Ten Computational or Semantic Issues in the Teaching of Finance

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Abstract

Ten computational or semantic issues commonly encountered in the classrooms while teaching finance to undergraduate and MBA students from major finance textbooks using the *Texas Instruments BA-II Plus Professional* financial calculator and *Microsoft Excel* spreadsheet are discussed. Highlighting and sharing these issues with instructors and students not only can spare them the frustration, but also increase the level of their comprehension and mastery of the materials delivered.

Keywords: CAPM, margin calls, growing annuity, arbitrage, symmetry in currency change, modified duration, sustainable growth rate, *Texas Instruments BA-II Plus Professional* calculator

Issue #1: Lead-lag in the capital asset pricing model, CAPM, rates

Only some finance textbook authors have the Nobel prize-winning Sharpe-Lintner-Mossin CAPM correctly presented as $E(r_i) = r_f + \beta_i[E(r_m) - r_f]$, i.e., with the expectation sign applied to r_i and r_m while the r_f is devoid of the expectation sign. The other authors simply left out the expectation sign. Unfortunately, the expectation sign has its significance. For example, given the following historical data,

Date	r_f	r_m
1/1/20x1	2.0%	6.0%
1/1/20x2	3.2	7.0
1/1/20x3	2.5	6.5

If the beta of firm i, β_i, is given as 1.25, then $E(r_i)$ on 1/1/20x1 is 2 + 1.25(7 - 2) = 8.25. Most students and textbooks would use the 6% instead of the 7% when applying the Sharpe-Litner-Mossin CAPM. Of course, it is assumed that the market correctly expected at 1/1/20x1 the $E(r_m)$ to be 7%.

For those textbook authors who simply dropped the expectation sign in front of r_j and r_m, their simplicity is complicit in perpetuating the mistake that the r_f is known at time t while $E(r_i)$ and $E(r_m)$ are the expected returns for asset i and the market portfolio for time t+1. Any *ex post* testing of the CAPM must take into this lead-lag subtlety.

From a practical standpoint, the strict requirement of having the r_f to lead the $E(r_i)$ and $E(r_m)$ is also consistent with the fact that investors know r_f at the beginning of the period (since all T-bills are sold at discount and therefore the return over the holding period is known at the beginning). The expected return for asset i and expected return for the market portfolio will be known only at the end of the period.

Issue #2: Rounding-off error in solving for price level of margin calls

Many major investment textbooks, including Bodie, Kane and Marcus (2018) among them, erroneously round off the price-level at which margins call will be made. For example, in Bodie, Kane and Marcus, p. 87, problem 10 that is repeated herewith:

You are bearish on Telecom and decide to sell short 100 shares at the current market price of $50 per share.

(a)   How much in cash or securities must you put into your brokerage account if the broker's initial margin requirement is 50% of the value of the initial position?

(b)   How high can the price of the stock go <u>before</u> you get a margin call if the maintenance margin is 30% of the value of the short position?

The solutions correctly give part (a) answer as $2,500. But, we disagree with the answer for part (b) which is given as $57.69 or higher, or [57.69, ∞). We maintain that the answer for part (b) should be $57.69 or lower, or (0, 57.69] algebraically since the word "before" is unambiguous in its intent.

Though the difference seems nuanced, such mistake can be easily turned into a multiple-choice problem in testing a student's true understanding of the issue. At 57.69, the short-sale position is still restricted, not under-margined yet even though it is the last highest price level at which it is restricted.

In short, the regular rounding of the thousandth digit by rounding down a "4" and rounding up a "5" to the next penny cannot be mechanically applied in the margin problem. Instead, financial theory of rounding <u>down</u> to the next penny for <u>long</u> margin and rounding <u>up</u> the next penny for <u>short</u> margin should be applied. Many authors in finance texts seem to commit such "penny" errors by simply applying the rounding rule learned in math without regard for the underlying financial theory.

Issue #3: An oxymoron expression in finance

In too many basic finance textbooks, authors show and derive the formula for the present value of a "*growing annuity*" as $PV = C_1*\{[1 - [(1+g)/(1+r)]^T/(r - g)\}$. In a section or two before they present this formula, the authors have defined annuity simply as a series of <u>*equal*</u> payments for a fixed number of periods. A few students and us have struggled tremendously and chronically with the negation of the implicit "equal" requirement in the definition of an annuity so soon by simply adding an adjective "growing" in front of the word "annuity." Such oxymoron confuses more than it clarifies. The best way to narrate such a cash flow is "a cash flow that grows at g% for T years from CF_0 of $x.yz"

Issue #4: Another oxymoron

In many basic investment textbooks, most authors assiduously and correctly teach the difference between arbitrage and speculation. Some even go as far to use the tradition analogy arbitrage : risk-free :: speculation : risky to highlight the difference between the two terms. However, if we were to perform a simple Boolean search in Google using the two-word expression "risky arbitrage," we will get literally thousands of hits, and some of the usage of this expression was indeed made by some of the distinguished gurus in the profession. We wonder why such lax in using terms that we had tried so hard to differentiate in the finance classrooms. Shouldn't we be more persistent in maintaining consistency in terminology within the profession?

Issue #5: Asymmetric discrete percent currency appreciation and depreciation

Example: If the dollar appreciates from 1.4000 $/€ to 1.2500 $/€, the % appreciation of the dollar is $[(1/1.25 - 1/1.40)]/(1/1.40) = 12\%$, and the euro depreciation is $(1.25 - 1.4)/1.4 = -10.71\%$. Many textbooks fail to recognize such numerical asymmetry. In addition, even more textbooks fail to be able to recognize that such asymmetry can be quickly reconciled by using the continuous model of change where $FV_T = PV*\exp(rT)$. In this particular example, the % appreciation of $ can be solved using $1/1.25 = (1/1.40)*\exp(x)$, $x = 11.3329\%$. For %

depreciation of the €, we solve 1.25 = 1.40*exp(x), x = -11.3329%. Hence, by using the continuous model, the numerical % appreciation and numerical % depreciation can be made symmetric.

Issue #6: Modified duration in BA-II Plus calculator and Microsoft Excel
Given settlement date on May 27, 2010 and maturity date on Nov 15, 2019, 7% p.a. coupon paid semiannually, and yield at 8%, the modified duration given by the "Bond" function of the Texas Instruments BA-II Plus Professional and that given by Microsoft Excel using the **=MDURATION("5/27/2010","11/15/2019",7%,8%,2,1)** syntax are not the same.

Calculator	Modified duration
BA-II Plus Professional	6.714482 years
Microsoft Excel	6.698662 years

So, which is the more correct answer? To find that, let us try settlement date on Nov 15, 2009 so that we can find the modified duration in the table format without having to deal with the complication that arises from accrued interest that arises as result of a fraction of half-year. Unfortunately, now the table format, the BA-II Plus Professional calculator, and the Excel mduration function all yield the same answer at 6.96778193 years. Now, let's try settlement date on Feb 15, 2010 for 19.5 full semi-annum. The table format cannot yield any modified duration due to the factional half-year count, the Excel syntax gives 6.723413 years while the BA-II Plus professional calculator gives 6.849355 years. It seems now plausible to conclude that the Texas Instruments BA-II Plus Professional calculator tends to give an answer that is a slight overestimate of modified duration whenever a fractional half-year is involved.

Issue #7: The "A" in WACC is a misnomer. The correct word is "M" for marginal.
Given $w_d=.6$ and $w_s=.4$, and break or jump point is at \$5m. Also given that cost of debt, $r_d=10\%$ at all levels, cost of retained earnings, $r_{s,RE}=12\%$, and cost of new equity, $r_{s,new} = 18\%$, and tax rate is 30%.
What is the WACC at \$8m?
What is the WMCC at \$8m?

Answers: $WACC_{(0,5m)} = .6(10\%)(1-.3) + .4(12\%) = 9\% = WMCC_{(0,5m)}$
$WMCC_{(5m,8m)} = .6(10\%)(1-.3) + .4(18\%) = 11.4\%$.
Therefore, WACC at \$8m = (5/8)(9%) + (3/8)(11.4) = 9.9%
and WMCC at \$8m = 11.4%.

Unfortunately, most textbooks do not differentiate between WACC from WMCC. We posit that WACC is very much a misnomer; the more correct English word should have been "marginal", not "average." Why? The jump occurs at \$5m, and therefore the weights are (5/8) and (3/8) of 9% and 11.4% respectively. Only in this way the expression WACC is more correct semantically!

Issue #8
This mistake has to do with *Texas Instruments BA-II Plus Professional* calculator and its advanced users who use it to find the present value of the oxymoron "growing annuity." A numerical example will make the mistake easy to follow.
Given discount rate, r=15%, growth rate, g=5%, T = 4 years, C_0=\$100. Find the present value of the 4-year growing annuity, i.e., C_1 through C_4.

From the given information, we have C_1=105.00; C_2= 110.25; C_3=115.7625; C_4=121.550625.

Using the formula provided by most textbook, we have PV = $C_1 * \left[\dfrac{1 - \left(\dfrac{1+g}{1+r} \right)^T}{r-g} \right]$. So, PV =

$105*[1-(1.05/1.15)^4/(.15 - .05)] = 320.28$.

Next, we use the CF key worksheet as if we would calculate the NPV. So, within the CF worksheet, we enter CF0=0, C01=105; F01=1; C02=110.25; F02=1; C03=115.7625; F03=1; C04=121.550625; F04=1; I=15; cpt NPV=320.28.

Advanced users of the BA-II Plus calculator will recognize that the growing annuity problem can be solved using the five keys in the third row by simply entering the *real* interest rate in percent into the I/Y key. So, from the given data in this problem, we simply recognize the 15% as the nominal rate, the 5% growth rate as the inflation or growth rate, and therefore the *real* rate will be [(.15 – .05)/1.05] *100 = 9.523809% and entering it into the I/Y key. Next, we enter N=4. Now, the formula as well as the Gordon's model will dictate us to enter 105.00 into the PMT key. But, if we do so, we will get PV=336.30. However, if we enter PMT=100 instead of 105, we will get the correct answer of 320.28 as we had obtained before this. This is because since we entered I/Y=9.523809% as the *real* rate, the PMT has to be a *real*, or inflation-adjusted, number too.

From the present value of the growing annuity formula above, if we impose the limits such that T→∞, and as long as g<r, then the (.)^T term vanishes to zero. We are left with the typical Gordon's model of perpetual constant-growth-rate where C_1=105, r=.15, g=.05, and therefore PV=\$1,050. If we enter N=9,999,999,999 to proxy for infinity; I/Y=9.523809%; PMT=100, then the BA-II Plus calculator give us PV=1,050. However, if we enter PMT=105, it will give us PV=1,102.50 which is obviously wrong though it is consistent with the Gordon's model result in using D_1 and not D_0 in the numerator. This again proves the importance of using the *real* number, and not the nominal number.

Issue #9: Inconsistent answer with Texas Instrument BA-II Plus calculator
The inconsistent answers arise from the Beginning and Ending modes of the Texas Instrument BA-II Plus model of the calculator in solving the following problem.

Source: Test bank that accompanies Brigham and Ehrhardt, 14th edition, 2014, Cengage Learning, Chapter 4, question 121.

Your aunt has \$500,000 invested at 5.5%, and she now wants to retire. She wants to withdraw \$45,000 at the beginning of each year, beginning immediately. She also wants to have \$50,000 left to give you when she ceases to withdraw funds from the account. What is the maximum number of \$45,000 withdrawals that she can make and still have at least \$50,000 left in the account? (Hint: If your solution for N is not an integer, round down to the nearest whole number.)

A. 13   B. 14   C. 15   D. 16   E. 17

Using the Beginning mode, we enter:
I/Y=5.5; PV = -500000; PMT = 45000; FV = 50000; CPT N, we get N= 15.05

Hence, C is the correct answer.

Using the Ending mode, we enter:
I/Y = 5.5; PV = -455000 (= –500,000 + 45,000); PMT = 45000; FV = 50000, CPT N, we get N = 13.99

So, if we add in the extra payment which causes the $500,000 to decrease to $455,000 at t=0, we should get the answer as 14.99, and B will be the correct answer.

Using the Microsoft's Excel spreadsheet's function syntax of =NPER(5.5%,45000,-500000,50000,1), we get the same answer as the BGN mode at 15.0549.

I wonder how Texas Instruments' software engineers will reconcile these two inconsistent answers in their product.

Issue #10: NI_1 and TE_0 in g=b*ROE are asynchronous

In almost all finance texts, return on equity, ROE, is defined as the ratio of net income, NI, to total equity, TE. Implicit in the definition is that both NI and TE are synchronous, i.e., they come at end-of-period values from the income statement and balance sheet respectively. Many of these finance texts, (except Ross, Westerfield and Jordan, and Ross, Westerfields and Jaffe), then proceed to present the sustainable growth rate, g, as $g = b * ROE$ where b is the plowback or retention ratio. We show here that this simple estimate of g implies that the ROE is indeed defined asynchronously, i.e., $ROE = NI_1/ TE_0$. Devoid such asynchronous definition in the ROE, sustainable growth g should be $g = (b*ROE)/(1 – b*ROE)$.

$$\text{From } g = \frac{bROE}{1-bROE} = \frac{\dfrac{RE_1}{NI_1} * \dfrac{NI_1}{TE_1}}{\dfrac{TE_1}{TE_1} - \dfrac{RE_1}{NI_1} * \dfrac{NI_1}{TE_1}} = \frac{RE_1}{TE_1 - RE_{.1}}$$

Since $TE_1 = TE_0 + RE_1$, therefore $TE_0 = TE_1 – RE_1$ which we substitute into the denominator, we will get:

$$g = \frac{RE_1}{TE_0} = \frac{RE_1}{NI_1} \frac{NI_1}{TE_0} = \frac{bNI_1}{TE_0} = b * ROE$$ where the total equity is coming from the beginning-of-year balance sheet.

Many finance texts continue to present the g=b*ROE model without highlighting the asynchronous difference between net income in the numerator and total equity in the denominator. Also closely related to the g=b*ROE equation is the additional funds needed, AFN, equation that we teach under Financial Planning chapter. Brigham and Ehrhardt (2014) presents AFN as:

$$AFN = \left(\frac{A_0^*}{S_0} - \frac{L_0^*}{S_0}\right)\Delta S - S_1 M (1 - payout\_ratio)$$

where
A_0^* and L_0^* are spontaneous assets and liabilities;
S_0 = sales at t=0, S_1 = sales at t=1
ΔS = change in sales = gS_0
M = profit margin = NI_1/S_1,

(1 – payout ratio) = b = retention or plowback ratio

At economic equilibrium, AFN = 0. We can substitute ΔS by gS_0, substitute M by NI_1/S_1, and then isolating g, we will get:

$$0 = \left(\frac{A_0^* - L_0^*}{S_0} \right)(gS_0) - b\left(\frac{NI_1}{S_1} \right)S_1 \text{ which implies}$$

$$g = \frac{bNI_1}{A_0^* - L_0^*} = \frac{bNI_1}{TE_0} = bROE_{1,0} \text{ since (Assets – Liabilities = Total Equity) is the universally-}$$

accepted balance sheet identity.

Hence, the AFN equation is a mere variant manifestation of the g=b*ROE model.

Conclusion

We hope the finance faculty will find these issues important enough to illuminate them to their students who will later become practitioners. We also hope that authors who write first editions or revise future editions will incorporate these issues into their texts. This update applies to the CFA Institute too as its curriculum still uses g = b*ROE model without recognizing the asynchronous numerator from the denominator. Indeed, the CFA Institute defines ROE_1 as $NI_1/[(TE_0+TE_1)/2]$. Lastly, we also hope Texas Instruments BA-II Plus financial calculator's software engineers will rid the inconsistency of the modified duration estimates on non-coupon-paying dates so that they become consistent with those of the Microsoft Excel.

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