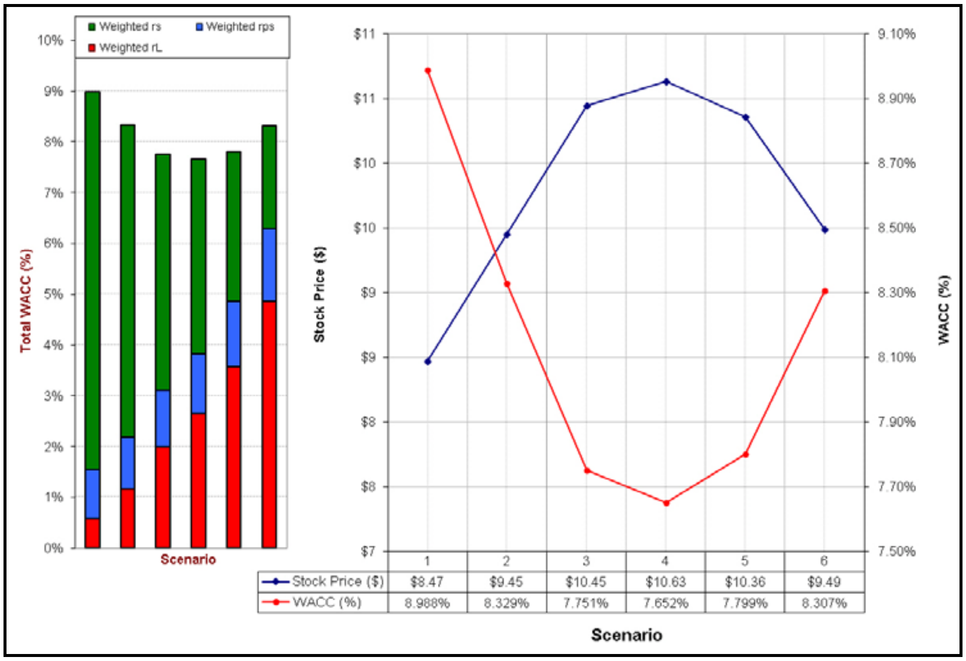
$$P_{ps} = \frac{D_{ps}}{r_{ps}} \tag{4}$$

From equation (1) and the cost of debt, preferred stock, and common stock calculations WACC is calculated in row 25 of the spreadsheet. Then, the user's input for the Free Cash Flow to the Firm (FCFF) is used to estimate the present value of all future free cash flows to the firm, i.e., the firm's market value. FCFF is the cash flow generated by the business after deducting investments in new capital so, FCFF = NOPAT - Net Investment[4]. WACC is the return that investors expect to make from investing in the enterprise and therefore is the appropriate discount rate for FCFF. The growth rate (g) of the FCFF is assumed to be zero without loss of generality. Hence, the Value of the firm is calculated from Equation (5).

$$\textit{Firm Value} = FCFF/WACC \tag{5}$$

Firm value does not show anywhere in the model but instead is used to estimate the number of shares. When the firm moves from the base capital structure to any of the higher debt scenarios a new bond is issued and the proceeds are used to buy back stock. This will reduce the number of shares. We assume that the number of shares in the base case scenario is 180,000. The new number of shares following recapitalization is calculated from Equation (6).

Figure 3. Charts Illustrating WACC, Stock Price, and Component Weights of WACC



$$Shares_{new} = Shares_{old}\left[\frac{FirmValue - (Debt_{new} + Preferred_{new})}{FirmValue - (Debt_{old} + Preferred_{old})}\right] \tag{6}$$

Based on Equation (6), the new number of shares is calculated in row 30 of the model. Finally, the common stock price is calculated in row 31 from Equation (7).

$$\begin{aligned} Common\ Stock\ Price &= \frac{FirmValue - Debt - Preferred}{Shares} \\ &= \frac{FCFF / WACC - Debt - Preferred}{Shares} \end{aligned} \tag{7}$$

Model Outputs

Once they complete the entries shown in Figure 1, students can see the WACC and the stock price for each of the six scenarios. In a second worksheet of the model, a graph (Figure 3) is generated to give the students a visual overview of all six scenarios. Students can observe the relative benefits of leverage in Scenarios 1 through 6. The more debt the company takes on, the lower the WACC, and the higher the company's stock price. But when debt is raised even further (Scenarios 5 and 6) the increased financial risk overcomes the benefits of increased leverage and students see that WACC goes up and firm value (as measured by the stock price) goes down. Students can easily confirm that when the WACC is minimized the company's value is maximized.

MONTE CARLO SIMULATION

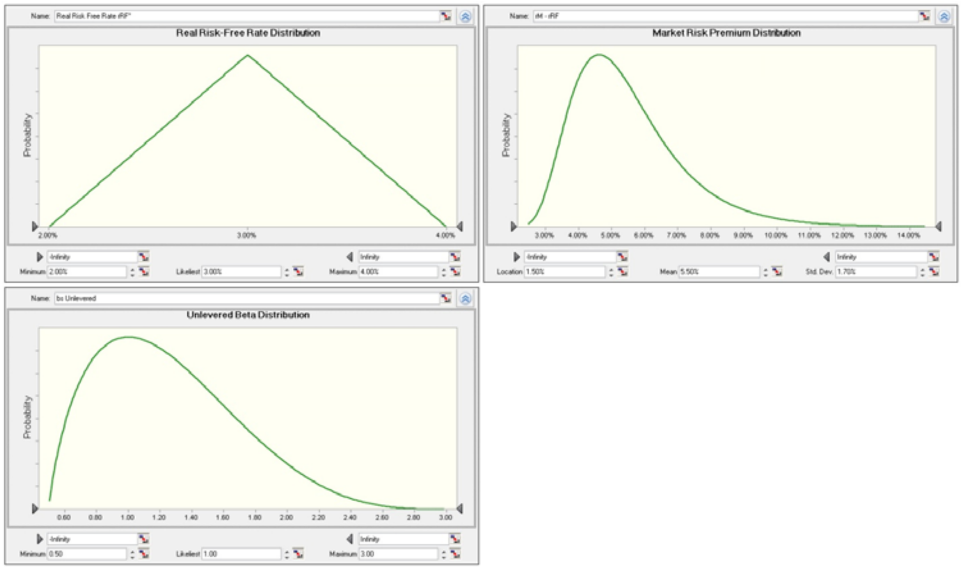
While scenario analysis is a powerful and useful tool, one serious limitation is that it does not explicitly consider probability and uncertainty (Markham and Palocsay, 2006). Several of the inputs to the model discussed in the previous section have uncertain values. An approach to estimating expected WACC that explicitly addresses this uncertainty is to apply Monte Carlo simulation[5]. Use of this tool is growing in the finance arena. For example, Rozycki (2011) describes the use of Monte Carlo Simulation in making capital budget decisions, and Chang and Dasgupta (2011) show how Monte Carlo Simulation can be used in capital structure research.

In this section, we describe how students use Monte Carlo simulation to understand how and to what extent the uncertain variables affect their estimates of the WACC, and how important the effect of uncertainty is for various debt-equity combinations. In a nutshell, students first identify the sources of uncertainty in estimating WACC parameters, then quantify the uncertainty around the estimation of each WACC parameter, and finally aggregate and quantify the uncertainty around the expected WACC via Monte Carlo simulation.

Monte Carlo simulation is a numerical approach used to solve problems or reveal more information about a situation by repeated random sampling. It can be thought of as artificially creating a chance event or series of related events (for example, a process) many independent times, and observing a summary or distribution of results. The estimated parameters of that distribution will be in error by some amount. One can never know the exact size of this error because the true value of the quantity estimated is unknown. One can show however, that the parameter estimate obtained from a simulated process or calculation is a consistent estimator of the true parameter. For example, as the number of random sample trials is increased, the half-width interval and corresponding standard error related to the estimated mean become smaller such that one has an asymptotically valid confidence interval for the mean (Barreto and Howland, 2006).

Typically, a model is prepared in which selected inputs are designated as having a distribution of values rather than point (single) values. This is done with those inputs which are not known with certainty. With tools available today almost any probability distribution can be assigned to an input of the model. When the distribution is unknown, the one that represents the best fit to the available data can

Figure 4. Distributions for Real Risk-Free Rate, Market Risk Premium, and Unlevered Beta



be used. In a given trial, a random value from each input variable's distribution is selected and calculation of outputs is performed with those random values. After thousands of trials, the model outputs can be plotted as a frequency distribution that shows not only the most likely outcome, but also a range of possible outcomes, and the probability of those outcomes. The simulation results remain estimates whose accuracy is defined by user inputs, but assuming the model is reasonably correct, the results can be more informative than alternative single-point estimates, or even scenario sets, that may be otherwise produced. If input variables exhibit correlation, this can also be modeled. The Monte Carlo simulation models were constructed using the Crystal Ball® software package (Crystal Ball® is spreadsheet-based application suite for predictive modeling, and is a registered trademark of Oracle Corporation). Students have access to this software in our school's financial lab.

Uncertain Input Variables

In the calculations of the base model all variables were specified by the user as single-point values. However, in reality several key inputs are not known with certainty. Beta is one of these uncertain variables. Students can use historical data to calculate the firm's beta and plug it into the base model as a single number. They can do the same with a second uncertain variable - market risk premium. Using their (single-point) estimate for the market risk premium, students can calculate the cost of equity using the CAPM equation. These two variables can never be predicted with certainty. Predictions also vary significantly for the real risk-free rate, which constitutes the third uncertain variable considered here. We now describe these key uncertain model inputs and characterize their variability. With students, these variables would typically be investigated using a combination of lecture and assigned research by the students to uncover the type and extent of variability involved. Depending upon the number of students involved, this can be a useful team exercise, with each team reporting to the class, proposing and defending a distribution for each variable. Figure 4 shows the distributions we have used for Real Risk-Free Rate, Market Risk Premium, and Unlevered Beta.

Real Risk-Free Rate

In general, the nominal or quoted rate on a security is composed of the risk-free rate plus compensation for risk. The Real Risk-Free Rate, denoted here as r_{RF*}, is the interest rate that would exist on a security that had no risk, including no inflation risk. This may be thought of as a US Treasury security in a world without inflation. The nominal rate, denoted here as r_{RF}, is equal to the risk-free component plus an inflation premium, i.e., $r_{RF} = r_{RF*} + IP$. Brigham & Houston (2010) cite the difficulty of measuring the Real Risk-Free rate but say most experts think that r_{RF*} has fluctuated in the range of 2 to 4 percent in recent years. Accordingly, we adopted that range and elected to use a triangular distribution with minimum of 2 percent and a maximum of 4 percent to represent the Real Risk-Free rate.

Market Risk Premium

The market risk premium is the premium investors require to hold an average stock compared to the least risky or risk-free investment, typically taken as a US Treasury bond. The size of the premium is a function both of the investor's risk aversion and how risky the investor perceives the market to be.

The market risk premium is not known with certainty, and so it must be estimated (Brigham and Houston, 2007). Of course, estimates vary depending upon the source. For example, Fernandez (2010) has reviewed more than 150 textbooks and finds that recommendations for the market risk premium range from three percent to ten percent. In a second paper, Fernandez, Aguirreanalloa and Corres (2011) find that professors, analysts and company managers use different estimates for the market risk premium (professors use 5.7%, analysts 5.0%, and managers 5.6%.). For the market risk premium distribution we elected to use a truncated lognormal distribution having a mean of 5.50 percent and a standard deviation of 1.70%, with lower and upper truncation values of 1.50% and 15% respectively.

Unlevered Beta

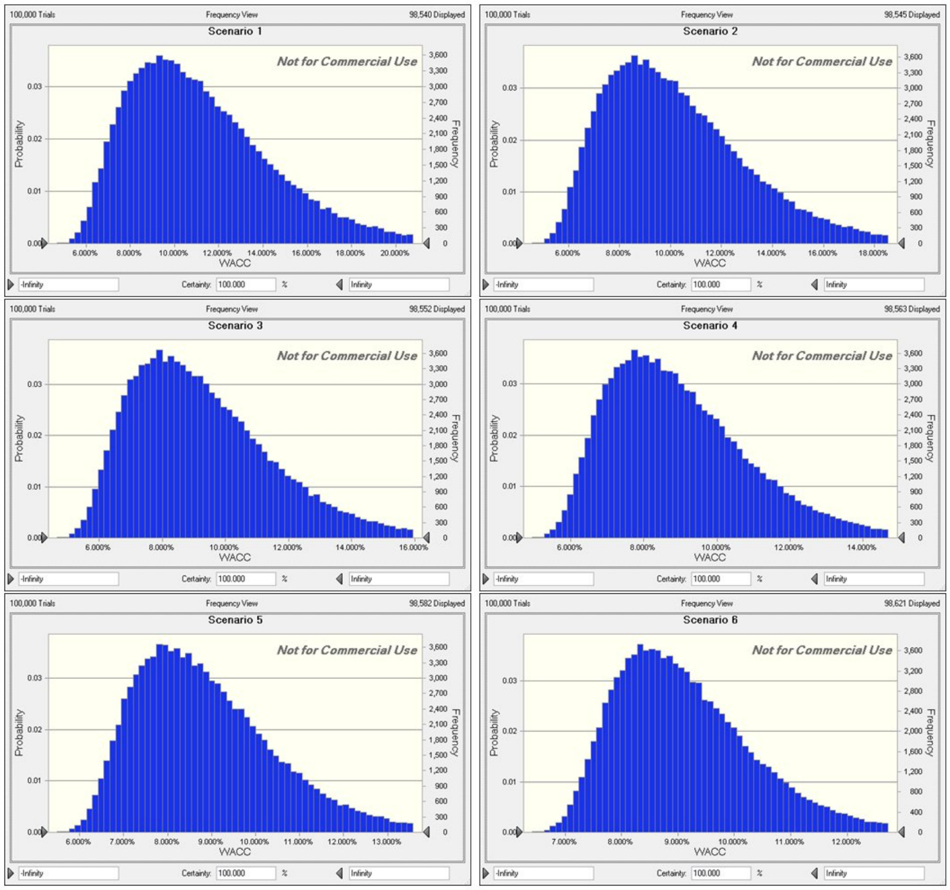
The beta coefficient for an asset is a relative measure of correlated volatility (risk) that compares the return on that asset with the return on a benchmark market portfolio. The beta of the benchmark market volatility (market beta) is usually taken to be unity. The "true" current beta of an asset is not known, and must be estimated using historical and other data. For example, in order to obtain a regression estimate of beta one must make at least three important data choices (Damodaran, 2011) which can have a major effect on the beta estimate (Armitage, 2005). One must choose a market index, decide how many years the data period will include, and also select a time interval for the return data (e.g., daily, weekly, monthly). For any such estimate there is an associated standard error – a reminder that the beta value obtained is not known with certainty.

To model beta for Monte Carlo sampling here, a skewed distribution of beta values was used that follows the shape and range found by Ang, Lui, and Schwarz (2010). They developed OLS regression estimates of beta for 29,096 firms in non-overlapping five year samples from 1960-2005 for all industries and found the distribution of beta values to be, as expected, centered around one. The distribution had a mean of 1.093 and a standard deviation of 0.765. The distribution of beta was positively skewed, at 0.783 and fat-tailed with a kurtosis of 6.412. The beta for a specific industry or specific firm would be expected to have somewhat less variability than all industries together. Because we are modeling a firm that is hypothetical, we elected to use a skewed distribution having a modal value of 1.000 with lower and upper extremes at 0.500 and 3.000 respectively. However, within the range of empirical reasonability, we would encourage students to experiment with different distributions for representing the unlevered beta.

Simulation Results

Once the distributions are assigned to all input variables, the model is recalculated repeatedly and automatically by starting the simulation. With each recalculation random values are drawn from the input distributions for use in the model, and WACC values are obtained for the six scenarios. We set the number of trials at 100,000 and thus obtained for each scenario 100,000 values of WACC. The software automatically tabulates statistics, produces frequency histograms, and provides related information about the outputs. Figure 5 shows frequency histograms for resulting WACC in the six scenarios. All six scenarios have output distributions of similar shape – skewness is consistent at a range of 1.03 to 1.09. Mean WACC values and standard deviations do differ somewhat as shown in Table 3, which gives summary statistics for 100,000 trials. Recall that in the single-value base model the minimum WACC occurred at Scenario 4 (see Figure 1); for the simulation here the minimum average WACC does not occur at Scenario 4, rather

Figure 5. WACC Frequency Diagrams for Six Scenarios



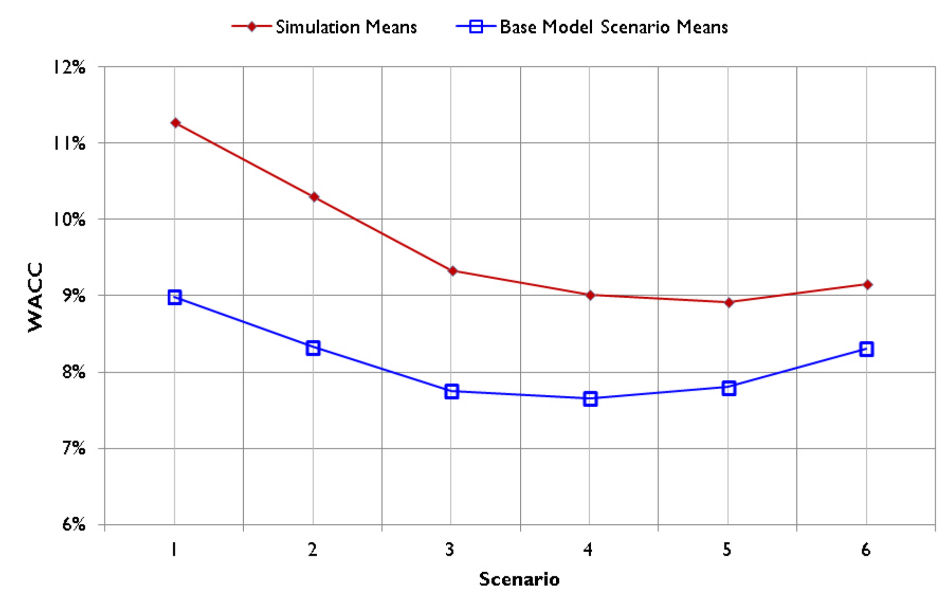
it is at Scenario 5.

It is of interest that the standard deviation becomes progressively smaller from Scenario 1 to Scenario 6. Even though (mean) WACC goes down and then up as expected (although not as markedly as in the single-value model) the uncertainty in WACC - as measured by the standard deviation of the resulting distribution - is a decreasing function of leverage. The higher the leverage the more certain we are of our estimate of WACC. This can be counter intuitive to students, and a rich source of discussion. Students are reminded that as leverage increases, the firm by definition is relying more on debt as a source of capital, and less on equity. With greater leverage, the contribution of equity to the WACC is reduced accordingly. By use of sensitivity analysis (standard outputs of the simulation), students can trace the

Table 3. WACC Values for Six Scenarios from Simulation and from the Base Model

Scenario	1	2	3	4	5	6
Std. Dev. WACC from Simulation	3.39%	2.93%	2.36%	2.03%	1.66%	1.28%
Mean WACC from Simulation	11.28 %	10.31 %	9.34%	9.01%	8.91%	9.15%
WACC from Base Model	8.99%	8.33%	7.75%	7.65%	7.80%	8.31%
WACC Difference between Simulation and Base Model	2.29%	1.98%	1.59%	1.36%	1.11%	0.84%

Figure 6. Mean WACC Values from Simulation and from the Base Model



sources of variance in WACC as well as the relative contributions of those sources. In doing so, students see that the most important source of variability (risk) is the unlevered beta (see Figure 9). While the unlevered beta has the greatest relative contribution to variance in WACC, the overall impact of beta is progressively

Figure 7. Probability of Scenario 4 WACC being 7.652% or Lower

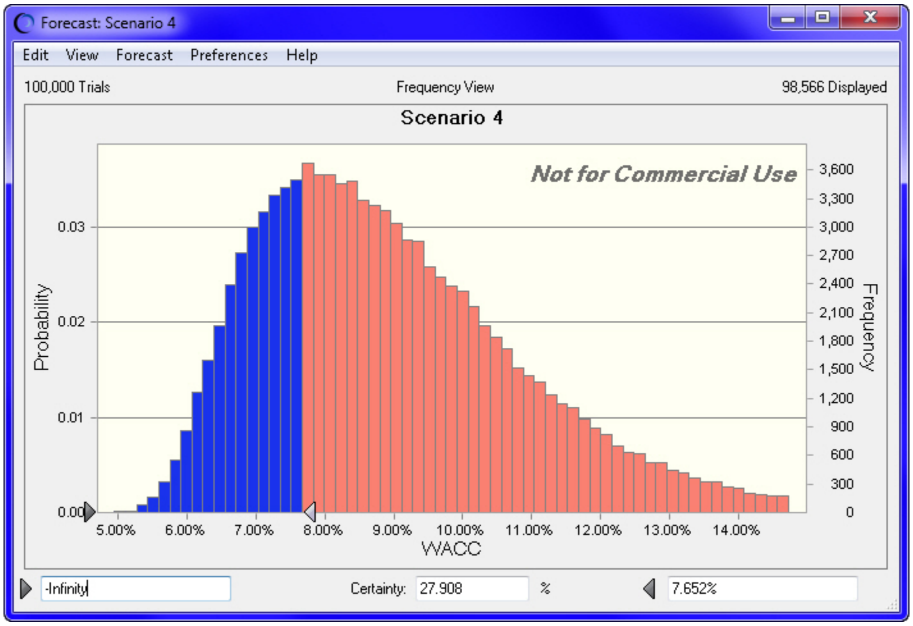


Figure 8. Probability of Scenario 5 WACC being 7.799% or Lower

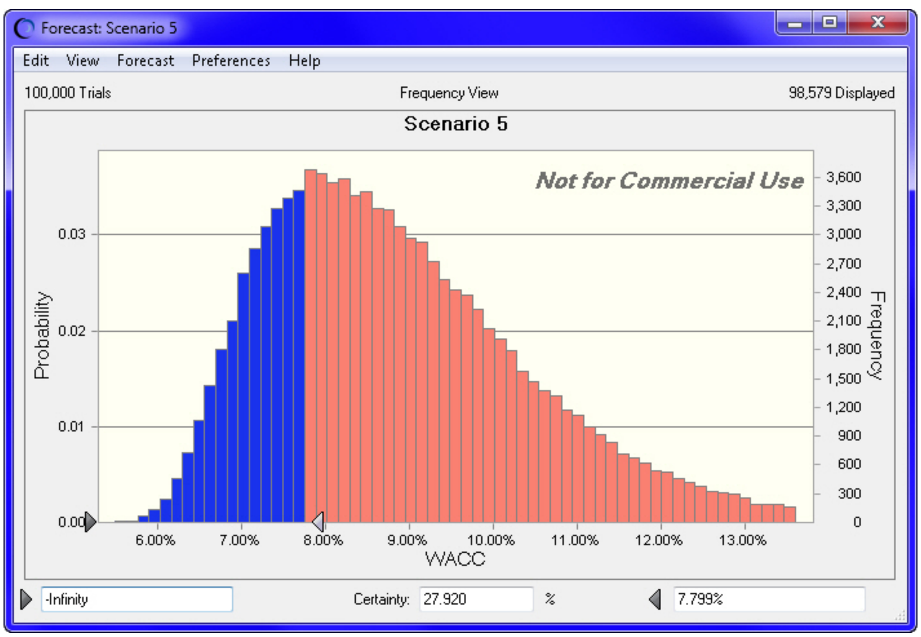
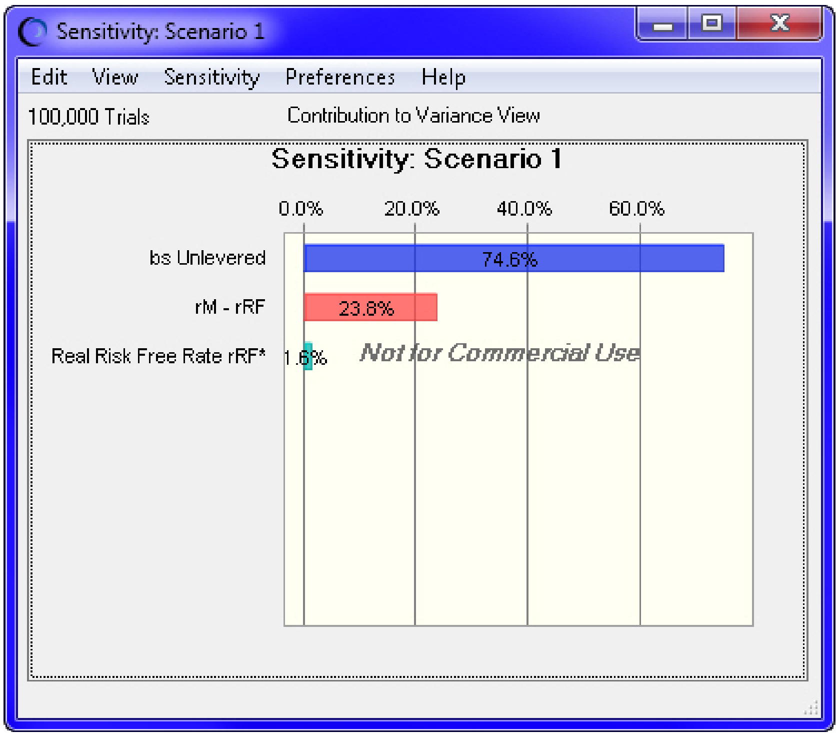


Figure 9. Contribution to Variance by the Three Input Variables – Scenario 1



diminished as leverage increases. Thus, while the mean value of WACC rises, its variance decreases.

There are substantial differences between the calculated WACC values in the base model and the mean values of WACC resulting from the simulation. For the students, this is food for thought! These differences are summarized in Table 3 and shown graphically in Figure 6. The difference diminishes progressively as the debt leverage grows. This is consistent with the earlier observation that uncertainty in mean WACC decreases with increasing debt leverage.

For Scenario 4 the most likely WACC value is about 8%, and the mean value is 9.01%, but the calculated value for that scenario from the base model is 7.652%. The simulation results indicate, as shown in Figure 7, that there is only about a 28% probability of WACC being 7.652% or less.

Taking Scenario 5 as a similar example, the most likely value of WACC is about 8% while the mean value is 8.91%. In the single-value base model, the WACC value for Scenario 5 was 7.799%. The simulation results indicate again, as shown in

Figure 8, there is only about a 28% probability of a WACC being 7.799% or better (less).

Figure 9 shows Scenario 1's contribution to variance by the three input variables. This is representative of all scenarios; contribution of Unlevered Beta ranged from 74.8% to 71.0% across the six scenarios. Corresponding ranges for Market Risk Premium and Real Risk-Free Rate were 23.7% to 22.7% and 1.6% to 6.3% respectively. Thus the relative impact of the three variables is fairly stable. From a review of the sensitivity charts, students readily conclude that the most important variable is Unlevered Beta, followed by Market Risk Premium - even for highly leveraged situations where most of the financing comes from debt.

LEARNING OBJECTIVES AND EVALUATION

The initial motivation for this work was a summary report from the Assurance of Learning (AOL) Committee where the authors teach. The capstone course for both graduate and undergraduate business majors includes a business simulation along with a related test that is available to all schools using the business simulation. Mean student performance at the authors' school on several discipline-specific test questions was significantly lower than peer group overall mean. In several other areas the same students were at par or higher than their peers. One of the finance-related topics on which performance was lower than desired was "Leverage and the Value of The Firm."

The mission of The Citadel School of Business Administration (CSBA) is to *educate and develop leaders of principle to serve a global community*. CSBA learning goals support the intent to build ethical leaders, but also reflect the belief that for its graduates to be successful, a necessary condition is that they be proficient in the traditional disciplines of business: Accounting, Economics, Finance, Management, Marketing, Operations, and Information Systems.

Three years ago, the first listed author learned of the perceived learning deficit related to leverage and firm value, a key idea in the finance discipline. To address this discipline-specific need, he developed the six-scenario, spreadsheet-based WACC model described here. He envisioned the model as a learning tool to help address the discipline-specific deficit. Using the WACC model in several classes he gathered anecdotal evidence and continued to make improvements based on student response and comments. During 2012 the other two authors joined the effort to further enrich the tool as a source of student learning by extending the interactive model with student-performed Monte Carlo simulation.

The spreadsheet model of capital structure appears to be very helpful to students. Evidence thus far is localized rather than program wide, and partly based on student self-reported data. Based on this preliminary evidence, the authors are optimistic about student use of the WACC model. The pedagogical value of having students use interactive spreadsheet models has been well summarized by Leon, Seal and Przasnyski (2006). As students create various capital structure scenarios for their hypothetical firm they can interact and receive immediate feedback via the calculated WACC and firm value. Students generally find this simple scenario analysis both challenging and easy to understand - it stimulates analytical thinking and facilitates the consideration of multiple interacting variables in an easy, accessible format. The model promotes critical thinking and questioning about firm capital structure. For example, after practicing with the model students:

1. Gain experience in setting different debt levels and immediately see the results and trade-offs of leverage.
2. See the effect of different values of the firm's Beta, via its relation with risk premium, on the cost of common equity.
3. Are able to better explain WACC and its importance within a firm.
4. Can articulate the importance of working toward minimum WACC, having observed memorably that minimum WACC occurs at the point where the firm's stock price is maximized.

In accord with evidence-based processes promoted by accrediting bodies, the Citadel School of Business is in the process of replacing course-specific objectives with measurable major learning outcomes. These outcomes or objectives will be shared across all sections of the same course. For the finance discipline, all faculty teaching the same course have agreed to include specific, measurable objectives, in this case, related to WACC and capital structure of the firm. The model and approaches presented here can be used within a class context in which student learning outcomes could include:

1. Explain the capital structure decision within an organization.

   A. Define WACC and explain its scope and importance within a firm.
   B. Identify the major interactions between components that make up WACC (e.g., greater debt increases risk, which increases both cost of debt and cost of equity).
   C. Recognize the effect of leverage on the price and yield of preferred stock.
   D. Describe the relationship between firm value and WACC.
2. Recognize and evaluate uncertainty in key components of WACC.
   A. Describe the impact of variability and uncertainty.
   B. Distinguish between traditional practice and risk modeling in developing WACC.
   C. Select and use appropriate distributions for uncertain WACC input variables.
3. Apply modeling and analytical skills to WACC decision-making.
   A. Assess the impact on WACC of a range of debt levels.
   B. Interpret simulation results and perform sensitivity analysis by tracing the effects that inputs have on the distribution of resulting WACC

values.

C. Choose and justify, from a range of debt levels, the level most appropriate for a given firm (i.e., the optimal capital structure).

The learning objectives suggested here correspond to several levels of the cognitive domain in Bloom's taxonomy - knowledge, comprehension, application, analysis, synthesis, and evaluation. The objectives can be measured by direct assessment through use of problem solving, embedded-questions in multiple-choice tests, or short essay questions. In coordination with our Assurance of Learning Committee cognizant faculty plan on initiating formal use of some or all of the objectives described here in Fall 2014 finance courses.

SUMMARY AND CONCLUSIONS

This pedagogy was developed and presented in three main stages. In the first stage, the student uses the experiential spreadsheet model to explore alternative mixes of bonds, preferred stock and common stock in six capital structure scenarios. The capital structure model calculates the resulting WACC and stock price for each student scenario, and displays a WACC and stock price curve. Students can immediately evaluate the results of their choices and modify them as they wish. Their optimal debt-to-equity choice will result in a minimum cost of capital and a maximum market value of the firm. In the second stage of the pedagogy, student experience is deepened by applying Monte Caro simulation to the same set of scenarios. The simulation allows the student to appreciate the character and degree of uncertainty associated with inputs for WACC. The resulting output distributions challenge the student to understand the impact that such uncertainty can have on the WACC and value of the firm. In the third stage a rationale is offered for the development and use of the model by the authors in a context of student learning needs. Related student learning outcomes are also suggested.

We conclude, along with Schoemaker (1993), that scenario construction and analysis is a practical way to stretch people's thinking, and we concur with Bunn and Salo (1993) that by studying even simple scenarios managers (and students) can become better prepared to make informed decisions. Our experience also mirrors that of Markham and Palocsay (2006) who found that discussion of scenarios and what-if analysis leads naturally to other modeling techniques, such as simulation.

Like scenario analysis, spreadsheet-based Monte Carlo simulation can provide the student with a powerful tool for investigating and understanding financial models when risk and uncertainty are present. Such simulation enables the student to (a) check the validity of the assumptions underlying a financial model; (b) explore the sensitivity of the model results to the input parameters whose values are uncertain or are subject to random variation; and (c) better understand the inherent variability of the final results.

The model described here takes a two-layer approach to exploring and understanding WACC. The first layer is the interactive WACC-Stock Price scenario analysis and the second layer is the Monte Carlo Simulation. The scenarios depict the potential range of plausible alternatives; the simulation explores the uncertainty and random variability associated with those alternatives. The model is highly interactive and provides many opportunities for student engagement and learning. These approaches are individually powerful tools for improved financial modeling and risk assessment. Together, they provide a potent mechanism for students to better understand the capital structure decision-making process.

ENDNOTES

[1] The authors are thankful for helpful suggestions and constructive comments from an anonymous reviewer and the Editor, as well as earlier encouragement and critique from attendees at the 2012 joint Annual Conference of the Academy of Business Education and the Financial Education Association.

[2] The base spreadsheet model is available to interested readers upon email request to the corresponding author at iordanis@citadel.edu.

[3]We are planning to expand our model so that the student would also select the type of business risk (using, for example, a combo box) and the spreadsheet will automatically select the debt rating and yield spreads.

[4] Even though NOPAT (Net Operating Profit After Tax) and Net Investment are both income measures, combined they represent the FCFF due to the depreciation expense impact being netted out in both income measures.

[5]Our purpose is not to describe details of Monte Carlo simulation; there are plentiful references that provide such information. One that gives a good overview of both Monte Carlo simulation and Crystal Ball is Charnes (2007).

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