



NaviPlan Standard Online/Offline

Monte Carlo Sensitivity Analysis

USA version 11.0

EISI, Winnipeg

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Monte Carlo Sensitivity Analysis

The NaviPlan Standard Monte Carlo Sensitivity Analysis Self-Study Guide was created using NaviPlan Standard Offline with the Ibbotson Asset Allocation option. This option allows you to use actual Ibbotson return rates in NaviPlan's calculations.

The exercises in this module are based on a version of NaviPlan Standard Offline that includes the Ibbotson Asset Allocation option, which means that the asset allocation settings are set up for you. If your version of NaviPlan Standard Offline does not include the Ibbotson Asset Allocation option, you can modify the data.

Learning objectives

This module will enable you to

- Identify the purpose and key concepts of Monte Carlo
- Appreciate the effects of deficit coverage
- Determine how success is measured
- Analyze the results of a *Monte Carlo Sensitivity Analysis*

Learning tools

This module includes some practice exercises. We recommend that you use the Nick and Lisa Brown (Brown, Nick and Lisa.nps) client file in the data folder of your installation of NaviPlan Standard Offline (the default path is C:\Program Files\EISI\Data, but you may have installed it elsewhere). It will be available when you run NaviPlan Standard Offline, as well as on the central server if you prefer to work in the online application.

Note: If you are using a version of NaviPlan Offline without the Ibbotson Asset Allocation option, or if you are using NaviPlan Online, there will be some differences between the guide and your version of NaviPlan.

Hint: In NaviPlan Standard Offline, to find the location of your data directory, go to the **User Preferences** menu – **System Settings** selection – **User Preferences - System Settings** dialog box – **File Locations** tab.

Identify the purpose and key concepts of Monte Carlo

Purpose of Monte Carlo

What is Monte Carlo?

Monte Carlo is a simulation tool that you can use to determine the effect of market and longevity risk on a completed plan. It is intended to perform a risk analysis.

The plan is based on the static assumptions you entered (e.g., fixed return rates and fixed life expectancies)

In reality these variables will not be static – market fluctuations will affect overall asset performance, and uncertain life expectancies may cause clients to outlive resources or they may not get the accumulation needed if they die early.

Monte Carlo helps assess the effect of risks on the plan by

- Randomizing return rates – this helps analyze the risk of market fluctuations (uses the standard deviation entered along with the account's return rate)
- Randomizing the life expectancy – this helps analyze the risk of dying too soon or outliving assets

By randomizing these variables Monte Carlo can help determine the effect of risk on a plan. In other words, does the plan have enough leeway to still enable the clients to achieve their goals if markets and life outcomes change? How well will the plan you have created for your clients perform, if the return rates and life expectancies do not meet expectation, or if they exceed expectations?

Key concepts of Monte Carlo

- Monte Carlo is based on cash flows
- Multiple projections / iterations are used
 - Projects the plan's results a number of times (trials or iterations).
For example: Naviplan analyzes the plan with one set of assumptions for life expectancy and varying return rates, records the success (or failure), and then runs the plan again with another set of variances.
 - You can specify the number of trials or iterations in the *Assign Settings* dialog box for the *Monte Carlo* graph.
- During each projection, variables change
 - Life expectancy (based on 1983 Group Annuity Mortality Tables).
Randomize Life Expectancy is an optional setting and if not used the client's life expectancy is based on the plan's deceased dates. The maximum life expectancy is 110 years old.

- Rates of return (based on standard deviation)
 - Uses normal distribution and an asset class standard deviation to define possible ranges of returns for the class
 - For each year in a projection, the projected asset class return is calculated based on the normal distribution
 - For users with the Ibbotson Asset allocation, correlations between classes are used to help determine projected returns
 - Resulting asset class returns are applied to individual accounts to determine account returns
 - This process continues for each year of projection
- Success is based on deficits for both the plan and each goal
 - Monte Carlo will assess the plan as a whole for deficits as well as individual goals
 - If a projection shows goal deficits beyond a set allowable amount (tolerance) the projection is considered a failure
 - If a projection shows no deficits or deficits within the allowable amount (tolerance) the projection is considered a success
 - Terminal net worth is displayed but is not a contributing factor to the success or failure of projections unless it is negative
 - For example: if assets are held in illiquid holdings, high net worth will not meet the clients' needs
- Percentage of successful projections is displayed
 - NaviPlan displays the percentage of projections that successfully met goals (they did not have deficits outside of the tolerance levels)
 - For example: out of 100 projections, if 85 did not show significant deficits, then an 85% success rate will be displayed

Understand the effects of standard deviation on assets

The figure below illustrates the effects of standard deviation on a Monte Carlo analysis.

Asset	Rate of Return	Standard Deviation
Nick's 401(k)	6.00%	0.00%

Goal	Success Rate	10th Percentile	50th Percentile	90th Percentile
Retirement Goal	100.00%	\$755,835	\$908,141	\$973,822

Asset	Rate of Return	Standard Deviation
Nick's 401(k)	6.00%	10.00%

Goal	Success Rate	10th Percentile	50th Percentile	90th Percentile
Retirement Goal	80.00%	(\$268,775)	\$836,835	\$1,925,527

The first plan has an account with a rate of return of 6% and standard deviation of 0%.

When you run a Monte Carlo analysis, notice that the change to the projected value between each percentile is small. This is because every iteration used a static 6% rate of return.

The second plan has an account with the same 6% rate of return but a 10% standard deviation.

Now the projected range of net worth has changed, and the differences between each percentile is much greater.

Interpretation of percentiles

- The 10th percentile reports that 10% of the results are lower than -\$250,000, or 90% of the results were above -\$250,000.
- The 50th percentile reports that 50% of the results are lower than \$800,000, or 50% of results were above \$800,000.
- The 90th percentile reports that 90% of the results are lower than \$1,900,000, or only 10% of results were above \$1,900,000.

Activate Monte Carlo

In order to have access to the Monte Carlo feature, it must be selected as one of the modules to included in the plan.

1. Go to the **Plan Management** section – **Modules** category – **Modules** page, and then click the **Select Modules** button. The *Select Modules* dialog box opens
2. Select the **Monte Carlo Analysis** check box, and then click **OK**.

Note: Monte Carlo is available in Level 2 and Level 3 Plans.

Set up account return rates and standard deviations

Standard deviation will affect the rates of return for an account during a Monte Carlo analysis. The standard deviation for an account can be located and edited during the initial setup of the account, or afterward.

Account Details (Investment Portfolio)

Description* Plan Type* Owner* Community Property
 Lisa's Brokerage Account Non-Qualified Lisa

Market Value* Cost Basis*
 \$55,000 \$46,000

Holdings Saving Strategies Return Rates

Override

	Pre-Retirement	Retirement
Interest	0.00%	0.00%
Dividends	1.80%	1.80%
Capital Gains	4.33%	4.33%
Tax Free	0.00%	0.00%
Deferred Growth	0.00%	0.00%
Total	6.13%	6.13%
Standard Deviations	24.98%	24.98%

Add Account | Previous Entry | Next Entry | OK | Cancel

Figure 1: Financial Picture section – Net Worth category – Accounts page – Account Details dialog box – Return Rates tab

To set up account return rates and standard deviation

1. Go to the **Financial Picture** section – **Net Worth** category – **Accounts** page.
2. Find the account you want to adjust and click the **Details** button. The *Account Details* dialog box opens.
3. Select the **Return Rates** tab, and then select the **Override** check box. The return rates and *Standard Deviations* fields become editable.
4. Enter the new values for the rates of return and standard deviation.
5. Click **OK**.

Access Monte Carlo

There are two ways to access the *Monte Carlo Sensitivity Analysis*:

- As a stand-alone graph (*Reports* menu – *Monte Carlo* – *Monte Carlo*)
- As a part of a client report (*Results* section – *Client Reports* category – *Client Reports* page – *Financial Needs Summary* report or *Financial Needs Analysis* report)

Assign Monte Carlo settings

The *Assign Settings* dialog box allows you to define the assumptions upon which the Monte Carlo analysis will be based.

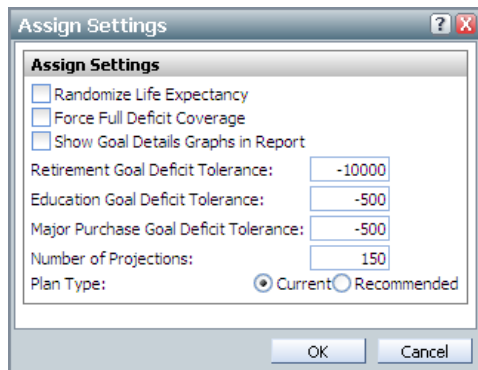


Figure 2: Reports menu – Monte Carlo – Monte Carlo – Assign Settings dialog box

- *Randomize Life Expectancy* – Select this check box to randomly select life expectancies for each iteration of the simulation. Monte Carlo theory suggests that using random life expectancies results in more realistic simulations. Life expectancies are based on a mortality table.
- *Force Full Deficit Coverage* – Select this check box to automatically redeem available assets throughout the entire plan (not just the retirement period, which is the default) to cover annual cash flow deficits. By default, any available non-qualified assets owned by the client or co-client are used to cover these deficits. Selecting this option does not change the plan in any way, but may result in a higher number of failures. For example, if assets funding retirement are depleted to cover deficits in the pre-retirement period, the likelihood that deficits occur during retirement increases. If a deficit is greater than the success tolerance, a failure is triggered.
- *Show Goal Details Graphs in Report* – Select this check box to include graphs that show the details about retirement/major purchase/education goals at the end of the report. This option is recommended if you want to see how individual projections are distributed or if you are interested in seeing the highest or lowest results that occurred during the Monte Carlo simulation.
- *Retirement Goal Deficit Tolerance* – Enter the deficit tolerance your clients feel comfortable with, expressed as a negative number.
- *Education Goal Deficit Tolerance* – Enter the deficit tolerance your clients feel comfortable with, expressed as a negative number.
- *Major Purchase Goal Deficit Tolerance* – Enter the deficit tolerance your clients feel comfortable with, expressed as a negative number.
- *Number of Projections* – Enter the number of projections that will be run. The number must be between 100 and 1,000. The more projections run, the longer it takes to complete the

simulation. Although the default is 150 projections, it is not usually a representative sample of all possible outcomes.

- *Plan Type* – Select *Current* or *Recommended* to identify which plan or scenario is to be analyzed.
 - *Current* – The clients' current financial situation, identified as the *Current Plan* on *Scenarios* pages in the *Goals* category
 - *Recommended* – The scenario marked as *Recommended* on *Scenarios* pages in the *Goals* category

Appreciate the effects of deficit coverage

Force Full Deficit Coverage invokes NaviPlan's automatic asset redemption where assets are redeemed throughout the entire plan period (not just the retirement period) to cover annual cash flow deficits.

Selecting this option does not change the plan in any way, but may result in a higher number of failures.

For example, if assets funding retirement are depleted to cover deficits in the pre-retirement period, the likelihood that deficits occur during retirement increases.

Before deciding whether or not to run Monte Carlo with *Force Full Deficit Coverage* selected, it is important to understand how deficit coverage works, and how it can influence the analysis results.

Asset availability when *Force Full Deficit Coverage* is selected:

- Any available investment assets owned by the client or co-client are used to cover deficits for the pre-retirement and retirement periods
- Qualified assets are not available until the clients retire
- Lifestyle, real estate, and business entities are not available
- Assets are redeemed in the most tax-efficient order

Since Monte Carlo in NaviPlan is based on cash flow as opposed to terminal net worth, this prevents cash flow deficits from causing projections to fail when the clients still have enough assets to cover the deficits.

When the *Force Full Deficit Coverage* check box remains cleared (not selected):

- Assets will only be redeemed throughout the retirement period when the first person retires until death to cover annual cash flow deficits.
- During pre-retirement, deficits and surpluses accumulate until the first person retires, and then are reset to zero. Therefore, any pre-retirement deficits accumulate until retirement and don't carry on into the retirement period.
- The *Force Full Deficit Coverage* option only affects the retirement goal.
- Any non-qualified assets that are owned by the clients that are linked to other goals will become available once the goal to which the asset is linked is satisfied.

Determine how success is measured

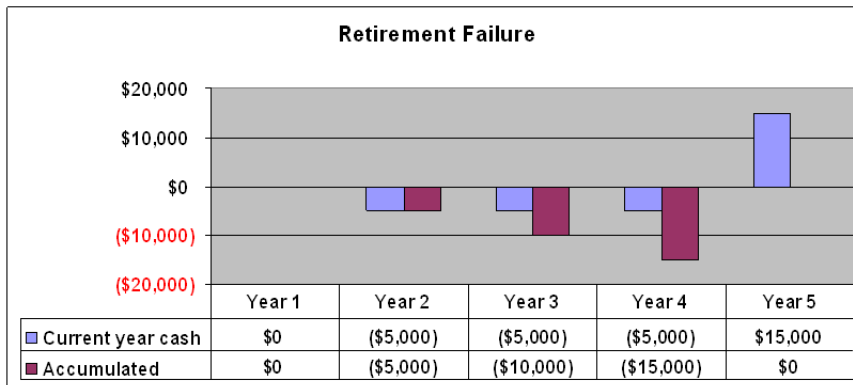
Each projection in the *Monte Carlo Sensitivity Analysis* is determined to be either a success or failure according to specific criteria dependent on the goal type.

Success or failure is based on cash flow and a negative net worth test. Terminal net worth appears in the *Monte Carlo* report but is not a contributing factor to the success or failure of projections unless it is negative. For example, a portfolio with low net worth but adequate cash flow can result in a high success rate. If a projection results in negative net worth in any year beyond the deficit tolerance for the goal, the projection is a failure. If a projection shows no deficits, or deficits do not exceed the deficit tolerance, the projection is considered a success. For example, if in 85 out of 100 trial projections deficits are within the specified tolerance, Monte Carlo reports an 85% success rate. The success rate is calculated by dividing the number of successful trials by the total number of trials run.

The success rate of all goals (education/major purchase/retirement) is determined only after the success rates have been determined for all goals of the same type. A trial is successful if all goals are successful. If one or more goals fail, then the trial fails for all goals of that type.

For each type of goal, there are some differences in how a goal is deemed successful:

- *Major purchase goals* – A separate analysis is done for each goal. Only the major purchase expense and any major purchase funding account redemptions in the purchase year are examined. If the funding amount either meets the goal amount or is within the specified deficit tolerance, the goal is successful.
- *Education goals* – A separate analysis is done for each goal. Cash flows are examined on a year-by-year basis only during years when the education expenses occur. For an education goal to succeed, in every year of the education goal, cash flow must either cover the goal expense or must be within the specified deficit tolerance.
- *Retirement goals* – Only the retirement years of each projection are examined. All cash flow sources in each year of retirement are used. If accumulated cash flow deficits are within the specified deficit tolerance, the goal succeeds. For all goals, success is determined when all goals succeed in a given trial.



Analyze the results of a Monte Carlo Sensitivity Analysis

In order to analyze the results of a *Monte Carlo Sensitivity Analysis*, generate one and take a look at the different parts of the report. For this case, use the recommended plan.

To generate a Monte Carlo Analysis

1. Go to the **Reports** menu and select **Monte Carlo – Monte Carlo**. The *Assign Settings* dialog box opens.
2. Select **Randomize Life Expectancy**, **Force Full Deficit Coverage**, and **Show Goal Details Graphs in Report**.
3. Leave the other settings at their defaults, and then select the **Recommended** plan type.
4. Click **OK**. The *Monte Carlo Sensitivity Analysis* report is generated.

Assumptions table

Assumptions

Assumptions	
Life Expectancy Randomized	Yes
Force Full Deficit Coverage	Yes
Retirement Goal Success Tolerance	(\$10,000)
Education Goals Success Tolerance	(\$500)
Major Purchase Goals Success Tolerance	(\$500)
Number of Projections	150

These are the assumptions you entered in the *Assign Settings* dialog box.

Asset Standard Deviations table

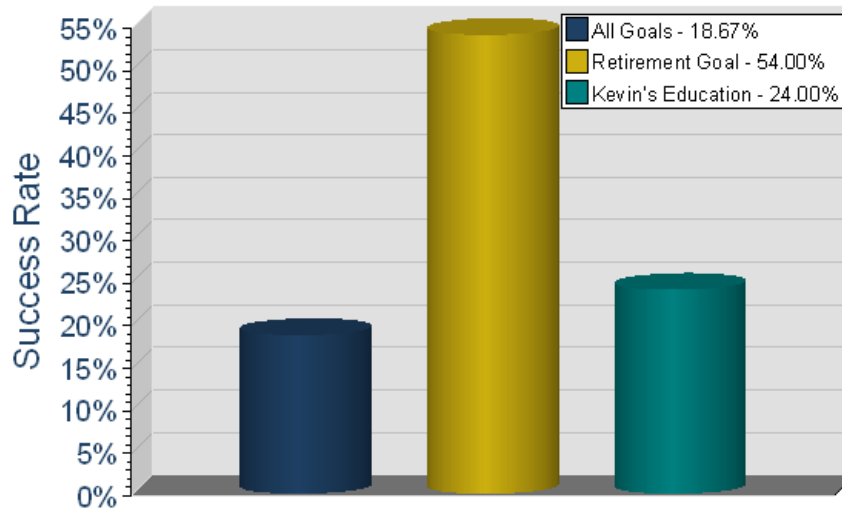
Asset Standard Deviations

Asset	Rate of Return	Standard Deviation
500 Smith Street (Joint/Real Estate)	3.50%	15.00%
Nick's Annuity (Non-Qualified)	8.66%	12.23%
25% of Joint Savings Account (Non-Qualified)	8.66%	12.23%
75% of Joint Savings Account (Non-Qualified)	8.66%	12.23%
Emergency Fund (Joint/Non-Qualified)	3.13%	3.01%
Lisa's Brokerage Account (Non-Qualified)	8.66%	12.23%
Nick's Brokerage Account (Non-Qualified)	8.66%	12.23%
Retirement Fund (Joint/Non-Qualified)	8.66%	12.23%
Lisa's Roth 401 (k/Roth IRA)	8.66%	12.23%
Nick's 403(b)	8.66%	12.23%
Kevin's 529 (Nick/529 Plan for Kevin)	8.66%	12.23%

This table displays the rate or return and standard deviation assigned to every asset in the plan.

Goal Summary graph

Goal Summary Graph



This graph shows how successful each of the goals are.

The success rate identified for all goals is assessed differently.

- If all of the goals succeeded in a projection, the entire projection is considered a success
- If at least one goal did not succeed in a projection, then the entire projection is a failure

For each type of goal there are some differences on how success is determined:

- Retirement goal – only retirement years are tested for success or failure
- Education goal – a deficit in any of the years that the education goal applies (for example, 4 years) means the trial has failed
- Major purchase goals – the trial must be successful at the goal's purchase date

For all goals, success is determined when all goals succeed in a given trial.

Goal Success Rates table

Goal Success Rates

Goal	Success Rate	10th Percentile	50th Percentile	90th Percentile
All Goals	18.67%			
Retirement Goal	54.00%	(\$2,154,881)	\$3,380,800	\$24,672,098
Kevin's Education	24.00%	\$57,765	\$67,931	\$94,831

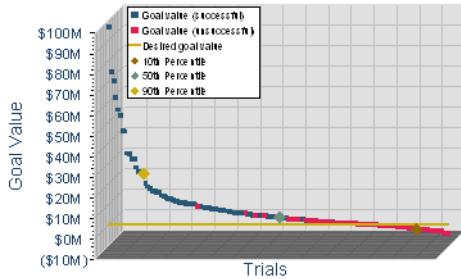
- Success rate – percentage of successful projections shown in the *Goal Summary* graph
- Percentiles for retirement goal – represent terminal net worth or net worth at last death (after estate expenses) which includes lifestyle assets, real estate, and business entities
- Percentiles for education and major purchase – represent the total after-tax asset values accumulated as of Dec. 31 of the year prior to the last year of the goal (includes residuals)

The percentiles represent the following:

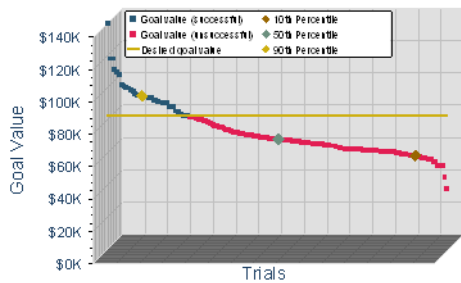
- The 10th percentile reports that 10% of the results are lower than this amount; 90% of results are higher
- The 50th percentile reports that 50% of the results are lower than this amount; 50% of results are higher
- The 90th percentile reports that 90% of the results are lower than this amount; 10% of results are higher

Retirement or Education Goal graphs

Retirement Goal



Kevin's Education



These graphs appear if the *Show Goal Details Graphs in Report* check box is selected in the *Assign Settings* dialog box prior to generating the *Monte Carlo Sensitivity Analysis*.

The graphs plot the goal value related to the corresponding goal for each projection.

- For example: If you have 100 projections, you will see 100 squares plotted on the graph. All projections are plotted from highest goal value, starting at the left, to the lowest goal value at the right.

Exercises

The exercises have been designed specifically for this module and assume that you are working with the original data in the *Brown Base Details* plan. Before starting the exercises, duplicate the **Brown Base Details** plan, rename the duplicate with a meaningful name (e.g., *Monte Carlo Sensitivity Analysis training*), and use it to complete the following exercises.

Hint: All copies of plans are managed in the *Plan Management* section – *Plan List* category.

Exercise 1: Identify the purpose and concepts of Monte Carlo

To find the answers, see “Answers to Monte Carlo Sensitivity Analysis exercises” on page 17.

1. Monte Carlo is a NaviPlan invention. True or false?
 - a) True
 - b) False

2. What are the plan risks NaviPlan can help analyze using the *Monte Carlo Sensitivity Analysis*?
 - a) Risk of clients outliving resources by living longer than expected
 - b) Risk of clients not accumulating the needed resources if they die earlier than expected
 - c) Risk of having insufficient resources for goals as a result of poor asset performance in early years
 - d) All of the above

Exercise 2: Appreciate the effects of deficit coverage

To find the answers, see “Answers to Monte Carlo Sensitivity Analysis exercises” on page 17.

1. Which factors should be considered when defining the deficit tolerance for a goal?
 - a) The clients’ overall risk tolerance
 - b) The clients’ net worth and ability to meet goal shortfalls by other means
 - c) The clients’ cash flow
 - d) All of the above

Exercise 3: Determine how success is measured

To find the answers, see “Answers to Monte Carlo Sensitivity Analysis exercises” on page 17.

1. NaviPlan determines a goal’s success based on which of the following?
 - a) The goal’s deficits
 - b) The plan’s terminal net worth
 - c) Both a) and b)

2. Complete the following exercise by answering *true* or *false*. If false, please indicate why.

Statement	True or false
a) Success for the retirement goal is based on the clients’ terminal net worth.	
b) <i>Randomize Life Expectancy</i> uses a maximum life expectancy of 120 years.	
c) Deficit tolerance is the amount the clients are willing to spend.	
d) <i>Force Full Deficit Coverage</i> implies that non-qualified assets are available in pre-retirement if necessary.	
e) Assets with low standard deviation indicate more risk than assets with high standard deviation.	
f) Monte Carlo should be generated on a completed plan.	
g) Traditional planning examines only one possible outcome.	
h) The maximum number of projections is 15,000.	
i) The minimum number of projections is 99.	

Exercise 4: Display the results of a Monte Carlo Analysis

Use the *Monte Carlo Sensitivity Analysis* sample below to answer the following questions. To find the answers, see “Answers to Monte Carlo Sensitivity Analysis exercises” on page 17.

Assumptions	
Life Expectancy Randomized	Yes
Force Full Deficit Coverage	No
Annual Cash Flow Deficit Tolerance	(\$10,000)
Education Goals Success Tolerance	(\$500)
Major Purchase Goals Success Tolerance	(\$500)
Number of Projections	100

Goal Success Rates				
Goal	Success Rate	10th Percentile	50th Percentile	90th Percentile
All Goals	33.00%			
Retirement Goal	63.00%	\$4,498,186	\$8,510,752	\$19,319,810
Kathy's Education	62.00%	\$134,977	\$160,351	\$196,628
Charles' Education	61.00%	\$126,043	\$192,787	\$296,371
Family European Vacation	68.00%	\$40,530	\$71,243	\$118,023

1. What are these Monte Carlo sample results telling us about this plan?

2. What could be done to modify the results?

3. The results are showing that even in the lowest percentile, or the worst situation, the clients have a high net worth. Why is the success rate so low?

Conclusion

This module has enabled you to

- Identify the purpose and key concepts of Monte Carlo
- Appreciate the effects of deficit coverage
- Determine how success is measured
- Analyze the results of a *Monte Carlo Sensitivity Analysis*

Answers to Monte Carlo Sensitivity Analysis exercises

Exercise 1: Identify the purpose and concepts of Monte Carlo

1. b) False – Monte Carlo is a probability tool used in multiple disciplines, including financial planning.
2. d) Using the *Monte Carlo Sensitivity Analysis*, NaviPlan can help analyze all the listed plan risks.

Exercise 2: Appreciate the effects of deficit coverage

1. d) You should consider all the listed factors when defining the deficit coverage tolerance for a goal.

Exercise 3: Determine how success is measured

1. a) NaviPlan determines a goal's success based on the goal's deficits.
2. See the answers in the table below.

Statement	True or false
a) Success for the retirement goal is based on the clients' terminal net worth.	False – based on cash flow
b) <i>Randomize Life Expectancy</i> uses a maximum life expectancy of 120 years.	False – 110 is the maximum
c) Deficit tolerance is the amount the clients are willing to spend.	False – amount clients are willing to borrow
d) <i>Force Full Deficit Coverage</i> implies that non-qualified assets are available in pre-retirement if necessary.	True
e) Assets with low standard deviation indicate more risk than assets with high standard deviation.	False – higher standard deviation indicates more risk
f) Monte Carlo should be generated on a completed plan.	True

Statement	True or false
g) Traditional planning examines only one possible outcome.	True
h) The maximum number of projections is 15,000.	False – 1,000 is the maximum
i) The minimum number of projections is 99.	False – 100 is the minimum

Exercise 4: Display the results of a Monte Carlo Analysis

1. All goals are coming up short.

While the clients have a high net worth, the plan fails because it is susceptible to market fluctuations and life expectancy changes. Increasing the amount of income that is fixed or safer from market fluctuations may improve the plan.

2. Here are two solutions:

- Change the assumption to force full deficit coverage. Assets are redeemed to cover the goal in pre-retirement.
- Increase the deficit tolerance and success tolerance. An annual cash flow deficit tolerance of \$10,000 and a \$500 success tolerance for the education and major purchase goals may be too small if the clients are easily able to borrow much more than this to cover shortfalls.

3. Non-liquid assets such as real estate assets, lifestyle assets, and business entities make up a large portion of the clients' net worth. The clients' liquid assets may not be sufficient to meet their goals.