

2014

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## Recommended Citation

Zhang, Chengping, "Incorporating Powerful Excel Tools into Financial Teaching" (2014). *Faculty Publications - School of Business*. Paper 51.

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# Incorporating Powerful Excel Tools into Finance Teaching

Chengping Zhang

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## Abstract

*Data Table, Charts, Scenario Manager, Goal Seek, and Solver are powerful Excel tools in solving financial problems. Incorporating these tools into finance teaching can help students understand finance concepts intuitively, and bridge the gap between financial theories and real-world applications. The learning goals defined for an Excel-integrated finance course have all been achieved. Students who took this course are more confident on their Excel skills and financial knowledge. This paper demonstrates how to effectively use Excel tools to teach key finance concepts, such as financial statement analysis, time value of money, stock and bond valuation, capital budgeting, portfolio theory, and financial derivatives. To prepare business students with Excel skills needed in the job market, business schools should promote to integrate Excel into other business core and major courses when appropriate.*

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# Incorporating Powerful Excel Tools into Finance Teaching

## INTRODUCTION

Excel skills are continually ranked high by current and prospective employers. Yet, many business schools do not offer Excel classes or integrate Excel into their business courses. Most students do not have the motivation to explore and learn Excel by themselves. Some self-motivated learners can be fairly proficient in Excel after self-studying, but they may still lack a sense of how Excel can be applied in the real business world. To equip students with Excel skills they need to be successful in their careers, business schools should consider integrating Excel into business core and major courses as part of curriculum improvement.

With an Excel element, lectures are more effective, and students are more actively engaged in the classroom. Carini, Kuh, and Klein (2006) show that student academic performance and learning outcomes are positively correlated with student engagement. An Excel-integrated finance course not only helps students understand financial concepts or theories intuitively, but also prepares students with Excel and modeling skills needed for success in college and career.

Incorporating Excel into finance courses has proven effective and efficient in student learning process. All learning goals defined for an Excel-integrated Financial Analysis and Strategy course have been achieved. Confirmation occurred on the achievement of the AACSP Assurance of Learning requirement of providing direct measures of learning. The percentage of students that demonstrated the abilities defined in the six learning goals ranged from 78% to 94%, with an average of 87%, all exceeding the desired threshold level of 70%. In an end-of-semester survey, more than 94% of the students agreed or strongly agreed that integrating Excel in the course deepened their understanding of the most difficult finance concepts, such as internal rate of return, crossover rate, efficient portfolio, and implied volatility. They also agreed or strongly agreed that this course prepared them well for their future job/career.

In this paper, I use detailed examples to demonstrate how to incorporate some of the most powerful Excel tools into finance courses. These tools can help professors teach finance more efficiently and effectively in the classroom. For example, Data Table is a great tool for sensitivity analysis. With the help of the Data Table tool, we can show students how the price of a stock changes with the required rate of return, or how a bond price changes over time. The Scenario

Manager is an excellent tool for evaluating portfolio performance under different market conditions. The Solver tool is useful to determine an efficient portfolio with and without short sale constraints. The Goal Seek tool can help students find break-even points, the crossover rate for two capital budgeting projects, or the implied volatility of an option. Additionally, the process of using Solver or Goal Seek will reinforce students' understanding of these key financial concepts.

Benninga (2008) and Holden (2012) have published a couple of books on financial modeling using Excel. Their books can be used as a supplementary material going with general corporate finance or investment courses, but they are not appropriate stand-alone textbooks for these courses. Besides, with busy teaching and research schedule, it is almost impossible for a finance professor to go over these books. This paper provides a quick guide to incorporating the most useful Excel tools into finance instruction. After investing a couple of hours practicing these tools, readers will find these tools to be readily incorporated into their teaching and learning process.

The paper is organized as follows. First, I introduce each of these Excel tools in this order: Data Table and Chart, Scenario Manager, Goal Seek, and Solver. For each tool, one or two applications relevant to some key finance concepts are presented with detailed steps and screenshots. Next I suggest how to implement Excel integration in the classroom. Then the learning goals and outcomes from an Excel-integrated Financial Analysis and Strategy course are presented before the paper concludes.

## DATA TABLE AND CHARTS

Students often have difficulties in understanding the relationship between two or more financial variables, especially when the relationship is nonlinear. For example, some students mistakenly think that for a lump sum, if the time period doubles, keeping present value and interest rate constant, the future value will double as well. They do not realize or understand the nonlinear relationship between future value and time periods due to the compounding effect (interest earned on interest).

Fortunately, Excel offers a very powerful sensitivity analysis tool called Data Table, which can be readily used to analyze how a change in one variable affects another variable. Data Table combined with Excel's Chart feature can readily help students understand and visualize the nonlinear relationship between future value and compounding period.

We begin with a spreadsheet to calculate the future value of \$1 in 6 years if the interest rate is 4.50%, as illustrated in Figure 1. The actual number used for the compounding period does not matter here. We can use any arbitrary number and we will still get the same data table and graph. In cell B4, we input `"=FV(B1,B2,0,-1)"`<sup>1</sup> and find that the future value of \$1 in 6 years is \$1.30 when the interest rate is 4.50%.

Insert Figure 1 about here

What would be the future value if the compounding period is 2, 4, 8, 10 or any other number of years? To examine the impact of a change in the compounding period on the future value, we can change cell B2 to another specific period that we need. Then cell B4 will reflect the corresponding future value automatically. But this will not give us a whole picture because we can only see one future value for a certain time period at a time.

Data Table provides an effective way to find the future values for a series of time periods simultaneously. We first teach students to fill a series of time periods in the cell range D4:D14.<sup>2</sup> Since these numbers are arranged in a column, the time period is a column input variable. We then insert a cell reference in E3 to the future value in B4.<sup>3</sup> Next, we select cells D3 through E14,<sup>4</sup> click on the "What-If Analysis" button on the **Data** tab, then click "Data Table..." from the drop-down list.<sup>5</sup> A dialog box opens up, as shown in Figure 1. Leave the "Row input cell" field blank, and refer the "Column input cell" to the original input variable cell (B2), and click "OK". Excel internally substitutes each time period in D4:D14 into cell B2, and automatically calculates the corresponding future values in E4:E14.

Figure 2 shows the complete data table. This is a one-input, or one-dimensional data table since time period is the only input variable. From the table, students can see that if we double time period from 6 to 12 years, the change in future value from the initial balance (the present value) is increased from \$0.30 to \$0.70, which is more than doubled. Using the Chart tool to plot future values (vertical axis) and time periods (horizontal axis) on a graph, we get an upward curve instead of a straight line. Clearly, the relationship between future value and time is nonlinear. For a one-year increase in time period, the increase in future value is higher in later years. The reason is the compounding effect, as more interest is earned in later years due to interest on the previously earned interest.

Insert Figure 2 about here

Two-input, or two-dimensional data table can be used to examine the relationship between one output variable with two input variables. For example, we can show students how the price of a bond changes with respect to interest rate and time to maturity at the same time in a two-input data table.

We start with a spreadsheet to calculate the price of a 10-year semi-annual coupon bond with 7% coupon rate and \$1,000 par value, when the yield to maturity is 5%. Cell B5 is set to 2 for semi-annual coupon bonds, indicating there are two coupon payments per year. For annual bonds, we just need to set B5 to 1. In cell B8, we input “ $=PV(B2/B5, B3*B5, B4*B6/B5, B6)$ ”<sup>6</sup> and find that the bond price should be \$1,155.89 as shown in Figure 3.

Insert Figure 3 about here

Next, we enter interest rates 3%, 4%, ..., 12% in cells D3:D12, and time to maturity from 10 years (when the bond is first issued) to 0 (when the principal must be repaid) in cells E2:J2. Because interest rate data are displayed in a column, the interest rate is a column input variable. Time to maturity data are in a row, so it is a row input variable. We click the cornerstone cell at the intersection (D2 in this case) of the row and column input variables, input “=”, then click the bond price cell B8. This links the cornerstone cell to the bond price, which is a function of interest rate and time to maturity. Select D2:J12, click the “What-If Analysis” button on the **Data** tab, then click “Data Table...”.

When the “Data Table” dialog box pops up, click the maturity cell B3 to enter the absolute cell address, \$B\$3, in the “Row input cell” text box; move the mouse pointer to the “Column input cell” text box, and then click interest rate cell B2 to enter \$B\$2 in the text box.

Click “OK”. Excel calculates the bond price for each pair of interest rate and time to maturity and generates the whole table automatically as shown in Figure 4.

Insert Figure 4 about here

After spending a couple of minutes generating the table, we now can teach students a lot of important features about bond valuation using this table.

1. When the interest rate is lower than the coupon rate (rows 3-6), the bond price is higher than the par value (a premium bond); when the interest rate is equal to the coupon rate (row 7), the bond price is the same as the par value (a par bond); When the interest rate is higher than the coupon rate (rows 8-12), the bond price is lower than the par value (a discount bond).

2. For a given time to maturity, there is an inverse relationship between bond price and interest rate (yield to maturity) as shown in each column. That is, bond price increases as interest rate drops. We can visualize this by plotting the bond prices for a given time to maturity. Figure 5 shows an apparent inverse relationship between bond price and interest rate when there is 10 years left to maturity using the data of column E in Figure 4.

Insert Figure 5 about here

3. If the market interest rate remains unchanged, the price of a premium bond declines over time and equals to its par value at maturity (rows 3-6); The price of a par bond remains constant over time (row 7); and the price of a discount bond increases over time and equals to its par value at maturity (rows 8-12).

4. Column J shows that, at maturity, the price of any bond equals to its par value. This is because that, at maturity, the expected cash flow from the bond is just the par value repayment on that day.

In summary, Data Table and Charts tools, when used together, can help students visualize and understand many important relationships in finance such as:

1. Present value versus interest rate and/or number of periods;
2. Future value versus interest rate and/or number of periods;
3. Stock price versus required rate of return and/or dividend growth rate;
4. Bond price sensitivity to market interest rate and/or time to maturity;
5. The relationship between expected return and risk (standard deviation for Capital Market Line (CML) or beta for Security Market Line (SML));

6. NPV profile of a proposed project (NPV vs. discount rate);
7. Payoff (profit) pattern of a call (put) option or other combined option strategy (covered call, protective put, straddle, spread, etc.);
8. Option price sensitivity to the underlying asset price, strike price, time to expiration, risk-free rate, and standard deviation of the underlying asset (Greek letters).<sup>7</sup>

## SCENARIO MANAGER

The Data Table tool allows us to perform a sensitivity analysis with one or two input variables. What if there are more than two inputs in a sensitivity analysis? Excel has another useful what-if analysis tool called Scenario Manager, which can perform sensitivity analysis for up to 32 input variables. It can store values of the input variables for each scenario and provide a summary of the output variables for all scenarios in one table. This tool is especially handy to show or teach students how to evaluate a portfolio's performance under different possible market conditions.

Suppose that we want to invest in mutual funds. After research, we believe that equity fund A and bond fund B are the best choices. Under a normal market condition, the expected return and standard deviation of the equity fund is 10.4% and 9.0%, respectively. The expected return and standard deviation of the bond fund is 8.6% and 4.5%, respectively. The correlation between these two funds is 0.23. To minimize portfolio risk, we are thinking to diversify across these two funds and invest 60% in the equity fund and the remaining in the bond fund. We want to know how this portfolio will perform next year in different market conditions.

Excel's Scenario Manager is designed to solve this type of problems and compare different scenarios side by side. We first enter the returns and standard deviations of funds A and B, and the correlation between these two funds in a spreadsheet. Then, we calculate the portfolio expected return and standard deviation when 60% is invested in fund A and 40% in B, as shown in Figure 6. The portfolio return and standard deviation are calculated as follows:

$$R_p = w_A \times R_A + (1 - w_A) \times R_B \quad (1)$$

$$\sigma_p = \sqrt{w_A^2 \sigma_A^2 + (1 - w_A)^2 \sigma_B^2 + 2w_A(1 - w_A)\rho_{AB}\sigma_A\sigma_B} \quad (2)$$



where  $R_A$ ,  $R_B$ , and  $R_p$  are the expected returns for Fund A, Fund B, and the portfolio, respectively;  $w_A$  is the money weight invested in Fund A;  $\sigma_A$ ,  $\sigma_B$ , and  $\sigma_p$  are the standard deviations of Fund A, Fund B, and the portfolio, respectively; and  $\rho_{AB}$  is the correlation between funds A and B.

Insert Figure 6 about here

To use the Scenario Manager tool, go to **Data** tab, click on “What-If Analysis” button, then “Scenario Manager...”.<sup>8</sup> This opens up a “Scenario Manager” window, as in Figure 7, Panel A. Click “Add...”. An “Edit Scenario” window is opened as shown in Panel B. We name our first scenario “Best”. Move the cursor to the field “Changing cells”, which defines the input variables. We select cells C2:C6 to enter the absolute cell address, \$C\$2:\$C\$6, in the field. Click “OK”. A “Scenario Values” dialog box appears for the values of the input variables. We provide the values accordingly, as illustrated in Panel C. Click “OK”, and we are back to the “Scenario Manager” window. Repeat the above steps to create “Normal” and “Worst” scenarios with respective input values. The “Scenario Manager” window lists all three scenarios we just created, as shown in Panel D.

Insert Figure 7 about here

To review portfolio risk and return for each scenario, we click “Summary” in the final “Scenario Manager” window, and choose cells C10:C11 as the result cells that will be displayed in the scenario summary report. The values of inputs (individual fund returns and standard deviations, and the correlation between two funds) and outputs (portfolio return and standard deviation) for all scenarios are nicely shown in one table for comparison, as in Figure 8.

Insert Figure 8 about here

## GOAL SEEK

Goal Seek tool in Excel enables us to find the value of an input variable needed for an output variable to achieve a specific value. It is very useful when we need to find the implied volatility of an option, or the crossover rate for two capital budgeting projects.

Black and Scholes (1973) showed that the price of a European-style call on a non-dividend-paying stock can be written as:

$$C = S \times N(d_1) - X \times N(d_2) \quad (3)$$

where

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(R + \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}} \text{ and}$$

$$d_2 = d_1 - \sigma \times \sqrt{T}$$

In the Black-Scholes model, C is the call price, S is the stock price, X is the strike or exercise price, R is the risk-free rate, T is the time to expiration, and  $\sigma$  is the standard deviation (a measure of volatility) of the underlying stock. N(x) denotes the probability of a standardized, normally distributed random variable less than or equal to x. If we know S, X, R, T, and  $\sigma$ , we can estimate the call price using the Black-Scholes model. The corresponding put price can be found using the put-call parity formula.

In reality, of the five factors that affect a call's value, the underlying stock price, strike price, risk-free rate, and time to expiration can be directly observed in the financial market. We can observe the price of a call option in the market as well. The Goal Seek tool can help us find the other unknown variable, the standard deviation of the underlying stock.

We first create a spreadsheet to calculate the value of a call option with a hypothesized volatility. Suppose that we observe the current stock price is \$48 and the risk-free rate is 0.60%. We assume the standard deviation of the stock is 20%. According to the Black-Scholes model, the price of a European-style call expiring in six months (0.5 years) with a strike price of \$45 should be \$4.48, as illustrated in Figure 9.

Insert Figure 9 about here

Assume that the actual call price observed in the option market is \$6. The underlying stock price, strike price, time to expiration, and risk-free rate are fixed at the point when the call price is observed. What would be the volatility of the underlying stock implied by the call market price? Goal Seek is a perfect tool to solve this type of problems.

In Microsoft Excel for Windows, we go to **Data** tab, click on “What-If Analysis” button, then “Goal Seek...”.<sup>9</sup> A “Goal Seek” dialog box appears. We set the call price cell \$B\$13 to 6 by changing the volatility cell \$B\$5. Click “OK”.

After running Goal Seek, we see that the call price cell has reached the target value, \$6, and the volatility cell has been changed to 32.53% correspondingly. That is, 32.53% is the

volatility implied by the Black-Scholes model when the call price is \$6, and thus the implied volatility. This is represented in Figure 10.

Insert Figure 10 about here

Implied volatility is one of the most difficult concepts in finance. The process of using Goal Seek can help students understand this concept intuitively. Another example is the crossover rate, which is defined as the rate of return for two projects to have the same Net Present Values (NPV). Traditionally, we calculate the crossover rate by finding the Internal Rate of Return (IRR) of the incremental cash flows from two projects. But students are often confused with this method. Students may ask why the IRR of the incremental cash flows from two projects is the crossover rate. Sometimes IRR concept itself is not easy to understand in the first place.

I now illustrate how the process of using Goal Seek can help students understand the crossover rate concept. We start with a worksheet in which the initial costs and projected cash flows of two hypothesized projects are entered as in Figure 11. The Net Present Values (NPV) and Internal Rate of Returns (IRR) are calculated in B10:C11.<sup>10</sup> Next, we use Data Table tool to find the NPVs of these two projects for different discount rates and plot the NPV profiles on the same graph as shown in Figure 12. The rate at which the two profiles intersect is the crossover rate.

Insert Figure 11 about here

Crossover rate is the rate of return for two projects to have the same net present values. That is, at the crossover rate, the difference between these two NPVs is zero. To find the numerical value of the crossover rate, we assume a crossover rate in cell B35, and recalculate the NPVs for both projects in cells B37 and C37, and find the difference of these two NPVs in cell B38 ( $=B37-C37$ ). According to the definition, if a rate in cell B35 makes the NPVs of projects A and B in cells B37 and B38 equal, or equivalently, makes cell B38 equal to zero, then the rate must be the crossover rate. We use Goal Seek to set the target cell B38 to zero by changing cell B35, and we find that the crossover rate is 13.08% as illustrated in Figure 12.<sup>11</sup>

Insert Figure 12 about here

## SOLVER

“Goal Seek” is simple and convenient when the target is set to a specific value and there is no constraint on the input variables. But sometimes we might not know the exact target value,

or there might be some constraints on the input variables. “Solver” is an ideal tool for this type of nonlinear problems. This section illustrates how to use “Solver” to find the minimum-variance portfolio (MVP) and construct an efficient frontier of several risky assets.

We first investigate how we can use “Solver” to find the MVP of several risky assets. Suppose we have three risky assets, a US stock fund, an international stock fund, and a US bond fund. Their expected returns, standard deviations, correlation, and the variance-covariance matrix are entered into a worksheet as in Figure 13 Panel A. To find the MVP, we begin by assigning some arbitrary weights on three funds in the range of B17:B19. The sum of the weights is calculated in cell B20. Then we calculate the portfolio return and standard deviation based on these weights in cells B22 and B23. This is illustrated in Panel B.

Insert Figure 13 about here

Next, we start Solver in the **Analysis** group on the **Data** tab.<sup>12</sup> Our goal is to find the weights on three funds for a portfolio that has a minimum variance among all possible portfolios consisting of these three funds. So we set portfolio variance cell B23 (the target cell) to “Min” by changing cells B17:B19. We add a constraint to reflect the fact that the sum of the weights in cell B20 must be 100%. This is shown in Figure 14. Click the “Solve” button. Solver runs until it finds a solution and a “Solver Results” window emerges as in Figure 15. Click “OK” to keep the Solver solution. Cells B17:B19 now have the correct weights of three component funds for the MVP (portfolio 1).

Insert Figure 14 about here

Insert Figure 15 about here

Solver finds that the weights on three component funds are -1.60%, 7.98%, and 93.62%, respectively, for the MVP. The negative weight for the US stock fund means that we should take a short position on this fund. The portfolio return cell B22 and variance cell B23 have changed to 3.52% and 4.88% to reflect these new weights on the three component funds.

An efficient portfolio is one that has the greatest expected return for a given level of risk (variance or standard deviation), or equivalently, the lowest risk for a given expected return. There is no portfolio with the same expected return as the MVP that will have a lower risk. So the MVP is an efficient portfolio.

Merton (1972) showed that every point on the efficient frontier can be formed as a combination of any two efficient portfolios. We just find one efficient portfolio, the MVP. To

construct the whole frontier, we just need another efficient portfolio. Suppose we want to find weights for an efficient portfolio in the range of C17:C19 with an expected return of 10% in cell C22. The Solver will be set up the same way as for the MVP, except that we need to add another constraint here,  $C\$22=0.10$  as in Figure 16. The weights generated by Solver are shown in cells C17:C19 (Portfolio 2) in Figure 13, Panel B.

Insert Figure 16 about here

With two efficient portfolios, we can now construct the whole efficient. As the linear combination of any envelope portfolios is also on the envelope, we can construct a new envelope portfolio with the MVP and portfolio 2. we assign a portfolio weight on the MVP and then use Data Table to find a series of envelope portfolios. Use Chart tool in Excel to plot the expected return and standard deviation pair and connect them with a smooth line, we obtain the portfolio envelope, as shown in Figure 17. Note that only the portion in black is the efficient frontier. The portion in blue is not efficient.

With the help of Solver, Data Table, and Chart tools in Excel, we are able to teach students how to construct efficient frontier in an easy and intuitive way. The whole process strengthens students' understanding on some most complicated concepts in portfolio theory, such as efficient portfolio, minimum-variance portfolio, feasible portfolio, portfolio envelope, and efficient frontier.

In the above example, we allow the weight to be negative. That is, we allow short selling on one or more of our component funds. If no short selling is allowed, we can simply add a constraint such that all weights have to be greater or equal to zero. With this extra constraint, we can construct the envelope portfolios and efficient frontier for the case when short selling is prohibited.

Insert Figure 17 about here

## CLASSROOM IMPLEMENTATION

At the beginning of a semester, an instructor can spend one class period teaching the basics of Excel if most students in the class have no or little Excel experience. To save class time, an instructor can also ask students to learn from some online Excel tutorials out of class by themselves. Microsoft Office website (<http://office.microsoft.com>) has a lot of training courses. There are some good Excel tutorials on YouTube as well. During a semester, after covering a

specific concept or topic in class, the instructor can use one or more Excel tools presented above as appropriate to help students learn and at the same time sharpen their Excel skills.

These Excel tools can be integrated into various finance courses. For introductory finance course, Data Table and Chart are most useful in help students understand and visualize the relationship between two financial variables. For example, after introducing the relationship between bond price and interest rate, we can use Data Table tool to create a table showing the bond prices for a series of different rates. Then use Chart feature to plot a graph and display the inverse relationship. This will generally take about 5 to 7 minutes of class time, but the table and graph offer students a deeper insight into the relationship between bond prices and interest rates. Similarly, we can use Data Table and Chart to investigate other relationships as listed in the corresponding section of this paper.

Scenario Manager is often useful in corporate finance or investment courses. We can use this tool to evaluate a firm's financial performance under different scenarios or the portfolio performance under different market conditions.

Goal Seek and Solver can help find solutions to a variety of financial problems. We can use Goal Seek or Solver in a financial derivatives course is to find the implied volatility of an option, and strengthen students' understanding on this concept at the same time. Other uses of Goal Seek and Solver include finding the breakeven points and crossover rate in corporate finance courses.

## LEARNING GOALS AND OUTCOMES

To conform to AACSB's (the Association to Advance Collegiate Schools of Business) requirements for providing direct evidence of Assurance of Learning (AOL), I have established a set of desired learning goals for an Excel-integrated course and assessed the achievement of these goals. The learning goals are presented in column 2 of Table 1.

Insert Table 1 about here

The current norm is that a learning goal is achieved if more than 70% of students demonstrate the ability specified in the goal. To measure the achievement of the learning goals presented in Table 1, I designed a final exam with seven problems for an Excel-integrated Financial Analysis and Strategy class offered in Spring 2013. Students were required to solve all problems in Excel and submit their work electronically. All submissions were assessed for

achievement of these learning goals. The percentage of students that demonstrated each of the abilities listed in the goals is presented in column 3 of Table 1. The percentages are all above the 70% threshold, so all six learning goals have been achieved in this Excel-integrated class. The traditional pedagogy in general does not offer an Excel component, so there is no direct comparison to the assessment results from an alternative traditional pedagogy.

I also designed an end-of-semester survey asking if each student strongly agrees, agrees, is neutral, disagrees, or strongly disagrees with some statements on his/her confidence on Excel skills and financial knowledge after taking this class. The detailed survey questions and results are presented in Table 2.

Insert Table 2 about here

All students indicate that their Excel skill has improved a lot throughout the semester. A majority of the students are confident on using Data Table, Goal Seek, and Solver tools to solve financial problems. More than 94% of the students agreed or strongly agreed that integrating Excel in the course deepened their understanding of the most difficult finance concepts, such as beta and efficient portfolio. All students agreed or strongly agreed that they would not have gained as much if Excel had not been part of the course. Overall, the survey result indicates that integrating Excel into a finance course helps students learn and prepare them with Excel skills that they need in their future jobs.

## CONCLUSION

This paper has presented how to incorporate some useful and important Excel tools into finance teaching. The integration of Excel with finance courses not only helps students visualize how financial problems are solved in the real world, but also enables students to solve problems from other courses or fields as their Excel skills are enhanced.

Data Table is a powerful and time-saving sensitivity analysis tool to investigate some important relationships in finance, such as present or future value versus interest rates or compounding periods, stock or bond price versus required rate of return, bond price versus time to maturity, option payoff or profit versus underlying stock price at expiration, portfolio return and standard deviation versus different weights in component stocks, net present value versus discount rates, and so on. With the help of the Chart feature, each of these relationships can be readily visualized in a graph.

Scenario Manager is another sensitivity analysis tool in Excel and is extremely helpful when there are more than two input variables. A good use of Scenario Manager is to find the portfolio performance under different market conditions.

Goal Seek and Solver are powerful tools to find solutions for non-linear problems. When there is no restriction on input variables, Goal Seek is more convenient. Finding the implied volatility of the underlying stock for a call or put option is an example of what Goal Seek can do. If there are constraints on input variables, Solver is more appropriate. For example, to find the weights on component assets for an efficient portfolio, its expected return must be maximized for a given level of risk (variance or standard deviation), or equivalently, the portfolio's risk must be minimized for a given expected return. Solver properly takes these constraints into account during its optimization process. The process of using Goal Seek or Solver can deepen students' understanding of relevant finance concepts, such as implied volatility, internal rate of return, crossover rate, and minimum-variance portfolio.

With an Excel element, finance classes become more interesting and less daunting. Students are more engaged and motivated in the classroom through hands-on Excel exercises. Incorporating Excel tools into teaching not only sharpens students' Excel skills, but also deepens their understanding of financial knowledge. All learning goals defined for a Financial Analysis and Strategy class were achieved. The feedback from students has been very positive and encouraging.

I suggest that business schools integrate Excel into business core and major courses when appropriate. This will help students gain Excel skills they need for the current job market, and help them excel in the competitive business world.

## ENDNOTES

<sup>1</sup> FV(rate, nper, pmt, [pv], [type]) is an Excel financial function to calculate the future value given interest rate (rate), number of periods (nper), payment amount (pmt), present value (pv), and whether the payments are made at the beginning or end of each period (type). The parameters in brackets are optional. Please refer to Excel Help for details.

<sup>2</sup> Tips: To fill 0, 2, 4, ..., 20 quickly to the cells D4:D14, we can input 0 and 2 in cells D4 and D5 first, select both cells, when we see a little solid cross (AutoFill handle), drag it down to cell D14 and the other numbers will be filled automatically.



<sup>3</sup> This is a one-input Data Table example, we are examining the impact of only one variable (compounding period) on another variable (future value) keeping all other variables (present value and interest rate in this case) constant. For one-input example, the cell reference to the output variable (future value in this case) must be inserted to the cell above and to the right of the first number of the input variable (compounding period).

<sup>4</sup> To select a group of cells, click on the first cell, hold the mouse button down, and drag the mouse over to the last cell in the group, and then release the mouse.

<sup>5</sup> In Microsoft Excel for Mac 2011, go to Data menu, then click “Table...”.

<sup>6</sup> The Excel function to calculate present value is  $PV(\text{rate}, \text{nper}, \text{pmt}, [\text{fv}], [\text{type}])$ .

<sup>7</sup> The spreadsheets for the above sensitivity analysis are available upon request from the author.

<sup>8</sup> In Microsoft Excel for Mac 2011, go to Tools menu, then click “Scenarios...”.

<sup>9</sup> In Microsoft Excel for Mac 2011, go to Tools menu, then click “Goal Seek...”.

<sup>10</sup> In cell B10, we input “=NPV(\$B\$9,B4:B8)+B3” to find the Net Present Value. Note that NPV(rate, value1, [value 2], ...) function in Excel is to calculate the present value of future projected cash flows. It does not calculate the net present value directly. So to calculate the net present value, we need to add back the initial cost (which is negative). In cell B11, we input “=IRR(B3:B8)” to calculate the internal rate of return. The first parameter given to Excel’s IRR(values, [guess]) function should be the initial cost.

<sup>11</sup> This might not work for non-conventional cash flow series, where the signs of cash flows change more than once. There are potentially multiple IRRs and multiple crossover rates.

<sup>12</sup> If you do not see the Solver command under the Data tab in Excel, you need to follow the following steps to load Solver first. Click the **Microsoft Office Button**, and then click **Excel Options**. Click **Add-Ins**, and then in the **Manage** box, select **Excel Add-ins**. Click **Go**. In the **Add-Ins available** box, select the **Solver Add-in** check box, and then click **OK**. To enable Solver in Mac Excel 2011 click ‘Tools’ then ‘Add-Ins’. Within the Add-Ins box, check ‘Solver.xlam’ then hit ‘OK’. Solver will be added to the Data tab.

## REFERENCES

Benninga, S., 2008. *Financial Modeling* (The MIT Press), 3rd edition.

Black, F., and M. Scholes, 1973. The Pricing of Options and Corporate Liabilities, *Journal of Political Economy* 81, 637–654.

Carini, R. M., G. D. Kuh, and S. P. Klein, 2006. Student Engagement and Student Learning: Testing the Linkages, *Research in Higher Education* 47, 1-32.

Holden, C. W., 2012. *Excel Modeling in Corporate Finance/Investments* (Pearson Education Inc.) 4th edition,

Merton, R., 1972. An Analytic Derivation of the Efficient Portfolio Frontier, *Journal of Financial and Quantitative Analysis* 7, 1851-1872.

Table 1. This table presents the evidence of AOL from an Excel-integrated Financial Analysis and Strategy course. Column 2 lists six desired learning goals of this course, and column 3 shows the percentage of students that demonstrated each of the abilities listed column 2. The last column shows if each learning goal has been achieved.

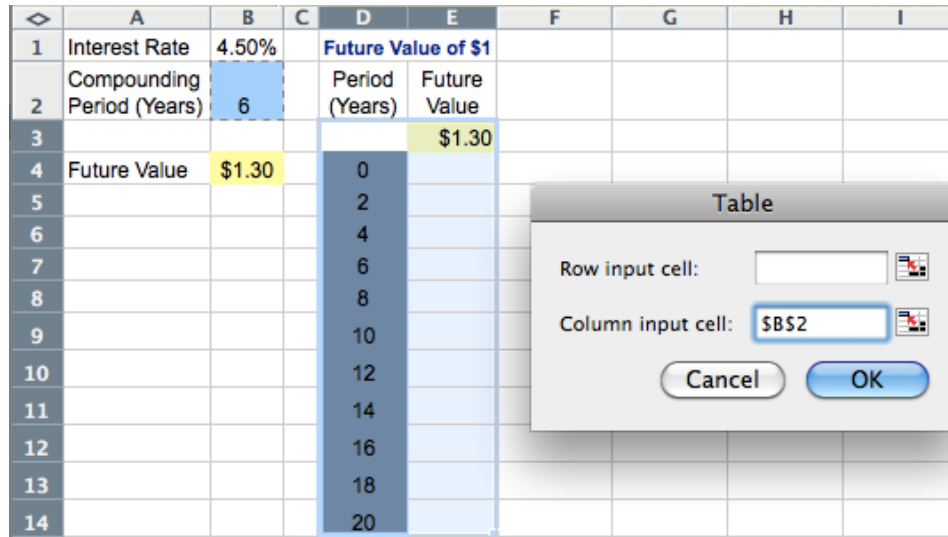
Item	Learning Goals	Percentage of Students Demonstrated the Ability	Learning Goal Achieved?
LG.1	Students will be proficient in using Excel including the basic features of Excel and financial functions.	94%	Yes
LG.2	Students will be capable of creating one- or two-dimensional Data Table to show the relationship between two or more financial variables.	94%	Yes
LG. 3	Students will be able to create charts/graphs that communicate information visually and effectively.	83%	Yes
LG. 4	Student will demonstrate the ability to solve a linear or nonlinear financial problem using Goal Seek or Solver.	89%	Yes
LG. 5	Students can apply Scenario Manager to evaluate various financial or business scenarios.	78%	Yes
LG. 6	Students will be able to create clear, well-organized, and easy-to-follow spreadsheets.	83%	Yes

Table 2. This table presents the questions and results of an end-of-semester survey on an Excel-integrated Financial Analysis and Strategy course. Each student is asked if he/she strongly agrees, agrees, is neutral, disagrees, or strongly disagrees with some statements on their confidence on Excel skills and financial knowledge after taking this class. 16 students responded to the survey.

<i>No.</i>	<i>Survey Questions</i>	<i>Strongly Agree</i>	<i>Agree</i>	<i>Neutral</i>	<i>Disagree</i>	<i>Strongly Disagree</i>
1	My Excel skills improved a lot throughout this semester.	69%	31%	0	0	0
2	I am very confident in using Data Table Tool in Excel.	38%	63%	0	0	0
3	I am very confident in using Goal Seek or Solver Tool in Excel.	31%	44%	25%	0	0
4	I am very confident in using Scenario Manager Tool in Excel.	19%	31%	50%	0	0
5	I understand how to project pro forma financial statements in Excel.	19%	69%	13%	0	0
6	I can solve time value of money problems in Excel.	69%	31%	0	0	0
7	I can perform sensitivity analysis of bond price versus time to maturity in Excel.	38%	50%	13%	0	0
8	I understand how to plot Net Present Value (NPV) profiles in Excel.	56%	44%	0	0	0
9	I know how to find the beta of a stock using its monthly price data in Excel and it deepens my understanding of the concept of beta.	50%	44%	6%	0	0
10	I know how to construct an efficient frontier in Excel and the process of constructing efficient frontier deepens my understanding of this concept.	25%	69%	6%	0	0
11	Integrating Excel in this course helps me understand other finance concepts, such as portfolio theory and option concepts better.	31%	69%	0	0	0
12	This course bridges the gap between financial theory and real-world application.	31%	50%	19%	0	0
13	What I learned from this class will be very helpful in my job/career.	38%	56%	6%	0	0
14	I would not have gained as much if Excel had not been part of this course.	56%	38%	6%	0	0

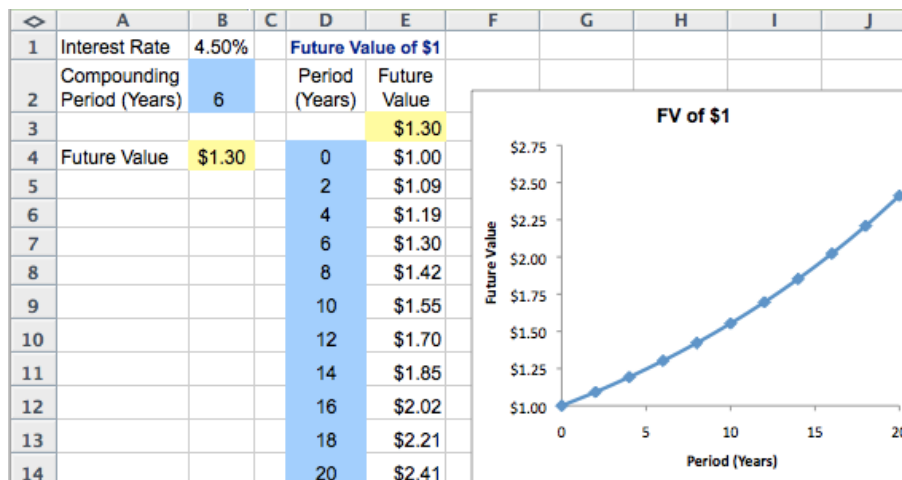
**Figure 1. Data Table Worksheet for Finding the Future Values in Different Time Periods**

This figure depicts the creation of a Data Table worksheet used to find the future values of one dollar with different compounding periods.



**Figure 2. The Relationship between Future Value and Compounding Period**

This figure shows the nonlinear relationship between future value and compounding period in a data table and a graph. The table is generated using the Data Table tool. The graph is plotted with Excel's Chart tool.



**Figure 3. Two-Dimensional Data Table for Bond Price Sensitivity Analysis**

This figure depicts the creation of a two-dimensional data table, which is used to find the bond price sensitivity to interest rate and time to maturity.

	A	B	C	D	E	F	G	H	I	J
1				Bond Price Sensitivity to Interest Rate (Column Input) and Time to Maturity (Row Input)						
2	Interest Rate	5%		\$1,155.89	10	8	6	4	2	0
3	Maturity (Years)	10		3%						
4	Coupon Rate	7%		4%						
5	Coupon Frequency	2		5%						
6	Par Value	\$1,000		6%						
7				7%						
8	Bond Price	\$1,155.89		8%						
9				9%						
10				10%						
11				11%						
12				12%						

Table

Row input cell:

Column input cell:

Cancel OK

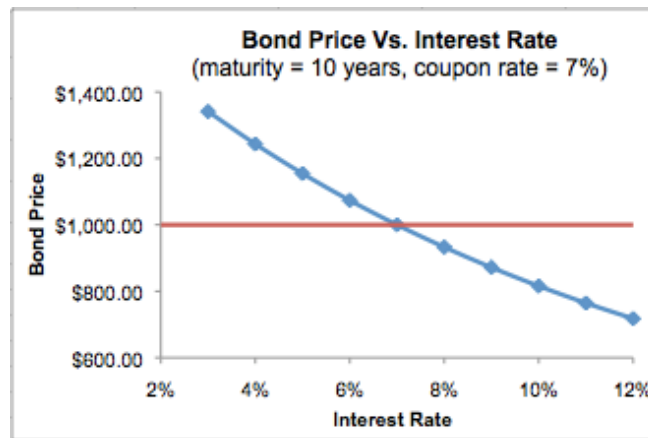
**Figure 4. Bond Price Sensitivity to Interest Rate and Time to Maturity**

This figure shows the bond price sensitivity to interest rate (column D) and time to maturity (row 2) in a two-dimensional data table.

	A	B	C	D	E	F	G	H	I	J
1				Bond Price Sensitivity to Interest Rate (Column Input) and Time to Maturity (Row Input)						
2	Interest Rate	5%		\$1,155.89	10	8	6	4	2	0
3	Maturity (Years)	10		3%	\$1,343.37	\$1,282.63	\$1,218.15	\$1,149.72	\$1,077.09	\$1,000.00
4	Coupon Rate	7%		4%	\$1,245.27	\$1,203.67	\$1,158.63	\$1,109.88	\$1,057.12	\$1,000.00
5	Coupon Frequency	2		5%	\$1,155.89	\$1,130.55	\$1,102.58	\$1,071.70	\$1,037.62	\$1,000.00
6	Par Value	\$1,000		6%	\$1,074.39	\$1,062.81	\$1,049.77	\$1,035.10	\$1,018.59	\$1,000.00
7				7%	\$1,000.00	\$1,000.00	\$1,000.00	\$1,000.00	\$1,000.00	\$1,000.00
8	Bond Price	\$1,155.89		8%	\$932.05	\$941.74	\$953.07	\$966.34	\$981.85	\$1,000.00
9				9%	\$869.92	\$887.66	\$908.81	\$934.04	\$964.12	\$1,000.00
10				10%	\$813.07	\$837.43	\$867.05	\$903.05	\$946.81	\$1,000.00
11				11%	\$760.99	\$790.76	\$827.63	\$873.31	\$929.90	\$1,000.00
12				12%	\$713.25	\$747.35	\$790.40	\$844.76	\$913.37	\$1,000.00

**Figure 5. The Relationship between Bond Price and Interest Rate**

This figure shows the inverse relationship between the price of a 7% annual coupon bond and market interest rate. The bond has a maturity of 10 years. When market interest rate increases, bond price drops.



**Figure 6. Calculating Portfolio Return and Standard Deviation**

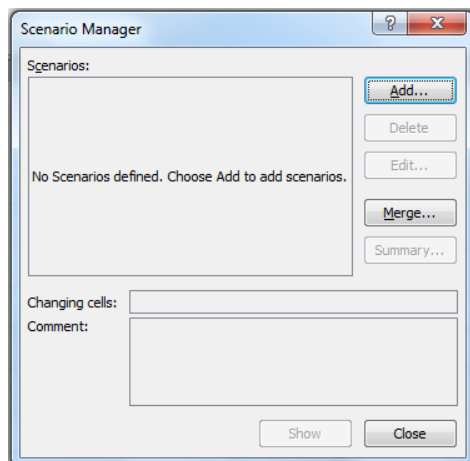
This figure shows a worksheet used to calculate the return and standard deviation of a portfolio consisted of two mutual funds.

	A	B	C
1			Expected
2	Equity Fund (Fund A)	Return	10.40%
3		Standard Deviation	9.00%
4	Bond Fund (Fund B)	Return	8.60%
5		Standard Deviation	4.50%
6	Correlation between A and B		0.23
7			
8	Portfolio	Weight in Fund A	60%
9			
10		Return	9.68%
11		Standard Deviation	6.07%

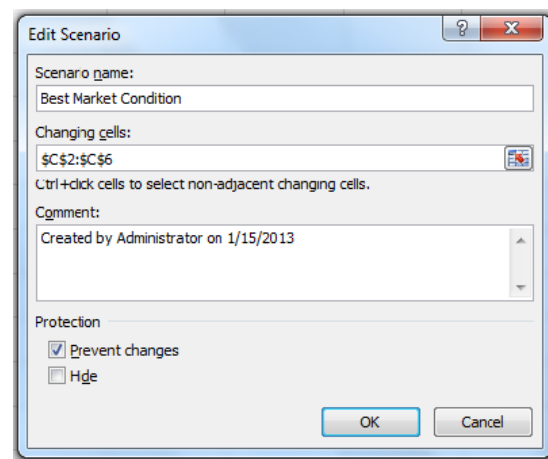
**Figure 7. Scenario Manager Screen Shots**

This figure shows screen shots during the process of using Scenario Manager tool in Excel. Panel A shows a new “Scenario Manager” window. Panel B shows an “Edit Scenario” dialog box for a specific scenario. Panel C shows a “Scenario values” dialog box where the input variable values of a specific scenario can be entered. Panel D shows the “Scenario Manager” window after all three scenarios being added.

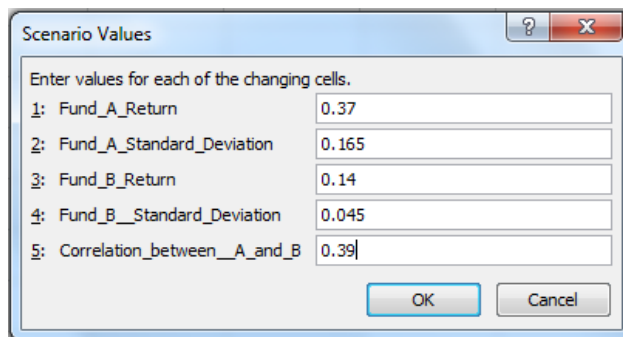
Panel A



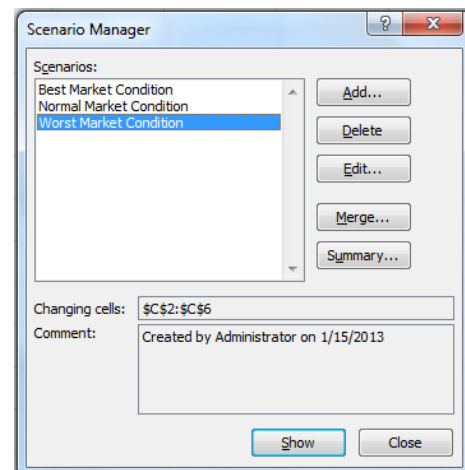
Panel B



Panel C



Panel D





**Figure 8. Scenario Summary Report**

This figure shows the summary report from a scenario analysis. The return and standard deviation of the portfolio consisted of an equity fund and a bond fund are reported under different market conditions.

Scenario Summary					
		Current Values:	Best Market Condition	Normal Market Condition	Worst Market Condition
Changing Cells:					
Fund_A_Return		10.40%	37.00%	10.40%	-35.00%
Fund_A_Standard_Deviation		9.00%	16.50%	9.00%	18.00%
Fund_B_Return		8.60%	14.00%	8.60%	-2.00%
Fund_B_Standard_Deviation		4.50%	4.50%	4.50%	5.00%
Correlation_between_A_and_B		0.23	0.39	0.23	0.11
Result Cells:					
Portfolio_Return		9.68%	27.80%	9.68%	-21.80%
Portfolio_Standard_Deviation		6.07%	10.73%	6.07%	11.20%

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

**Figure 9. Finding the Price of a Call Option**

This figure shows a worksheet created to find the price of a call option based on the Black-Scholes model assuming that the volatility of the underlying stock is known.

	A	B	C	D	E
1	Current Stock Price S	\$48			
2	Strike Price X	\$45			
3	Risk-free Rate R	0.60%			
4	Time to Expiration T (years)	0.50			
5	Volatility	20%			
6					
7	$d_1$	0.5483			
8	$d_2$	0.4069			
9					
10	$N(d_1)$	0.7083			
11	$N(d_2)$	0.6579			
12					
13	Call price	\$4.48			

Goal Seek

Set cell:

To value:

By changing cell:

Cancel OK

**Figure 10. Finding the Implied Volatility**

This figure shows Goal Seek solution of the implied volatility of an underlying stock for an observed call price.

	A	B	C	D	E	F	G
1	Current Stock Price S	\$48					
2	Strike Price X	\$45					
3	Risk-free Rate R	0.60%					
4	Time to Expiration T (years)	0.50					
5	Volatility	32.53%					
6							
7	$d_1$	0.4086					
8	$d_2$	0.1786					
9							
10	$N(d_1)$	0.6586					
11	$N(d_2)$	0.5709					
12							
13	Call price	\$6.00					

**Goal Seek Status**

Goal Seeking with Cell B13

found a solution.

Target value: 6

Current value: \$6.00

OK

Cancel

Step

Pause

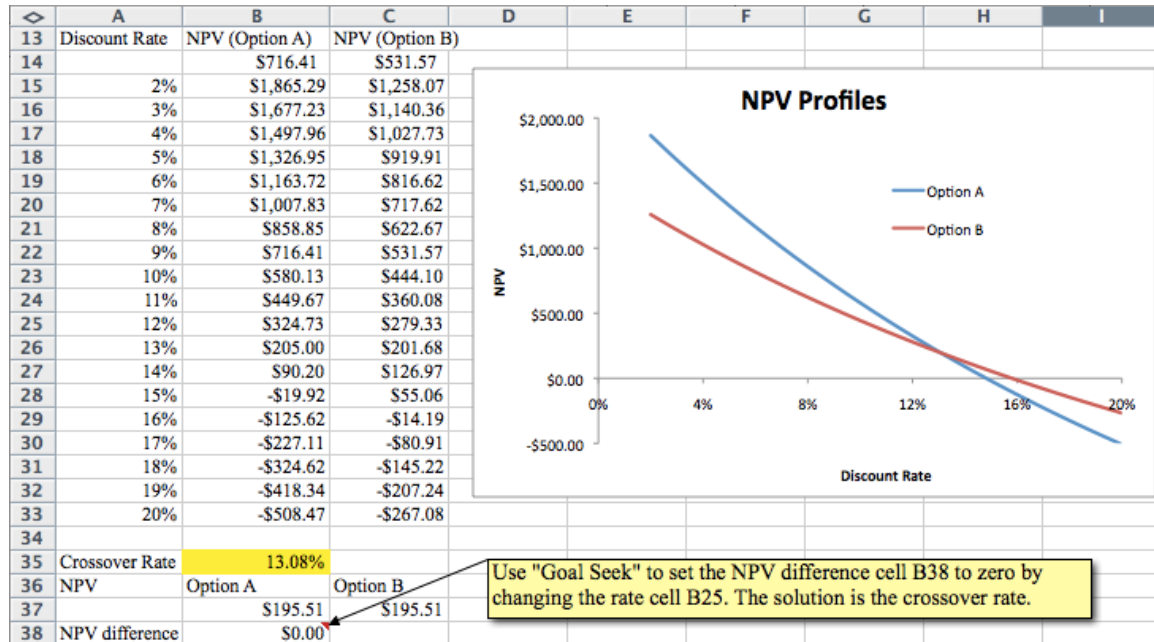
**Figure 11. NPVs and IRRs of Two Hypothesized Projects**

This worksheet shows the cash flows from two hypothesized projects. The Net Present Value (NPV) and Internal Rate of Return (IRR) are calculated in rows 10 and 11.

	A	B	C
1		Cash Flows	
2	Year	Option A	Option B
3	0	-\$4,300.00	-\$3,150.00
4	1	\$1,240.00	\$1,165.00
5	2	\$1,310.00	\$1,060.00
6	3	\$940.00	\$880.00
7	4	\$830.00	\$520.00
8	5	\$2,250.00	\$1,035.00
9	Cost of Capital	9.00%	
10	NPV	\$716.41	\$531.57
11	IRR	14.82%	15.79%

**Figure 12. NPV Profiles and Crossover Rate**

This figure shows the NPVs of two projects for different discount rates using Data Table tool. The NPV profiles are plotted as well. The crossover rate is found in cell B35 using Goal Seek.



**Figure 13. Finding Efficient Portfolios**

This figure shows how to find efficient portfolios, including the minimum-variance portfolio, in Excel. Panel A shows the returns, standard deviations, and variance-covariance matrix of three component funds. Panel B shows the returns and standard deviations of two efficient portfolios created using these three funds. A new portfolio (envelope portfolio) is created using these two efficient portfolios (1 and 2).

**Panel A**

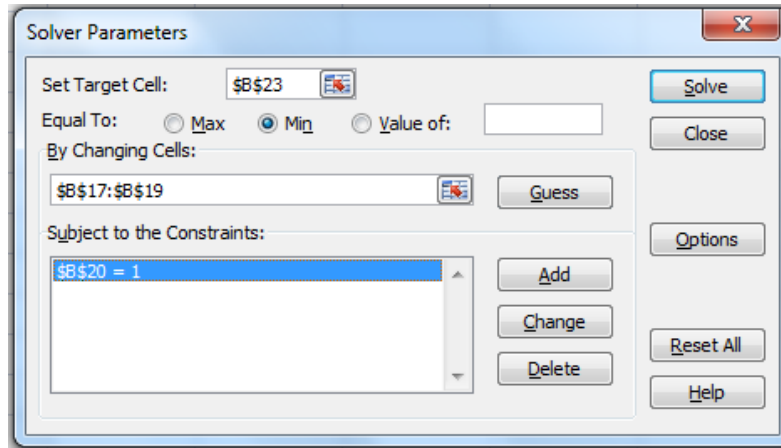
	A	B	C	D
1		Return	Standard Deviation	
2	US Stock Fund	12.00%	17.50%	
3	International Fund	9.00%	15.20%	
4	US Bond Fund	3.20%	5.00%	
5				
6	Correlation Matrix	US Stock Fund	International Fund	US Bond Fund
7	US Stock Fund	1.00	0.58	0.20
8	International Fund	0.58	1.00	0.11
9	US Bond Fund	0.20	0.11	1.00
10				
11	Variance-Covariance Matrix	US Stock Fund	International Fund	US Bond Fund
12	US Stock Fund	0.0306	0.0154	0.0018
13	International Fund	0.0154	0.0231	0.0008
14	US Bond Fund	0.0018	0.0008	0.0025

**Panel B**

	A	B	C
16	Portfolio	1	2
17	Weight in US Stock Fund	-1.60%	59.77%
18	Weight in International Fund	7.98%	26.56%
19	Weight in US Bond Fund	93.62%	13.67%
20	Sum	100%	100%
21			
22	Portfolio Return	3.52%	10.00%
23	Portfolio Variance	4.88%	13.36%
24	Correlation between 1 & 2	0.0024	
25			
26	Envelope Portfolio		
27	Weight in Portfolio 1	50%	
28	Return	6.76%	
29	Standard Deviation	7.12%	

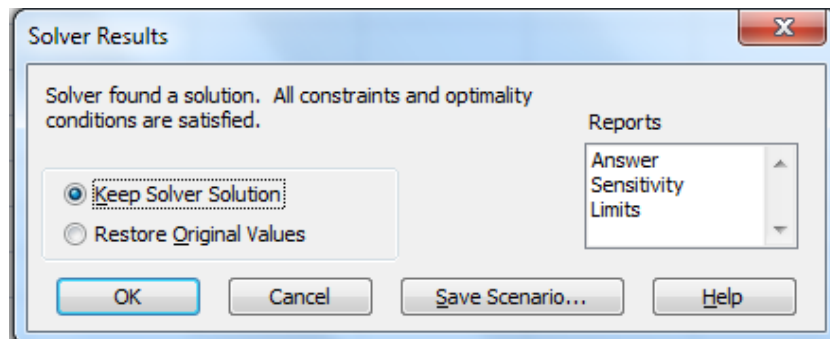
**Figure 14. Setting Solver Parameters**

This figure shows a typical “Solver Parameters” window where we can set up the target variable, input variable(s), and constraints.



**Figure 15. Solver Results Dialog Box**

This figure shows a “Solver Results” dialog box after a solution is found by Excel’s Solver. After we confirm to “Keep Solver Solution”, the values of changing cells (input variables) will be changed to the values found by Solver.



**Figure 16. Solver Parameter Setup for an Efficient Portfolio with 10% Expected Return**

This figure shows the setup of Solver Parameter window to find the weights of an efficient portfolio with an expected return of 10%. The setup is similar to what is shown in Figure 14 for the minimum-variance portfolio, except that there is an additional constraint that the portfolio return is equal to 0.10.

**Figure 17. Constructing Efficient Frontier**

This figure shows a portfolio envelope generated in Excel. The black portion of the envelope is the efficient frontier and the blue part is not efficient.

