

## The Capital Structure of Firms with Negative EBIT – Applying the MM Propositions

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### Introduction

Even though recent studies have yielded significant insights into the dynamics of capital structure for academic specialists, most of the models are too complicated to be of any use in the business world. Therefore, textbook discussions on capital structure continue either to rely on the classic concept of estimating bankruptcy costs and applying the Modigliani and Miller (MM) propositions (1958, 1963) (see, e.g., Van Horne (2001) and Ross, Westerfield and Jordan (2006)) or to rely on a simple application of the Capital Asset Pricing Model (see, e.g., Brigham and Ehrhardt (2005)).

Both types of analysis (MM and CAPM) state that the optimal level of debt is the point where the value of the firm or its stock is maximized (or its equivalent in equilibrium, where the firm's weighted average cost of capital is minimized). However, each suffers from significant drawbacks in practice. The MM type of discounted cash flow (DCF) analysis is especially problematic when the firm's earnings or EBIT are negative. At the same time, the simple application of CAPM ignores the monetary value of tax benefits as demonstrated by MM (1963). The purpose of this paper is to present a model to identify the optimal capital structure of a firm with negative EBIT by *combining* both the standard Modigliani and Miller (MM) propositions on capital structure and the CAPM.

The remaining of this paper is organized into four sections. The next section briefly discusses the capital structure theories typically found in textbooks and presents the issues raised therein. Section two demonstrates the application of real data in the model. The results and implications are discussed in the following section. Section four concludes the paper.

### Incorporating MM Theories into the Model

A standard corporate finance textbook typically states that the optimal capital structure for a firm is that particular mix of debt and equity at which the firm's value is maximized or its overall cost of financing (i.e. the weighted average cost of capital) is minimized. In mathematical terms, a firm should seek to minimize:

$$\text{WACC} = (\% \text{ debt}) \times (\text{cost of debt})(1 - t) + (\% \text{ equity}) \times (\text{cost of equity}) \quad (1)$$

where WACC is the firm's overall financing cost, % debt + % equity = total assets of the firm, and t denotes the marginal tax rate of the firm.

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While the concept of an optimal capital structure for a firm is easy to grasp qualitatively, most studies or textbooks have failed to provide quantitative guidance regarding the optimal leverage. As such, the findings from these studies are of limited value to practitioners who want to identify the optimal debt level of a firm quantitatively. Most corporate financial theories agree that because of the tax deduction benefits and the lower perceived risk of debt, the cost of debt for a firm is lower than its cost of equity. Accordingly, a firm should use a certain amount of debt to maximize these debt benefits (and therefore lower its WACC). In fact, Modigliani and Miller (1963) show that in a world with taxes, the optimal capital structure is to use 100% debt. On the contrary, Miller (1977) contends that in a world with complex personal and corporate taxes, leverage itself may not affect a firm's WACC at all. Capital structure, therefore, is neither value adding nor value destroying for the firm.

Following traditional models, students are then told that even if debt involves lower costs than equity because of its lower risk and substantial tax benefits, the amounts of debt a firm should incur in the real world are nonetheless limited due to bankruptcy costs. As the level of debt increases, the costs of potential bankruptcy also increase, which eventually will offset the benefits associated with using debt. The optimal capital structure of a firm then is the level of debt at which the expected costs of bankruptcy equal the benefits of using debt rather than equity. This is similar to the well known economic principle that a company should produce a product until its marginal cost equals its marginal revenue of production.

The fundamental problem with this type of traditional DCF analysis is that the expected value of the costs of bankruptcy must be estimated. Expected bankruptcy costs are simply the product of the probability of bankruptcy and the present value of potential bankruptcy costs. Rather than attempting to estimate the probability of bankruptcy by using statistical models and presenting empirical evidence on the potential costs of bankruptcy (both implicit and explicit costs),<sup>1</sup> the typical textbook solution is to “assume” a certain amount of expected bankruptcy costs and then find the optimal capital structure by employing the MM model (see, e.g., Van Horne, 2001).

In the real world, however, the expected bankruptcy costs for a particular firm cannot possibly be assumed or fairly approximated as is typically done in a textbook. Further, a relatively small change in the bankruptcy costs estimate will affect the resulting capital structure choice substantially. The model presented here builds on the insight that by combining the capital asset pricing model (CAPM) and the Modigliani and Miller capital structure theories, one can bypass the necessity of assuming expected bankruptcy costs.

#### A. CAPM (Hamada) Model

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<sup>1</sup> For bankruptcy prediction models, see Altman (1968) and Ohlson (1980).

Extending the basic capital asset pricing theory, Hamada (1969) shows that a firm faces two fundamental risks – business risk and financial risk. Business risk relates to the volatility of a firm's EBITs, whereas financial risk relates to a firm's use of leverage and the resulting effects on the volatility of net income or earnings per share. The Hamada model decomposes a firm's stock beta into business risk beta and financial risk beta.

Presumably, as the level of debt increases, the firm's financial risk beta will increase without any effect on the business risk beta (which is affected by market conditions, location, etc.). Therefore, one can recalculate the stock beta by using the following Hamada function, which implicitly incorporates bankruptcy costs, assuming that the stock market is by and large efficient, as follows:

$$\beta^u = \beta^L / [1 + (1 - t) B/S] \quad (2)$$

where  $\beta^u$  is the pure financial risk beta,  $\beta^L$  is the observed stock beta,  $t$  is the marginal corporate tax rate,  $B$  is the market value of debt for the firm and  $S$  is its market value of equity.

#### B. Modigliani and Miller Model

Meanwhile, Modigliani and Miller's capital structure theory (1963), albeit with restrictive assumptions, provides a useful analytical framework for estimating the benefits of leverage as follows:

$$V^L = V^u + t(B) \quad (3)$$

where  $V^L$  is the value of a company with debt  $B$ ,  $V^u$  is the value of the same company if it does not have any debt, and  $V = B + S$  with  $S$  denoting the market value of equity. Note that the benefit of using debt for a company equals  $t(B)$ , the tax shield on debt.

#### **Application of the Model**

Incorporating both the Hamada function and the Modigliani and Miller function as noted above and recalculating the WACC recursively based on different hypothetical leverages, the combined model here provides a theoretically justifiable method for estimating the optimal level of debt for a firm. This model does not require any explicit assumptions of bankruptcy costs, and the results are quantitative instead of merely qualitative.

Data from a real company is used to emphasize the linkage between the application of academic theories and the real world. A firm listed on NASDAQ, Vicor Corp. is used. To simplify the issues, this firm is chosen primarily because it does not use long-term debt and is relatively small and simple to analyze. Table I presents an actual assignment given to the MBA class. To dovetail with textbook illustrations, the computations here are purely static. That is, the levels of debt are increased at discrete rather than continuous amounts.

All the information about the firm can be obtained from various online sources. The specific data required for this simulation are: stock price, number of shares outstanding and

estimated beta.<sup>2</sup> To demonstrate the model's applicability, data from the 2001 annual report of the firm will serve as a basis for the calculations herein. Table II shows the selected data from the 2001 annual report.

A. Estimating the Market Value of Equity and Debt

Base on the data in Table II, the average stock price is estimated to be \$14.85 by averaging the 4th Quarter 2001 high and low prices as follows:

$$$(17.53 + 12.16) / 2 = \$14.85;$$

Obviously, an argument can be made that an average of all four quarters' prices should be used. But simplicity has its virtue in this exercise since the focus here is to demonstrate how to use this model to identify the optimal leverage.

Next, the market value of equity for the firm is estimated as:

$$\$14.85 \times 42,342,000 \text{ shares} = \$628,778,700;$$

B. Estimating the Beta of the Firm

From various online sources and analysts' reports, the estimated betas of the firm fall in the range of 1.67 to 1.8. Given that this company has no long-term debt and noting that the company's beta estimates are higher than those of the industry average, 1.67 is used instead of 1.8. The reason why the beta estimates for the company is higher than those for the industry as a whole is probably that Vicor is a small company relative to its peers and currently has negative EBIT.

C. Applying the Hamada Model and the MM Propositions

As shown in equation 2, *supra*, Hamada's model can be used to decompose the firm's stock beta into the financial risk beta and the business risk beta. The firm's business risk beta is simply the beta of the firm if it has no financial risk (i.e. the unlevered firm) and can be calculated as follows:

$$\beta^u = \beta^L / [1 + (1 - t) B/S];$$

Here, since Vicor does not use long-term debt, its stock beta is identical to its business beta. Hence, the firm's  $\beta^u$  should be 1.67 as well.<sup>3</sup> Applying CAPM, the firm's cost of equity (and its cost of capital) can be calculated as:

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<sup>2</sup> If the firm has issued long-term debt, then the price of its outstanding bonds and the number of bonds are needed to calculate the market value of its outstanding debt.

<sup>3</sup> One can argue that even if a firm has no debt, it can still get into financial distress. However, the probability of this happening is remote such that one can safely assume that the firm has no financial risk for the purpose of investigating its optimal capital structure. This is a conventional assumption used in the current literature.

$$K_e = 3\% + 1.67(8\% - 3\%) = 11.35\%;$$

and the WACC for the firm currently should be 11.35% as well.

Next, assume that \$50,000,000 market value of debt is now issued, what will be the firm's WACC? Since the goal here is to find the optimal capital structure of the firm, the theoretical size of the firm must be controlled so that any changes in the firm's total value (and the WACC) is due solely to its financing changes. Therefore, the \$50,000,000 proceeds from issuing debt are used to buy back outstanding shares. As such, only the firm's financial structure is changed and nothing else.

However, Modigliani and Miller (1963) show that in a world with corporate taxes, the value of a levered firm equals the value of the unlevered firm and the value of the tax shield. Thus, the market value of the firm will actually increase even if the debt proceeds are merely used to buy back outstanding shares. Increasing leverage can be a value-added exercise as long as the equity holders' risk (and their required rate of return) does not increase disproportionately. Here, with \$50,000,000 of debt, the total value of the firm according to the MM model is:

$$V^L = \$628,778,700 + 0.34(\$50,000,000) = \$645,778,700;$$

and the value of the firm's equity is:

$$S = \$645,778,700 - \$50,000,000 = \$595,778,000;$$

Because of the \$50,000,000 debt, Hamada's model is applied to recalculate the firm's beta as follows:

$$B^L = 1.67[1 + (1 - 0.34)(50,000,000/595,778,700)] = 1.76;$$

Note that with a debt level of \$50,000,000, the value of the firm's equity is \$595,778,000. Many students, not mindful of the MM model, will probably incorrectly use \$628,778,700 - \$50,000,000 = \$578,778,700 as the denominator in the Hamada model. The consequence is that the estimated beta and the resulting WACC are exaggerated.

Now, with an estimated  $\beta$  of 1.76, the firm's cost of equity can be calculated:

$$K_e = 3\% + 1.76(8\% - 3\%) = 11.8\%;$$

Assuming a pre-tax debt cost of 8% as shown in Table I, at \$50,000,000 of debt the firm's cost of capital is estimated as follows:

$$\begin{aligned} \text{WACC} &= (50,000,000/645,778,700)(8\%)(1 - 0.34) + (595,778,000/645,778,700)(11.8\%) \\ &= 11.30\%; \end{aligned}$$

The above iterations are then repeated to estimate the firm's cost of capital at different levels of debt.

### Results and Discussion

The results of the simulation are summarized in Table III. The results indicate that at the \$50,000,000 debt level, the theoretical WACC is minimized at 11.3%. From basic corporate financial theories, we know that the firm's value should be maximized at this point as well since its WACC is minimized. Therefore, the optimal debt level for the firm is \$50,000,000.

This conclusion can be surprising for many since it is generally advantageous to use debt at a higher percentage because debt is tax deductible and because the cost of debt is lower than the firm's cost of equity. Thus, \$50,000,000 of debt appears to be rather low for this firm. So what could account for this relatively low leverage result?

First, note that the firm has a net loss in 2001 rather than net income. In fact, the company has negative EBIT. Therefore, the normal advantage of using debt is much mitigated here. In addition, the number might be skewed because the cost of debt assumptions may not be realistic.

Also, the results here can be used to discuss the validity of capital structure theories. For example, Modigliani and Miller's (1963) conclusion, which suggests that a firm should use a very high percentage of debt, is apparently not supported here because their model does not consider bankruptcy costs and other issues even though the simulation here applies the MM framework. Table III shows that the WACC curve drops first and then eventually rises.

One may wonder why the discounted cash flow (DCF) model is not used at all. Under the DCF analysis, the value of the firm with standard capital structure assumptions such as perpetual cash flows and constant discount rate can be obtained by computing the present value of the firm's cash flows as follows:

$$V = \text{EBIT}(1 - t)/\text{WACC} \quad (4)$$

Once the value of the levered firm is calculated from the MM model and given the EBIT, WACC can be easily estimated from the equation. Theoretically, WACC calculated by the DCF model should match that calculated by CAMP as used herein. In reality, the results will likely differ because of imperfect information. Here, the 2001 EBIT of the firm simply cannot be used because they are negative.

Indeed, it is not appropriate to use DCF valuation in the present case at all (even if 2001 EBIT were positive). The reason is quite simple. The expected costs of bankruptcy must be explicitly estimated in a DCF valuation model. Instead, a combined MM and Hamada model is proposed here because the beta of the firm is used as a proxy for financial distress. Since the calculation of expected bankruptcy costs is tenuous at best and beta presumably takes into

account financial risk of the firm, this paper argues that CAPM can be used to calculate the firm's cost of capital instead, once the MM propositions are incorporated.

It should be noted that the model presented is not meant to be used to find the "true" value of the firm or its "true" WACC. We are only interested in identifying the optimal level of debt within certain parameters. As long as the same assumptions are present in each discrete debt level used in the exercise, the resulting choice of optimal leverage is valid even if the model's assumptions are restrictive.

Finally, the company's ability to incur long-term debt will be limited by the book value of its assets. Most banks and debt investors would have stopped lending to the firm long before its debt level matches its assets' book value. Therefore, the health of the firm's balance sheet may affect the results, albeit in an indirect and subtle manner.

### **Conclusion**

This paper presents a model combining the MM Model and the CAPM to estimate the optimal level of debt for a firm with negative EBIT. Unlike most textbook examples, this model does not require making an assumption on the present value of bankruptcy costs which is often unrealistic. In addition to the theoretical construct, this paper illustrates the model's applicability with a numerical example using financial data from a real company. At present, one of the most frustrating aspects of investigating capital structure is that most research papers provide only qualitative guidance. There is a dearth of applicable quantitative results. This paper therefore fills the gap by providing practical quantitative guidance in identifying the optimal leverage of a firm, even if it has negative EBIT.

**Table I**  
**Capital Structure Simulation Assignment**

You have just been retained by Vicor Corporation, a power module manufacturer, to examine the company's current capital structure. Vicor is listed on NASDAQ and its ticker symbol is VICR. You need to obtain a copy of the annual report (10-K), dated December 31, 2001, which was filed at the end of March 2002. The company's 10-K report can be obtained from EDGAR at [www.sec.gov](http://www.sec.gov). You may use any other sources (online or otherwise) to obtain an estimate of the company's beta and/or market capitalization as long as you state your sources. [Hint: I obtained one estimate of the company's beta from Yahoo-Finance.] To simplify the exercise, we will assume that the average T-bill rate is 3% and the average S&P 500 return is 8%. In addition, Vicor can issue debt at par for an 8% yield at debt levels below \$80 mil., beyond that, the yield will increase to 9%. The firm's marginal tax rate is 34%.

Questions:

In order to estimate the best capital structure for the company, you are asked to calculate the WACCs for Vicor as follows:

1. At its current debt amount;
2. At \$50,000,000 of debt;
3. At \$150,000,000 of debt;
4. At \$300,000,000 of debt.

Based on your calculations, what level of debt is best for Vicor? Are you now convinced that perhaps MM or Miller is right about the capital structure after all?

Note:

You are asked to evaluate the capital structure of Vicor Corp. and to combine the various techniques you learned throughout the semester. You are also asked to justify your results using the theories you learned in this course. The value of this exercise is that there is currently no standard textbook that explains how to realistically run a simulation of the firm's capital structure and the current state of the capital structure theory is unsettled. However, if you are a consultant or a financial analyst for the company, you still have to apply what you learned in class and to put them together in a coherent manner.

**Table II**  
**Selected Data from the 2001 Annual Report**  
**Vicor Corporation**

Income Statement Data:

Net Revenue	\$195,910,000
Income from operations	(5,017,000)
Net Income	(559,000)
Weighted average shares (diluted)	42,342,000

Balance Sheet Data:

Working capital	\$153,159,000
Total assets	289,622,000
Current liabilities	15,341,000
Deferred income taxes	9,444,000
Total liabilities	24,785,000
Stockholders' equity	264,837,000

Stock Price Data:

	High	Low
1Q	\$ 39.94	17.63
2Q	26.09	15.65
3Q	22.85	13.59
4Q	17.53	12.16

**Table III**  
**WACC,  $\beta$ ,  $K_e$  and Firm Value at Different Debt Levels**

Debt Levels	Value of firm <sup>a</sup> (MM with taxes)	$K_d$ <sup>b</sup>	Estimated $\beta$ <sup>c</sup>	$K_e$ <sup>d</sup>	WACC <sup>e</sup>
\$0 mil. (current)	\$628778700	-	1.67	11.35%	11.35%
\$50 mil.	\$645778700	8%	1.76	11.80%	11.30%
\$150 mil.	\$679778700	9%	1.98	12.90%	11.36%
\$300 mil.	\$730778700	9%	2.44	15.20%	11.40%

Notes:

The risk free rate of return is assumed to be 3% and the market risk premium is assumed to be 5%.

<sup>a</sup> Value of the firm is calculated by applying the MM formula:

$$V^L = V^u + t(B);$$

At \$150 mil. of debt,  $V^L = \$628778700 + 0.34(\$150000000) = \$679778700$ .

<sup>b</sup> To simulate the real world, we assume that as the firm increases its borrowing it needs to pay a higher interest rate. Therefore, starting at \$150 mil. of debt, we increase  $K_d$  by 1%.

<sup>c</sup> Estimated  $\beta$  is calculated by applying the Hamada model as discussed in this paper. At \$150 mil. of debt,  $\beta^L = 1.67[1 + (1 - 0.34)(150000000/529778700)] = 1.98$ .

<sup>d</sup> At \$150 mil. of debt,  $K_e = 3\% + 1.98(8\% - 3\%) = 12.9\%$ .

<sup>e</sup> At \$150 mil. of debt,  $WACC = (150000000/679778700)(9\%)(1 - 0.34) + (529778700/679778700)(12.9\%) = 11.36\%$

### References

- Altman, E., 1968, "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy." *Journal of Finance* 23, 589-609.
- Brigham, E. and M. Ehrhardt, 2005. *Financial Management: Theory and Practice*, 11<sup>th</sup> ed., Thomson.
- Hamada, R., 1969, "Portfolio Analysis, Market Equilibrium and Corporation Finance." *Journal of Finance* 24, 19-30.
- Miller, M., 1977, "Debt and Taxes." *Journal of Finance* 32, 266-268.
- Modigliani, F. and M. Miller., 1958, "The Cost of Capital, Corporation Finance and the Theory of Investment." *American Economic Review* 48, 267-297.
- Modigliani, F. and M. Miller., 1963, "Corporate Income Taxes and the Cost of Capital: A Correction." *American Economic Review* 53, 433-443.
- Ohlson, J., 1980, "Financial Ratios and the Probabilistic Prediction of Bankruptcy." *Journal of Accounting Research* 18, 109-131.
- Ross, S., R. Westerfield and B. Jordan., 2006, *Fundamentals of Corporate Finance*, 7<sup>th</sup> ed., McGraw Hill.
- Van Horne, J., 2001, *Financial Management and Policy*, 12<sup>th</sup> ed., Prentice Hall.