**University of Texas at Dallas**
**School of Management**

Finance 6310 Professor Day
Investment Management Spring 2009

Spreadsheet Assignment 1:
(*Due February 24*)

This assignment requires you to use Excal's solver function to examine a variety of asset allocation problems. The Lecture Note that begins on page *4* of this handout covers the same ground as the Excel presentation included in Lecture *4* on the WebCT site for the course demonstrating how Excel can be used to build a spreadsheet model for solving asset allocation problems. The assigned problems below are ***due at 4 P.M. on February 24***. Construction of your asset allocation spreadsheet must be an individual effort, with each student being required to build a unique spreadsheet from the ground up and to *provide an answer along with an intuitive analysis of the solution/allocation for each of the six asset allocation problems listed below*. Although each spreadsheet assignment will require a series of explicit numerical solutions, your ability to describe and discuss the results of your spreadsheet analysis will be the most important consideration in determining your grade on the assignment.

Your work must be printed on *8-1/2 x 11* paper, (*2*) double-spaced with *1*-inch margins, and (*3*) in a font no smaller than a *12 pt*. Additionally, you must ***e-mail me a copy of the excel file*** containing both your spreadsheet model and any 'answer reports' or 'estimation results' created by Excel's Solver function or the Data Analysis package (***you do not need to include the answer reports with the write-up of your solutions***).

Until you are instructed otherwise, please use the assumptions about expected returns, standard deviations and correlations listed on page 5 that are used to illustrate the use of Excel in solving asset allocation problems. In particular, start your analysis by assuming that Treasury bills are risk-free (having a standard deviation of *0.0*) and that the correlation between the returns on Treasury bonds, small stocks, and large stocks are as stated in the note describing the construction of the excel allocation model (the correlation between the returns for T-bonds and small-cap stocks is *0.14,* the correlation between the returns for T-bonds and large-cap stocks is *0.3,8* and the correlation between the returns for large-cap stocks and small-cap stocks is *0.70*). Apart from building the asset allocation model, your most important goal should be to provide an intuitive explanation for the solution to each problem. *Remember that the purpose of this exercise is to sharpen your understanding of the economic factors that determine asset allocation and the level of diversification available to investors. Therefore, your intuition/explanations for the solutions to these problems is far more valuable than the numerical solutions that you will provide.*

1. Assume that the target expected return on your portfolio is *8.0* percent. Further, assume that (as before) the standard deviation for Treasury bonds remains at *0.10*. However, holding expected returns constant, assume that the standard deviation of the returns for large cap stocks and small cap stocks are respectively *24* percent (*0.24*) and *30* percent (*0.30*).

   a. determine the portfolio weights and the standard deviation of the minimum variance (standard deviation) portfolio having an expected return of *8.0* percent. (Be sure to save the Answer Report for your solution.)

   b. provide an intuitive explanation for any change (relative to the example in the attached teaching note) in portfolio weights.

   c. determine the portfolio weights and the standard deviation of the minimum variance (standard deviation) portfolio having an expected return of *10* percent.

   d. provide an intuitive explanation for any change (relative to part a) in portfolio weights.

2. Assume that the yield on T-bills increases to *5.0* percent (*0.05*) and that the expected return for T-bonds increases to *6.75* percent (*0.0675*). However, the expected returns for large stocks and small stocks are as assumed previously, with the standard deviations and correlations for each asset class as assumed in problem 1 (i.e., assume that large-cap stocks have a standard deviation of *24* percent and that small-cap stocks have a standard deviation of *30* percent). Assuming that the target expected return for your portfolio is *10* percent (as in part c of problem 1)

   a. determine the portfolio weights and the standard deviation of the (minimum variance) portfolio that satisfies your objective for expected return,

   b. give an intuitive explanation for any differences in your portfolio allocation from the optimal portfolio weights determined in part c of problem 1.

3. Assume that the expected returns and risks for Treasury bills, Treasury bonds and stocks are exactly as described in problem 2. However, instead of minimizing the risk (standard deviation) of your portfolio subject to achieving a target return of *10* percent, change the target cell in the spreadsheet to *B16* (the expected portfolio return) and select maximize so that solver will maximize the expected portfolio return subject to limiting portfolio risk (standard deviation) to the same level of risk attained (standard deviation) as the optimal solution to problem 2. Then compare the portfolio weights and expected return with the solution for problem 2.

   **Hint:** The solution to this problem demands that you change some of the settings when you select "***Solver***" from the appropriate EXCEL menu. To make these changes, select solver. When the input menu appears on the terminal screen, change the "**Set Target Cell**" box from *B17* (or whatever cell holds the formula for the portfolio standard deviation) to *B16* (expected portfolio return). Change Min to **Max** by clicking on the circle next to Max. Finally, delete the constraint that "$B16 \geq 0.10$" in the "Subject to Constraints" box (highlight the constraint and click the delete box) and replace it with the constraint (then click the add button and create the new constraint on portfolio standard deviation) that $B17 \leq \sigma_P$ . When you have made these changes to the input menu, solve for the portfolio weights of the portfolio having the highest expected return, given that you require that risk be no greater than $z$ percent.

4. Assume that your investment opportunity set (the expected returns and standard deviations of the four asset classes in which you can invest) is identical to that in problems 2 and 3. However, assume that you are willing to accept a portfolio (risk) standard deviation as high as *20* percent ( *0.20* percent).

   a. Determine the portfolio weights that maximize expected portfolio return subject to the constraint that portfolio standard deviation be no greater than *0.20* (*20* percent).

   b. provide an intuitive explanation for any change in asset allocation (relative to problem 3).

   c. determine the portfolio weights that maximize expected portfolio return subject to the constraint that portfolio standard deviation be no greater than *0.22* (*22* percent).

   d. provide an intuitive explanation for any change in asset allocation (relative to problem 4a).

5. Assume that correlation between the returns on large cap and small cap stocks decreases to *0.55*, but that the remainder of your investment opportunity set (the expected returns and standard deviations, and correlations for the four asset classes in which you can invest) is identical to that in problems 3 and 4. Assuming that you are willing to accept a portfolio standard deviation of only *20* percent,

   a. determine the portfolio weights that maximize expected portfolio return subject to the constraint that portfolio standard deviation be no greater than *0.20* (*20* percent).

   b. provide an intuitive explanation for any change in asset mix (relative to problems 3 and 4)

6. The AMZ pension fund wishes to diversify globally. The portfolio manager expects a return of *13* percent from the U.S. market and a return of 16 percent from a diversified index of stocks traded on the Singapore stock exchange. The standard deviation of the return for the U.S. stock market is *20* percent (*0.20*). The standard deviation of return for the Singapore is *38* percent (*0.38*). Assume that Treasury bills and Treasury bonds have expected yearly returns of *4.5* percent and *6* percent respectively, and that T-bonds have a standard deviation of *0.08* with respective correlations of *0.05* with stocks traded in Singapore and *0.38* with U.S. stocks. The correlation between stock returns in the U.S. and Singapore is *0.40*.

   a) Assuming that the pension fund's trustees require you, as manager of the fund, to assure that the fund's portfolio maintain a portfolio standard deviation (risk) of no more than *0.22* (*22* percent), determine the portfolio weights that maximize the expected return on the portfolio subject to the constraint that portfolio standard deviation be no greater than *0.22*.

   b) Assume now that the correlation between the returns on U.S. and Singapore stocks is only *0.25* (rather than *0.40* as before). Given that you remain under contract to hold the risk of the portfolio to *22* percent or less, (i) determine the new set of portfolio weights and (ii) give an intuitive explanation for the shift in the asset allocation for the portfolio.

   c) Now consider whether a portfolio of U.S. stocks and borrowing or lending at the Treasury bill rate of *4.5* percent could be used to provide a better combination of risk and return than the globally diversified portfolio created in part (a). To solve this problem, constrain the portfolio weights for the Singapore market and Treasury bonds to equal zero and eliminate the constraint that the weight on Treasury bills in cell *B12* be equal to or greater than zero. A negative weight on T-bills can be interpreted as borrowing at the T-bill rate of *4.5* percent.

7. The income return on long-term U.S. Government bonds has been *5.02* percent per year over the last *25* years, while the geometric average yearly return on the market has been *8.59* percent. During this period, the consumer price index increased at a geometric average yearly rate of *4.5* percent. After adjusting for inflation, earnings have grown at a geometric average rate of *2.25* percent per year. The average dividend yield and the return from dividend reinvestment have respectively been *3.76* percent and *0.17* percent. Assuming that the standard deviation of the yearly return on the market has been *20* percent, determine the arithmetic equity premium that can be expected over the next *25* years assuming that future stock returns will be not be affected by the changes in price to earnings multiples that occurred during the last *25* years. (*10* points)

**University of Texas at Dallas**
**School of Management**

Finance 6310 — Professor Day
Investment Management — Fall 2008

Asset Allocation and Mean-Variance Efficient Portfolios

This exercise requires that you determine the portfolio weights for mean-variance efficient portfolios from a "buy list" of four asset classes, Treasury bills, long-term Treasury bonds, "small cap" stocks and "large cap" stocks. The exercise has the dual purpose of teaching spreadsheet skills and assisting you in developing intuition concerning the impact of the respective risk premiums and asset correlation's for alternative asset classes on an efficient portfolio allocation. Given a series of assumptions concerning expected returns, standard deviations, and correlation's, you are required to form a portfolio that minimizes portfolio risk, subject to the constraint that the portfolio achieve a target level of expected return. The solution to these problems requires the use of an Excel function named ***Solver***. Once solver has determined the solution to your problem, you may request that solver prepare an ***Answer Report***. The "Answer Report" provides a convenient summary of the solution to each of the respective homework problems that you will find useful in interpreting the results of your portfolio analysis.

The ***Solver*** function is found under the ***Tools*** menu in recent versions of Excel (i.e., Office 98 and later). Earlier versions of Excel include the solver function under a menu titled ***Function***. If Solver is not included as an option under the Tools menu, select ***Add-Ins*** (which is available on the Tools menu). Excel will then display a menu of options to be added to the Tools menu. Select the ***Solver Add-In*** and then press the button labeled ***update Add-In links***. You should then be able to invoke the solver function directly from the ***Tools Menu***. Some Excel packages (both on campus and at your place of work) have been installed using a custom installation that may have omitted the Solver function in order to save disk space. If this is the case, then you probably will be unable to use that machine for this exercise since you need the original disk to install the omitted functions. However, the ***Solver Add-In*** is available on most of the computers available for your use in the ***School of Management Computer Lab.***

Recall that the standard deviation of the return on a portfolio having two risky assets can be determined using the formula

$$\sigma_P = \sqrt{x_1^2\,\sigma_1^2 + x_2^2\,\sigma_2^2 + 2x_1 x_2\,\rho\,\sigma_1\,\sigma_2}$$

where $x_1$ and $x_2$ are the proportions of the portfolio invested in assets one and two, $\sigma_1$ and $\sigma_2$ are the respective standard deviations of the two assets, and $\rho$ is the correlation between the two risky securities. Although the formula for the standard deviation of a portfolio of three risky assets is somewhat more complicated, the formula is very similar to that above, with a series of terms reflecting the impact of the total variance of each security *i* on the risk of the portfolio $x_i^2\,\sigma_i^2$, and a series of terms that reflect the covariance between the returns for each security in the portfolio with the returns for every other security included in the portfolio ( $2\,x_i\,x_j\,\rho_{ij}\,\sigma_i\,\sigma_j$ ) where $\rho_{ij}$ denotes the correlation between the returns for security *i* and security *j*. The formula for the standard deviation of a portfolio having *3* risky assets is

$$\sigma_P = \sqrt{x_1^2\,\sigma_1^2 + x_2^2\,\sigma_2^2 + x_3^2\,\sigma_3^2 + 2x_1 x_2\,\rho_{12}\,\sigma_1\,\sigma_2 + 2x_1 x_3\,\rho_{13}\,\sigma_1\,\sigma_3 + 2x_2 x_3\,\rho_{23}\,\sigma_2\,\sigma_3}$$

To make the problem more concrete, assume that the expected returns on Treasury bills, long-term Treasury bonds, small stocks and large stocks are respectively

$$E(\tilde{R}_{T\text{-}bill}) = .010,$$

$$E(\tilde{R}_{T\text{-}Bond}) = .040$$

$$E(\tilde{R}_{Small\ Stocks}) = .130$$

$$E(\tilde{R}_{Large\ Stocks}) = .105$$

The standard deviation of the rate of return on Treasury bills ( $\sigma_{\text{T-bill}}$ ) over any given year is equal to zero. Assume that the standard deviation of the rate of return on long-term Government bonds ($\sigma_{T\text{-}bond}$) is *10* percent, with respective standard deviations for the returns on large cap stocks and small cap stocks ($\sigma_{Large}$ and $\sigma_{Small}$ ) of *36* percent and *46* percent. Although the correlation between the returns on Treasury bills (for any given year) and the returns for other asset classes is equal to zero, the correlation between the returns for T-bonds, small stocks and large stocks are respectively

$$\rho_{Small\ Stocks/T\text{-}Bonds} = 0.14$$

$$\rho_{Large\ Stocks/T\text{-}Bonds} = 0.38$$

$$\rho_{Large\ Stocks/Small\ Stocks} = 0.70$$

Your assignment is to use these four assets classes to form portfolios having the minimum portfolio risk subject to the constraint that the expected portfolio return is equal to or greater than a given target return level. In other words, you must determine the percentage of the portfolio that should be invested in Treasury bills ($x_{T\text{-}bill}$), Treasury bonds ($x_{T\text{-}bond}$), small cap stocks ($x_{Small}$) and large cap stocks ( $x_{Large}$) so that you minimize portfolio risk given that on average you wish to have a particular level of portfolio return.

To solve the problem described above you should first enter the inputs to the problem in an EXCEL spreadsheet. The inputs (or parameters) to this problem are the expected returns on the three asset classes, the standard deviations for each asset class, and the correlation between the returns on stocks and Treasury bonds. To keep track of these parameter estimates, I suggest that you enter each of the inputs to the problem in Column B and label each of the inputs in Column A. For example, your spreadsheet could be set up as follows

| | Column A | Column B |
|---|---|---|
| *Row 1* | *Expected Return: T-bills* | *.010* |
| *Row 2* | *Expected Return: T-bonds* | *.040* |
| *Row 3* | *Expected Return: Small Stocks* | *.130* |
| *Row 4* | *Expected Return: Large Stocks* | *.105* |
| *Row 5* | *Standard Deviation: T-bills* | *.000* |
| *Row 6* | *Standard Deviation: T-bonds* | *.100* |
| *Row 7* | *Standard Deviation: Small Stocks* | *.460* |
| *Row 8* | *Standard Deviation: Large Stocks* | *.360* |
| *Row 9* | *Correlation: Small Stocks/T-bonds* | *0.14* |
| *Row 10* | *Correlation: Large Stocks/T-bonds* | *0.38* |
| *Row 11* | *Correlation: Large Stocks/Small Stocks* | *0.70* |

Assume that we wish to create a minimum variance (efficient) portfolio that has an expected return of *8.0* percent. That is, you want Solver to select the portfolio proportions (weights), $x_{T\text{-}bill}$, $x_{T\text{-}bond}$, $x_{Small}$, *and* $x_{Large}$ so that the expected return on the portfolio is equal to *8.0* percent, which implies that

$$x_{T\text{-}bill} * B1 \;+\; x_{T\text{-}bond} * B2 \;+\; x_{Small} * B3 \;+\; x_{Large} * B4 \;=\; .072$$

In the expression above, the values stored in cells *B1, B2, B3* and *B4* represent the expected returns on the four asset classes. We must also ensure that *100* percent of the portfolio is invested in some combination of the three assets. In other words, portfolio weights must add to one,

$$x_{T\text{-}bill} + x_{T\text{-}bond} + x_{Small} + x_{Large} = 1$$

If we already know the portfolio weights for T-bonds, small cap stocks, and large cap stocks [$x_{T\text{-}bond}$, $x_{Small}$ *and* $x_{Large}$ ], then the expression above implies that the fraction of the portfolio invested in Treasury bills must equal

$$1 - x_{T\text{-}bond} - x_{Small} - x_{Large}$$

We're now ready to deal with one of the two most important parts of the portfolio selection problem. Select a trial solution having *60* percent of the portfolio invested in Treasury bonds, *0* percent invested in small stocks and *30* percent invested in large stocks. (Don't worry! If this isn't the correct solution to the problem, solver will keep adjusting the portfolio weights until a superior combination of risk and return is found.) Input these portfolio weights respectively in cells *B13*, *B14*, and *B15* and then label these cells to be the fractions of the portfolio invested in Treasury bonds, small stocks and large stocks. Define cell *B12*, the fraction of the portfolio invested in Treasury bills, to be equal to *1* minus the values in cells *B13*, *B14*, and *B15* (*remember that you need an = to define any formula in EXCEL*) so that the fraction of the portfolio invested in Treasury bills is equal to *0.10*. Your spreadsheet should look something like this

| | Column A | Column B |
|---|---|---|
| *Row 12* | *Portfolio Weight: T-bills* | *= 1 - B13 - B14 - B15* |
| *Row 13* | *Portfolio Weight: T-bonds* | *0.600* |
| *Row 14* | *Portfolio Weight: Small Stocks* | *0.000* |
| *Row 15* | *Portfolio Weight: Large Stocks* | *0.300* |

Now that we have set up trial values for the portfolio weights, we need to enter the formula for the expected return on the portfolio (put this in cell B16), as shown below

| | Column A | Column B |
|---|---|---|
| Row 16 | *Expected Portfolio Return* | *= B12*B1 + B13*B2 + B14*B3 + B15*B4* |

The formula in the Expected Portfolio Return cell is simply the proportion of the portfolio invested in T-bills (*B12*) multiplied by the return on Treasury bills (*B1*) plus the proportion of the portfolio invested in Treasury bonds (*B13*) times the expected return on Treasury bonds (*B2*) plus the proportions invested in small stocks and large stocks (*B14* and *B15*) times the respective expected returns for small stocks and large stocks (*B3* and *B4*).

The formula for the portfolio standard deviation is too large and complicated (as a practical matter) to put in a single cell. Instead, I suggest a matrix approach, where the formulas for the individual components of the variance formula are input to separate cells as shown below,

| Row | | Column E<br>T-bonds | Column F<br>Small Stocks | Column G<br>Large Stocks |
|---|---|---|---|---|
| 3 | T-bonds | = *(B13*B6)^2* | | |
| 4 | Small Cap | = *2*B9 *(B13*B6)*(B14*B7)* | = *(B14*B7)^2* | |
| 5 | Large Cap | = *2*B10*(B13*B6)*(B15*B8)* | = *2*B11*(B14*B7)*(B15*B8)* | = *(B15*B8)^2* |

Note that in EXCEL an expression such as *(B13*B6)^2* represents the square of the product $x_{T-bond}\ \sigma_{T-bond}$. That is, (*B13*B6)^2* is equivalent to the $x^2_{T-bond}\ \sigma^2_{T-bond}$ component of the formula for the variance of the return on a portfolio having three assets.

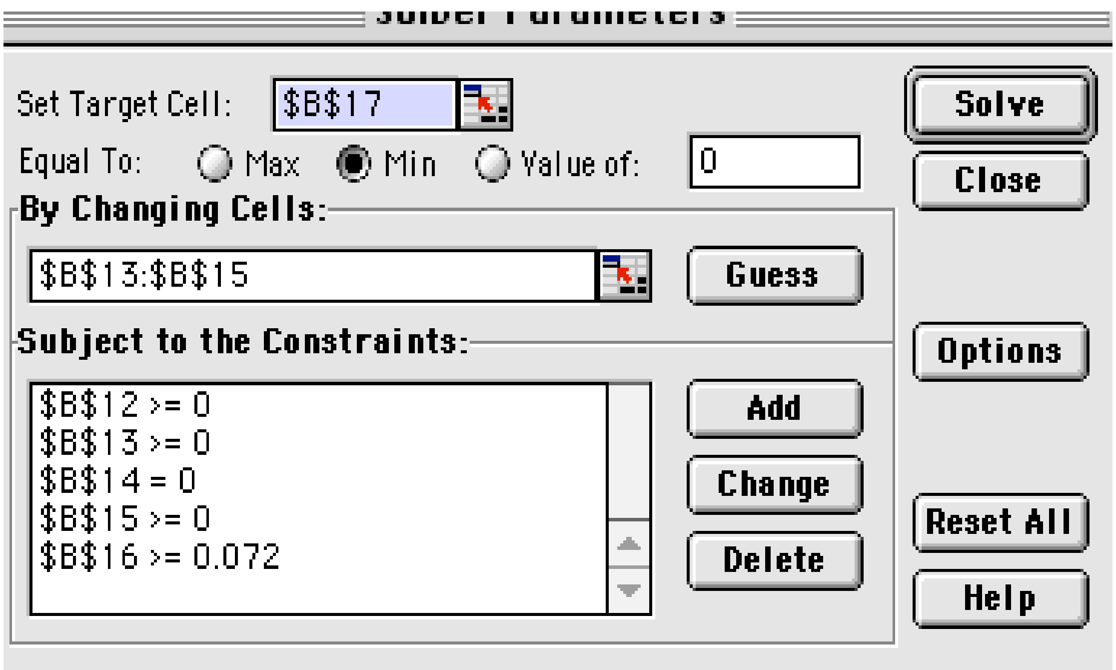
Once you have computed the values for the individual components for the portfolio variance, you can add them together using EXCEL's SUM function, and then take the square root to determine the portfolio standard deviation as shown below:

| | Column A | Column B |
|---|---|---|
| *Row 17* | *Portfolio Standard Deviation* | = *( Sum(E3:G5) )^0.5* |

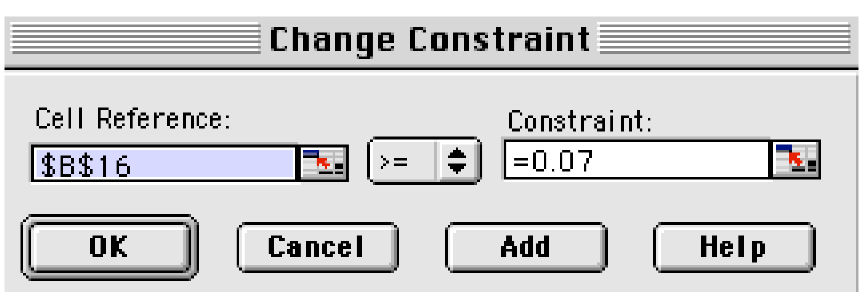
If you have correctly entered the suggested parameters (expected returns and standard deviations) and formulas (you may need to execute a save to get EXCEL to perform all the required computations), then the expected return on the portfolio (in cell *B16*) should be equal to *0.0565* (*5.65* percent) and the portfolio standard deviation (in cell *B17*) should be equal to *14.21* percent. If your spreadsheet doesn't report these values for the portfolio expected return and standard deviation, check your work carefully before proceeding with the exercise.

You have probably noticed that the expected return on the portfolio of *5.65* percent is less than our target expected return of *8.0* percent. This is where the Solver function can help. Solver is able to quickly determine the portfolio that offers an expected return of *8.0* percent, reporting to you the combination of assets that gives you an *8.0* percent return with the lowest possible standard deviation. To put solver to work, go to either the Formula Menu or the Tools Menu (depending on the version of EXCEL that you are using) and select solver. An input menu will then appear on the terminal screen. To minimize the standard deviation of your portfolio subject to the attaining a target return of *8.0* percent, solver needs to know where the information that is needs is stored.

First, in the "**Set Target Cell**" box, input *B17* to tell solver that you want to optimize the value of the formula (for portfolio standard deviation) stored in cell *B17*. Be sure to click on the circle next to **Min** (rather than Max) to tell solver that you wish to minimize the value in cell *B17*. Next, you need to input a range of cells in the box "**By Changing**." Type "*B13:B15*" in this box (without the quotes) to tell solver that you want it to change the values currently in cells *B13* through *B15* (the fractions of the portfolio invested in each of the three assets) as it searches for the portfolio weights that minimize the portfolio standard deviation in cell *B17*.




Finally, you need to tell solver whether or not there are "job requirements" that limit how cells *B13*, *B14*, and *B15* can be altered in minimizing the standard deviation of the portfolio. It is critical that you impose five constraints on the problem. Most importantly, you want to assure that the portfolio has an expected return of *8.0* percent. To do this, select "**Add**" next to the "**Subject to the Constraints**" box. When the constraint screen comes up, type "*B16*" in the "**Cell Reference**" on the left hand side of the Add Constraint box to tell solver that you want to restrict the possible values of cell *B16*. On the right-hand side, type in "*0.080*" to tell solver that you want cell *B16* to be equal to *0.080*. In the very middle of the box, solver allows you to select either (a) equal to or less than "<=" , (b) equal to "=" or (c) equal to or greater than "=>". Since our target return is *8.0* percent (i.e., *0.080*), we need to select either "=" or "=>" (we can't get more than *8.0* percent because we are simultaneously minimizing the risk of the portfolio). Then click on the **OK** button and solver will add this constraint to the problem.



Most investors are unable (large institutional investors are sometimes an exception) to use the proceeds from short sales (i.e., the cash flow from "owning a negative amount" of a financial asset cannot be used to purchase positive amounts of other financial assets). Therefore, we also need to constrain cells *B12, B13, B14*, and *B15* to be greater than zero. However, just to illustrate the value of diversification, suppose that we initially constrain the fraction of assets to be invested in small-cap stocks (cell *B14*) to be exactly equal zero. These constraints are summarized as,

$$\begin{aligned} B12 &\geq 0 \\ B13 &\geq 0 \\ B14 &= 0 \\ B15 &\geq 0 \end{aligned}$$

After adding these constraints, you will find yourself back in the solver screen. Click the "**solve**" button and solver will minimize the portfolio standard deviation, subject to these non-negativity constraints above and the requirement that the portfolio must have an expected return of *8.0* percent (or more). When solver is finished you will be prompted to save the solution to the problem. Before you select "OK", you may request that solver prepare an "Answer Report" for you. If you click on "**Answer**" in the "**Reports**" box, Excel saves an "Answer Report" that includes the optimal portfolio standard deviation and the required portfolio weights as a separate sheet in your worksheet. This worksheet can then be printed out when you are ready to provide an intuitive interpretation for your solutions to the asset allocation exercise. Note that the Answer Report for this problem that is attached below shows that the minimum variance portfolio having an expected return of *8.0* percent has a standard deviation of *23.88* percent, with a weight of *0.3846* on Treasury bonds (cell *B13*), weights of 0.000 on Treasury bills and Small-Cap stocks (cells *B12* and *B13*), and a weight of *0.6154* on Large-Cap stocks (cell *B15*):

Target Cell (Min)

| Cell | Name | Original Value | Final Value |
|---|---|---|---|
| $B$17 | Portfolio Standard Deviation | 0.1421 | 0.2388 |

Adjustable Cells

| Cell | Name | Original Value | Final Value |
|---|---|---|---|
| $B$13 | Weight: T-bonds | 0.6000 | 0.3846 |
| $B$14 | Weight: Small Stocks | 0.0000 | 0.0000 |
| $B$15 | Weight: Large Stocks | 0.3000 | 0.6154 |

Constraints

| Cell | Name | Cell Value | Formula | Status | Slack |
|---|---|---|---|---|---|
| $B$12 | Weight: T-bills | 0.0000 | $B$12>=0 | Binding | 0.0000 |
| $B$16 | Expected Portfolio Return | 0.0800 | $B$16>=0.08 | Binding | 0.0000 |
| $B$13 | Weight: T-bonds | 0.3846 | $B$13>=0 | Not Binding | 0.3846 |
| $B$15 | Weight: Large Stocks | 0.6154 | $B$15>=0 | Not Binding | 0.6154 |
| $B$14 | Weight: Small Stocks | 0.0000 | $B$14=0 | Not Binding | 0 |

To illustrate the benefits of diversification (in this case the benefits from including an additional asset class in our portfolio), click on the solver function again. When the solver parameters box appears, change the constraint restricting your investment in small stocks to equal zero (Cell *B14*), so that your investment must be equal to or greater than zero, and then hit the "**solve**" button again. You should find, as shown on the solver solution report on the following page, that adding small stocks to your portfolio allows you to achieve your expected return objective at a reduced portfolio standard deviation of *21.29* percent, with a weighting of *0.000* on Treasury bills (cell *B12*), a weighting of *0.4997* on Treasury bonds (cell *B1*3), and respective weightings on Small-Cap and Large-Cap stocks of *0.2993* and *0.2010* (cells *B14* and *B15*).

Target Cell (Min)

| Cell | Name | Original Value | Final Value |
|---|---|---|---|
| $B$17 | Portfolio Standard Deviation | 0.2388 | 0.2129 |

Adjustable Cells

| Cell | Name | Original Value | Final Value |
|---|---|---|---|
| $B$13 | Weight: T-bonds | 0.3846 | 0.4997 |
| $B$14 | Weight: Small Stocks | 0.0000 | 0.2993 |
| $B$15 | Weight: Large Stocks | 0.6154 | 0.2010 |

Constraints

| Cell | Name | Cell Value | Formula | Status | Slack |
|---|---|---|---|---|---|
| $B$12 | Weight: T-bills | 0.0000 | $B$12>=0 | Binding | 0.0000 |
| $B$16 | Expected Portfolio Return | 0.0800 | $B$16>=0.08 | Binding | 0.0000 |
| $B$13 | Weight: T-bonds | 0.4997 | $B$13>=0 | Not Binding | 0.4997 |
| $B$15 | Weight: Large Stocks | 0.2010 | $B$15>=0 | Not Binding | 0.2010 |
| $B$14 | Weight: Small Stocks | 0.2993 | $B$14>=0 | Not Binding | 0.2993 |