Continuing Education Course #287
Engineering Methods in Microsoft Excel
Part 2: Applied Optimization

1. Which of the following is NOT an element of an optimization formulation?
- a. Objective function
- b. Constraints
- c. Mathematical programming
- d. Decision variables

2. In an optimization model, the main constraints are used to
- a. define the domains of the decision variables
- b. govern the interactions between the decision variables
- c. specify the relationships between the decision variables in the objective function

3. The purpose of classifying mathematical programs is to
- a. determine the tractability of the problem
- b. select a method that can be used to analyze and solve the problem
- c. improve the tractability of probabilistic models

4. An optimal solution is
- a. a feasible solution where the objective function reaches the optimal value.
- b. any real solution where the objective function reaches the optimal value
- c. the feasible solution computed as a closed-form solution only

5. The concept of improving search in solving optimization models involves
- a. using graphical methods to test points within the feasible region to identify the optimal solution
- b. starting the numerical search process at a feasible solution, testing neighboring solutions, and moving the search process in the direction that will lead to rapid convergence
- c. starting the numerical search process at some non-optimal solution, testing neighboring solutions, and moving the search process in the direction of the superior neighbors

Use the following information and the supplied *Excel* file to work Question 6 through Question 25.

Engineers Trust Bank of Florida has $40 million in capital, $300 million in checking account deposits, and $120 million in savings account deposits, that it wants to invest. Like any other bank, Engineers Trust Bank of Florida is seeking an investment plan that results in maximizing return on investment. The bank also wants to track the risk associated with any investment plan it adopts. The following products are available for the bank to invest in:

Investment Product	Return Rate (%)	Liquid (Cash) Component (%)	Risk (%)
1. Cash	**0.0**	**100.0**	**5**
2. Short Term Bonds	**4.0**	**99.5**	**10**

3. Government Bond 1 – 5 years	**4.5**	**96.0**	**0**
4. Government Bond 5 – 10 years	**5.5**	**90.0**	**0**
5. Government Bond over 10 years	**7.0**	**85.0**	**0**
6. Installment Loans	**10.5**	**0.0**	**75**
7. Mortgage Loans	**8.5**	**0.0**	**60**
8. Commercial Loans to small businesses	**9.5**	**0.0**	**50**

The following requirements must be followed:

1. **The total investments in all products cannot exceed the total of the capital and deposits amounts.**
2. **At least 5% of the funds should be invested in each of the eight products, for diversification of the portfolio.**
3. **At least 30% of funds should be invested in commercial loans to small businesses, to maintain the banks "small business friendly" status.**
4. **For the risk, the bank stands to lose the specified percentage of the money it invests in that product.**
5. **Federal regulations require that a reserve of at least 14% of the checking account deposits plus 4% of the savings account deposits be maintained at all times.**
6. **Federal regulations require that the total of the liquid components of the investments be at least 47% of the checking account deposits plus 36% of the savings account deposits**

Let x_1 denote the amount ($) invested in product #1.
Let x_2 denote the amount ($) invested in product #2.
:
:
Let x_8 denote the amount ($) invested in product #8.

The standard form of this optimization model is as follows.

Objective function:

maximize $0.0\,x_1 + 0.04\,x_2 + 0.045\,x_3 + 0.055\,x_4 + 0.07\,x_5 + 0.105\,x_6 + 0.085\,x_7 + 0.095\,x_8$
[return on investment]

Subject to:

$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 \leq 460{,}000{,}000$
[total investment]

$0.95x_1 - 0.05x_2 - 0.05x_3 - 0.05x_4 - 0.05x_5 - 0.05x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #1]

$-0.05x_1 + 0.95x_2 - 0.05x_3 - 0.05x_4 - 0.05x_5 - 0.05x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #2]

$-0.05x_1 - 0.05x_2 + 0.95x_3 - 0.05x_4 - 0.05x_5 - 0.05x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #3]

$-0.05x_1 - 0.05x_2 - 0.05x_3 + 0.95x_4 - 0.05x_5 - 0.05x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #4]

$-0.05x_1 - 0.05x_2 - 0.05x_3 - 0.05x_4 + 0.95x_5 - 0.05x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #5]

$- 0.05x_1 - 0.05x_2 - 0.05x_3 - 0.05x_4 - 0.05x_5 + 0.95x_6 - 0.05x_7 - 0.05x_8 \geq 0$
[diversification for product #6]

$-0.05x_1 - 0.05x_2 - 0.05x_3 - 0.05x_4 - 0.05x_5 - 0.05x_6 + 0.95x_7 - 0.05x_8 \geq 0$
[diversification for product #7]

$-0.05x_1 - 0.05x_2 - 0.05x_3 - 0.05x_4 - 0.05x_5 - 0.05x_6 - 0.05x_7 + 0.95x_8 \geq 0$
[diversification for product #8]

$-0.3x_1 - 0.3x_2 - 0.3x_3 - 0.3x_4 - 0.3x_5 - 0.3x_6 - 0.3x_7 + 0.7x_8 \geq 0$
[small business loans]

$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 \leq 413{,}200{,}000$
[required reserve per Fed regulation]

$1.0x_1 + 0.995x_2 + 0.96x_3 + 0.9x_4 + 0.85x_5 \geq 184{,}200{,}000$
[liquid components per Fed regulation]

$x_1 \geq 0$ [variable-type 1]

$x_2 \geq 0$ [variable-type 2]

$x_3 \geq 0$ [variable-type 3]

$x_4 \geq 0$ [variable-type 4]

$x_5 \geq 0$ [variable-type 5]

$x_6 \geq 0$ [variable-type 6]

$x_7 \geq 0$ [variable-type 7]

$x_8 \geq 0$ [variable-type 8]

The risk associated with the investment plan is
$0.05x_1 + 0.1x_2 + 0.75x_6 + 0.6x_7 + 0.5x_8$
[risk]

Open the *Excel* file supplied with the test and review the implementation of the investment plan on the spreadsheet and in *Excel Solver*. Please do not change any of the data entries unless specifically instructed to do so.

Set the decision variables and the objective function.
Set the solving method to Simplex LP.
Run the model.

6. The optimal total investment for maximization of returns is
- ○ a. $102,346,705
- ○ b. $124,674,970

○ c. $413,200,000

7. The optimal return on investment is
○ a. $31,643,165
○ b. $124,674,970
○ c. $413,200,000

8. The total risk associated with the optimal investment plan is
○ a. $123,006,705
○ b. $123,960,000
○ c. 124,674,970

9. The optimal investment amounts for product 1 and product 5 are
○ a. $20,660,000 and $31,643,165 respectively
○ b. $20,660,000 and $123,006,705 respectively
○ c. $20,660,000 and $20,660,000 respectively

Increase the capital to $100,000,000.
Rerun the model.

10. There is an increase in the optimum return on investment.
○ a. True
○ b. False

11. The optimal total investment for maximization of returns is now
○ a. $413,200,000
○ b. $473,200,000
○ c. $460,000,000

12. The total risk associated with the optimal investment plan is now
○ a. $166,379,382
○ b. $413,200,000
○ c. $520,000,000

13. The optimal investment amounts for product 4 and product 8 are now
○ a. $23,660,000 and $37,339,371 respectively
○ b. $23,660,000 and $141,960,000 respectively
○ c. $23,660,000 and $23,660,000 respectively

Reduce the capital to $40,000,000.
Increase the checking account deposits to $400,000,000.
Rerun the model.

14. The optimal total investment for maximization of returns is now
○ a. $499,200,000
○ b. $560,000,000
○ c. $682,000,000

15. The optimal return on investment is now
○ a. $31,643,165
○ b. $33,011,579
○ c. $37,872,432

16. The total risk associated with the optimal investment plan is now
- a. $222,569,558
- b. $142,980,705
- c. $124,674,890

17. The optimal investment amounts for product 3 and product 5 are now
- a. $24,960,000 and $158,799,058 respectively
- b. $24,960,000 and $149,760,000 respectively
- c. $158,799,058 and $149,760,000 respectively

Reduce the checking account deposits to $300,000,000.
Increase the savings account deposits to $200,000,000.
Rerun the model.

18. The optimal total investment for maximization of returns is now
- a. 540,000,000
- b. 490,000,000
- c. 152,644,852

19. The optimal return on investment is now
- a. 24,500,000
- b. 37,748,426
- c. 81,026,470

20. The total risk associated with the optimal investment plan is now
- a. 152,644,852
- b. 142,980,705
- c. 124,674,890

21. The optimal investment amounts for product 6 and product 7 are now
- a. 81,026,470 and 147,000,000 respectively
- b. 24,500,000 and 147,000,000 respectively
- c. 81,026,470 and 24,500,000 respectively

Reduce the savings account deposits to $120,000,000.
Rerun the model, and note the maximum return on investment.
Change the objective function to maximize risk.
Rerun the model.

22. Maximizing the risk resulted in an increase in the return on investment
- a. True
- b. False

Change the objective function to maximize return on investment.
Rerun the model, and note the optimal return on investment.
Change the objective function to minimize risk.
Rerun the model.

23. The optimal total investment for risk minimization is now
- a. 322,450,765
- b. 460,000,000
- c. 520,000,000

24. The return on investment under risk minimization is now
- a. 37,872,432
- b. 31,643,165
- c. 20,717,461

25. The total risk associated with risk minimization plan is now
- a. 72,551,422
- b. 124,674,890
- c. 142,980,705

26. The optimal investment amounts for product 6 and product 8 are now
- a. 128,980,306 and 96,735,229 respectively
- b. 16,122,538 and 128,980,306 respectively
- c. 16,122,538 and 96,735,229 respectively

27. Sensitivity analysis is
- a. required in all optimization studies
- b. strongly recommended for most optimization studies
- c. only relevant based on the solving method used.

28. The solving method selected in *Excel Solver*
- a. should be selected based on the classification of the optimization model
- b. should be selected based on the number of reports the user would like to produce
- c. is not important, as all solution methods use improving search algorithms

29. *Excel Solver* cannot solve nonlinear optimization models
- a. True
- b. False

30. There are no limits on the size of the optimization model that can be implemented in *Excel Solver*.
- a. True
- b. False