A Method for Teaching Overinvestment and Underinvestment Problems in Corporate Finance Courses

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One of the most important concepts in corporate finance is agency theory. When the financiers of a firm are not also the managers of the firm, the incentives of different financiers (lenders and owners) often conflict. One of the biggest problems in agency theory is that of overinvestment and underinvestment due to misalignment of shareholder and bondholder incentives. While this problem has many real applications, the underlying concepts frequently seem quite abstract to business students. This paper presents an implementation of a simple numerical spreadsheet model that can clearly illustrate the conflicting incentives of lenders and owners that lead to overinvestment and underinvestment.

INTRODUCTION

Since this is an abstract model, we remove everything that is not necessary to illustrate the problem. The agency problem exists because debtholders have a ceiling on how much they receive from a project, and therefore do not benefit from a risky project that has a potentially high payoff but also a potentially low payoff. The shareholders have a residual claim that provides high payoffs when the firm does well. When the firm does poorly, the shareholders have a floor of zero (no payoff), while debtholders can see the value of their claim decrease in value. This results in a conflict between shareholders and bondholders, where shareholders prefer to take risky projects that have a possibility of a high payoff, while debtholders don't like risky projects because there is an increased chance of receiving less than the "ceiling" of the principal value plus any interest.

In this model, the firm lasts one year. At the beginning of the year, the lenders loan $60 and the owners invest the remainder, $40. At the end of the year, the owners (equity) and lenders (debt) liquidate the firm; the lenders receive payment first, up to a maximum of $60; the owners receive any residual cash. The project is a risky project, with a 50/50 chance of an up or down market. The discount rate is 0%, simplifying the calculations significantly. The project is a risky project that costs $100, all the cash that is available to the firm. The owners have to decide whether to invest in the project. Because lenders provided some of the funding, there is a lender-owner (bondholder-shareholder) agency problem, with shareholders willing to take on risky projects that bondholders would prefer to reject.

RISKLESS FIRM WITHOUT THE PROJECT

Students begin by entering the text from Figure 1 into an Excel spreadsheet.

Figure 1: Title and Introductory Comments.

	A	B	C
1	**Overinvestment and Underinvestment: Up/Down Markets and**		
2	**Expropriation**		
3			
4	Base firm, lasts one year, then liquidated.		
5	The firm consists of $100 in cash, supplied by two investors, a		
6	debtholder and a shareholder, and one project that the firm		
7	can accept or reject.		
8	50/50 chance of up or down market		

One of the features of this spreadsheet is that the instructor can change many of the variables by using spin buttons. We will demonstrate how to add a spin button in Excel 2016. First, enter the items in figure 2 into a blank spreadsheet. Since we will be using a number of spin buttons, we will first add a spin button icon to the quick access toolbar. To accomplish this, click on the "Customize Quick Access Toolbar" icon. Scroll down to "More Commands." Select "More Commands." Choose "All Commands." Scroll down to "Spin Button (Form Control)." Select "Spin Button (Form Control)," then double-click on "Add." Finally, click ok (not illustrated) at the lower right-hand of the Excel Options pop-up menu. This process adds the spin button icon to your toolbar. After doing all of that, change the tab name to "1."

Figure 2: Customize Quick Access Toolbar Icon.

Figure 3: Customize Quick Access Toolbar

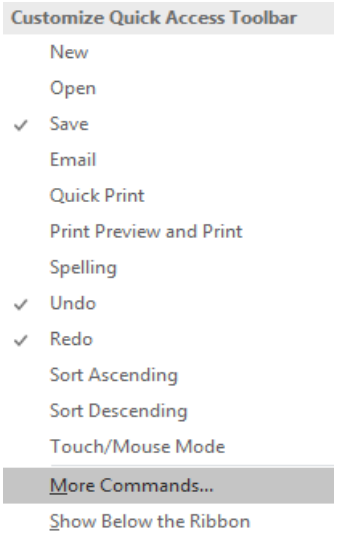


Figure 4: Excel Options, All Commands, Spin Button (Form Control)

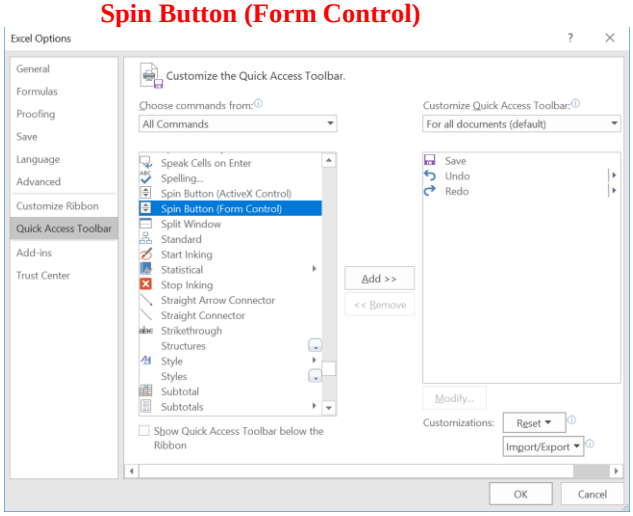


Figure 5: Spin Button Icon

Debt financing is the first variable of interest. Type the entries in Figure 6 into the spreadsheet. This will be the first part of the spreadsheet, where we will calculate the outcome if the firm does not take the project. In this case, the cash flow is $100 (no uncertainty).

Figure 6: First Model Entries

	A	B
10	**Outcome if the firm does not take the project**	
11	Debt financing, face value (r = 0)	
12	Cash flow at time 1, up market	
13	cash flow at time 1, down market	
14	Payment to the lenders at time 1 (up)	
15	Payment to the owners at time 1 (up)	
16	Payment to the lenders at time 1 (down)	
17	Payment to the owners at time 1 (down)	

Insert a spin button in cell C11; this allows the instructor to easy manipulation of the capital structure of the firm. First, click on the spin button icon; use the resulting "+" shape to draw a spin button. Go to the upper left-hand corner of cell C11, hold down the left mouse button, and drag to the lower right-hand corner of the cell. Then, release the left mouse button. This creates a spin button. Click on a blank cell somewhere else in the spreadsheet, then come back to cell C11 and right-click on the spin button. This will open a menu illustrated in figure 7. Choose "Format Control." The "Format Control" menu will appear next (See Figure 8). Click on the box next to the "Maximum Value" and enter "100" (no dollar sign, just use currency formatting). In this first example, the value of debt will only vary between $0 and $100. Click inside the "Cell link" box and then click on cell B11. (See Figure 8). Click "OK." Now the spin button will send its raw output to cell B11. Click on a blank cell somewhere else in the spreadsheet, then come back to C11. You can hold down the up arrow on the spin button in C11 until the spin button output in cell B11 reaches $60. If the value goes too high, you can click on the down arrow on the spin button to lower the value back down to $60.

Figure 7

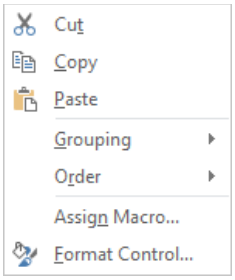
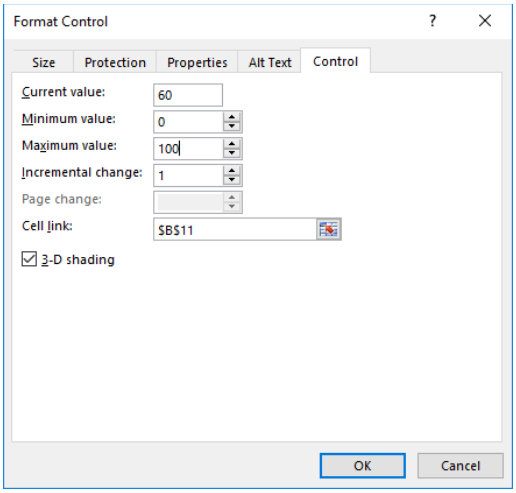


Figure 8: Format Control



In B11 and B12, enter the values "100" and "100," respectively (again, no dollar sign is necessary). These will be constant in this first example (The cash flow is certain at $100). Next, we need to calculate the value of the payments to the lenders and the owners. For the owners, in the "up" state, the payment in cell B15

= B12 – B11

For the owners, in the "down" state, the payment in cell B17

= B13 – B11

The payment to the lenders at time 1, for both the "up" and "down" states, in cells B14 and B16, is

= B11

The result is displayed in Figure 9.

Figure 9: Outcome if the Firm Does Not Take the Project.

	A	B	C
10	**Outcome if the firm does not take the project**		
11	Debt financing, face value (r = 0)	$60	
12	Cash flow at time 1, up market	$100	
13	cash flow at time 1, down market	$100	
14	Payment to the owners at time 1 (up)	$40	
15	Payment to the owners at time 1 (down)	$40	
16	Payment to the lenders at time 1 (up)	$60	
17	Payment to the lenders at time 1 (down)	$60	

It will be useful to make a stacked graph of the firm with no project in order to compare with the graph of the firm with the project that will be created later. Enter the text "Up Market" in cell A29 and "Down Market" in cell A30. These will be the horizontal axis labels for both the graph of the firm with no project and for the graph of the firm with the project. Next, highlight cells B14 and B15. Click on the Insert tab, choose "Charts," then "All Charts, then choose "column and stacked column." Click on the stacked bar chart, then click OK.

Figure 10: Insert Chart, Stacked Column

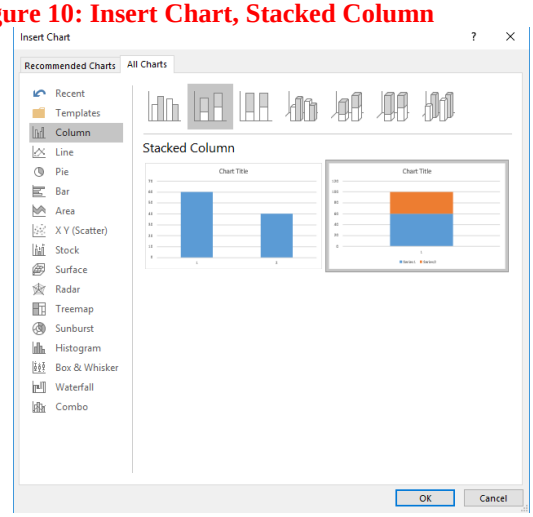
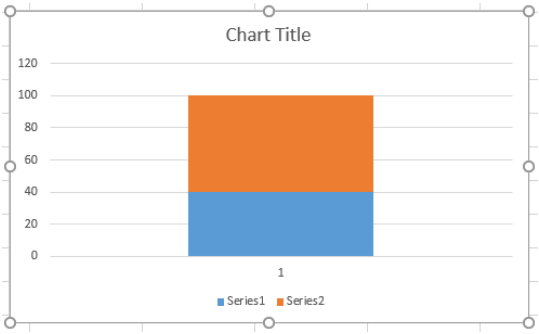


Figure 11: Stacked Bar Chart with no Labels and Only One State



Double-click on the "Chart Title" and enter "Stacked Chart, Debt and Equity with no Risky Project." Then, right-click on the chart and choose "Select Data." A menu will open, entitled "Select Data Source." Go to the "Legend Entries (Series)." Click on "Series1," Then click "Edit." For the series name, type "Debt" and click "OK." Next, add the value of debt for the "up" state. In "Series values," change the contents to

=('1'!$B$14,'1'!$B$16)

Series2 is similar. Label Series2 "Equity." Go to "Select Data" again, then "Select Data Source. Click on "Series2," then click "Edit." For the series name, type "Equity" and click "OK." Next, add the value of debt for the "up" state. In "Series values," change the contents to

=('1'!$B$15,'1'!$B$17)

While "Select Data Source" is still open, go to the right-hand side under "Horizontal (Category) Axis Labels." Click on "Edit." The axis labels box like Figure 12 should appear. Click on the "Axis Label Rang," delete any text that is already in the box, then highlight cells A28:A29 and click "OK." The "Select Data Source" box should look like Figure 13. Then, click "OK." Finally, right-click on the vertical axis, choose "Format Axis," then change the minimum and maximum bounds to 0 and 200. Change the major units to 50 (if Excel doesn't do that automatically). You might want to change the font sizes on the axis labels to make it easier to read. The graph should look like Figure 14.

Figure 12: Axis Labels

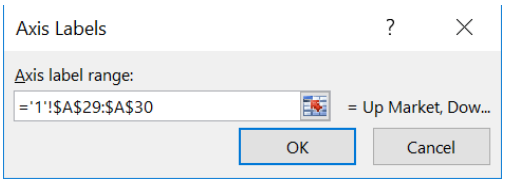


Figure 13: Select Data Source after Creating Labels for the Graph

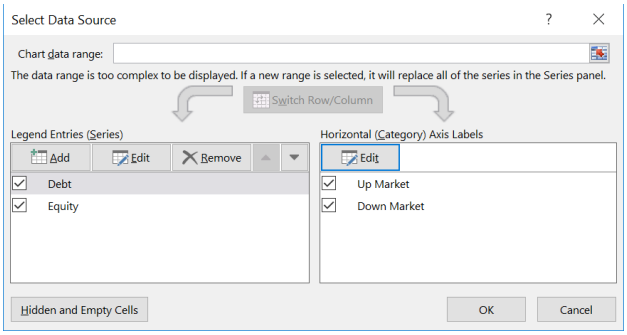
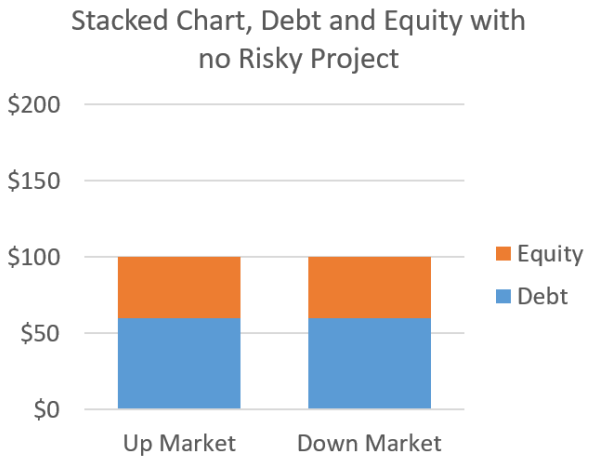


Figure 14: Stacked Chart for the Firm without the Project



THE FIRM TAKES THE RISKY PROJECT

The next step is to look at the project. For this project, cash flows are allowed to vary in both the up state and the down state. Enter the following text and spin buttons. Set the maximum values of the spin buttons to $200 so that they will fit on a graph with the same range as in Figure 14. The expected value in cell B22 should be

= B20 * 0.5 + B21 * 0.5

Since the interest rate is zero for this example, the calculation of the NPV is straightforward. The NPV in cell B23 should be

= B22 – 100

Figure 15: Project Cash Flows in Up and Down Markets

	A	B	C
19	**Project**		
20	Cash flow at time 1, up market	$160	
21	cash flow at time 1, down market	$40	
22	Expected CF at time 1	$100	
23	NPV	$0	

The capital structure and the payoff to debtholders is the next part of the spreadsheet. Enter the following text and spin button. Put the raw output from the spin button into cell B26.

Figure 16: Capital Structure and Payoff to Debtholders

	A	B	C
25	**Capital structure**		
26	Debt financing, face value (r = 0)	$60	
27	Payoff to debtholders at time 1		
28	Up Market	$60	
29	Down Market	$40	
30	Expected payoff	$50	

Set the spin button to $60. The debtholders have a required payoff equal to $60, similar to the previous example. The maximum that debtholder will be paid is $60. However, if there is a down market, the debtholders will receive only $40, because that is all the firm receives in the down market. This spreadsheet will be a dynamic spreadsheet that updates when the face value of the debt is changed.

If the cash flow generated by the firm at the end of the period is greater than $60, debtholders receive $60 and shareholders receive the residual cash flow. If the cash flow generated by the firm is less than or equal to $60, debtholders receive all the cash flow generated by the firm and shareholders receive nothing. Set the value of the debt in B28 equal to

=MIN(B20,B26)

Set the value of the debt in B29 equal to

=MIN(B21,B26)

The next step is to calculate the payoffs to the shareholders in each state. Enter the text in column A from Figure 17. The shareholders have a residual claim to all the cash that is left over after the bondholders are paid. In the up market, the firm is worth $160, so shareholders receive the difference of $160 - $60 = $100. In the down market, the firm is worth only $40, so shareholders get nothing. The expected payoff is just the average of the two values. More generally, set the payoff to shareholders in the up market in B33

= B20 – B28

and set the payoff to shareholders in the down market in B34

= B21 – B29

Set the expected payoff equal to the average,

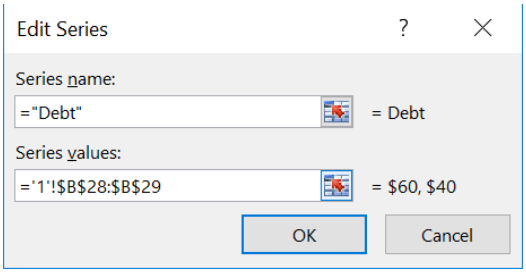
= 0.5 * B33 + 0.5 * B34

Figure 17: Payoff to Shareholders

	A	B
32	Payoff to shareholders at time 1	
33	up market	$100
34	down market	$0
35	Expected Payoff	$50

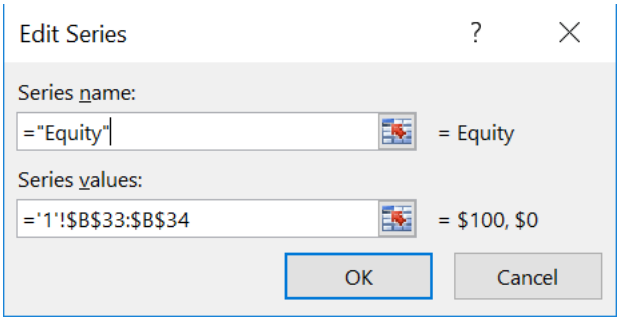
Insert another stacked column chart similarly to the case of no project and no risk examined earlier. Right-click on the chart and choose "Select Data." Remove any existing legend entries, then add the data as follows.

Figure 18: Edit Series, Debt



Enter "Debt" in the "Series name." Clear any previously existing text in the "Series values" and then left-click on cell B28, hold and drag to cell B29, and release. The "Edit Series" input box should look like Figure 18. Then, click "OK."

Figure 19: Edit Series, Equity



Again, right-click on the chart and choose "Select Data." Remove any existing legend entries, then add the data as follows.

Clear any previously existing text in the "Series values" and then left-click on cell B33, hold and drag to cell B34, and release. The "Edit Series" input box should look like Figure 19. Then, click "OK."

From the "Select Data Source" menu, on the right-hand side, just under "Horizontal (Axis Category) Labels, click on "Edit." In the "Axis Labels" popup, clear any existing text, then highlight cells A28:A29 (or cells A33:A34) and click "OK."

Similar to the risk-free example, set the vertical axis range from 0 to 200 and change the font sizes of the text if they are too small.

Click on the graph once to see the menu to the right side of the graph, as in Figure 20. Click on the "+" icon, then click on "Chart Title." Type "Stacked Chart, Debt and Equity with the Risky Project." The graph should now look like Figure 21.

Figure 20: Chart, After Selecting with Mouse, Illustrates the Menu to the Right of the Chart

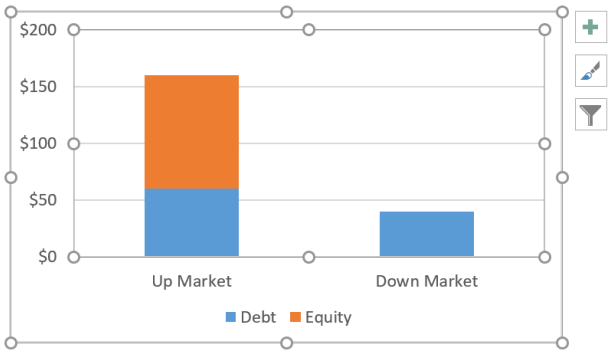
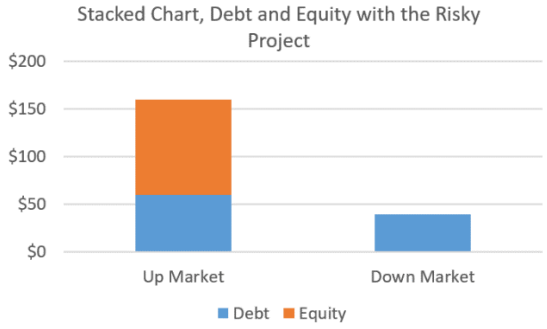


Figure 21: Stacked Chart with Project



NPV AND EXPECTED PAYOFFS TO SHAREHOLDERS AND DEBTHOLDERS

Enter the text from column A in Figure 22 into the spreadsheet. For the firm with the project, the initial payment is $100. The total expected cash payment at the end is also $100. Enter

=B23

in cell B37. For the expected payoff to shareholders without the project, recall the first part of the project, where the payoffs without the project are calculated. Take the weighted average of the payoffs to shareholders for this case. Enter

=B14*0.5+B15*0.5

in cell B38.

For the payoff to shareholders with the project, take the weighted average of the payoffs to shareholders for the firm with the project. Enter

=B33*0.5+B34*0.5

in cell B39.

Calculate the increase (or decrease if negative) by taking the difference of the expected payoff to shareholders with the project and without the project. Enter

=B39-B38

in cell B40.Perform a similar set of calculations for debtholders. Enter

=B16*0.5+B17*0.5

in cell B42. Enter

=B28*0.5+B29*0.5

In cell B43. Enter

=B43-B42

in cell B44.

After calculating the expected payoffs and expected changes in shareholder and debtholder value, calculate the net value created (or destroyed if negative) by adding the changes in shareholder value and debtholder value. Enter

=B40+B44

Figure 22

	A	B
36		
37	NPV	$0
38	E[Payoff], shareholders (w/o project)	$40
39	E[Payoff], shareholders with project	$50
40	Increase (decrease) in shareholder value	$10
41		
42	E[Payoff], debtholders (w/o project)	$60
43	E[Payoff], debtholders with project	$50
44	Increase (decrease) in debtholder value	-$10
45		
46	Net value created	$0
47	ΔE[Payoff], shareholders' expropriation	$10

APPLICATIONS

The instructor (and students) can use this spreadsheet to illustrate many examples of agency conflicts between shareholders and debtholders. First, change the project cash flow in the up market to $166 in cell B20. This changes the expected cash flow at time 1 to $103 and the NPV to $3. The bondholders still experience the same decrease in debtholder value (see cell B44) even though the project has a positive NPV.

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