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A Guide to the Smart Investment Tools

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Smart Investment Tool version 1.0.2
Smart Investment Tool Express (SITExpress) version 1.0

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Abstract

This report serves as a guide to the Smart Investment Tool and Smart Investment Tool Express (SITExpress). These tools aid a user in conducting an investment analysis with a focus on those in the manufacturing industry; however, the methods can be used for any investment. The Smart Investment Tool is an Excel tool that allows users to specify detailed cash flows and estimates net present value, internal rate of return, payback period, and examines sensitivity using Monte Carlo analysis. SITExpress is an express version of the Smart Investment Tool where it estimates similar metrics (net present value, internal rate of return, payback period, and the benefit cost ratio) from user data. The express version, however, is an online tool where the user enters aggregated total annual cash inflows and outflows; that is, the user only enters two values for each year: cash inflow and cash outflow. The express version also does not have the ability to conduct sensitivity analysis.

Keywords

Investment; manufacturing; net present value; present value; internal rate of return; payback; investment analysis

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1. Introduction and Methods

This document guides a user in an investment analysis using the Smart Investment Tool (Thomas 2024). and its companion express version the Smart Investment Tool Express (SITExpress) (Thomas et al. 2024). These tools aid a user in conducting an investment analysis with a focus on those in the manufacturing industry; however, the methods can be used for any investment. For instance, the tools can be used to answer questions such as:

- I have 5 possible investments, but do not have enough funds for all of them. Which ones do I choose?
- There are 3 different machinery design options. Which one is the most cost effective?
- Is it more cost effective to invest in a new HVAC system or continue with the existing one?

The Smart Investment Tool is an Excel tool that allows users to specify detailed cash flows and estimates net present value, internal rate of return, payback period, and examines sensitivity using Monte Carlo analysis. SITExpress is an express version of the Smart Investment Tool where it estimates similar metrics (net present value, internal rate of return, payback period, and the benefit cost ratio) from user data. The express version, however, is an online tool where the user enters aggregated total annual cash inflows and outflows; that is, the user only enters two values for each year: cash inflow and cash outflow. The express version also does not have the ability to conduct sensitivity analysis.

Section 1.1 discusses methods for investment analysis including net present value, internal rate of return, payback period, and benefit cost ratio. Section 2 guides a user through the Smart Investment Tool while Section 3 guides the user through SITExpress.

1.1. Methods for Investment Analysis

Net present value and internal rate of return are used in both tools with the Smart Investment Tool conducting sensitivity analysis using Monte Carlo techniques. For a more complete discussion on net present value, internal rate of return, and Monte Carlo analysis, see Thomas (2017). The tool also calculates payback period and discounted payback period.

An article by Graham and Campbell (2001 pg 187-243) provides some insight into the usage of net present value and internal rate of return for investment analysis. They surveyed 392 chief financial officers (CFO) about the cost of capital, capital budgeting, and capital structure. Surveys were sent to CFO's for firms listed in the Fortune 500 rankings. Approximately 40 % of the firms were manufacturers and another 15 % were financial. Respondents were asked on a scale from 0 to 4, "how Frequently does your Firm use the Following Techniques when Deciding which Projects or Acquisitions to Pursue." It listed 11 techniques with 0 representing "never use it" and 4 meaning "always use it." The most prominent method used in economic decision making seems to be the internal rate of return. The survey revealed that 75.61 % of respondents always or almost always use this method when making investment decision. The second most common metric was the net present value, where 74.93 % of respondents

indicated that always use it or they use it most of the time. These two metrics are the primary methods used in the Smart Investment Tool and SITExpress. The methods are discussed below.

1.1.1. Present Value

A critical concept for evaluating an investment decision is the time value of money; that is, the relationship between cash flows occurring at different time periods. For example, receiving $1000 today is typically preferred to receiving $1000 one year from now. In order to compare these two cash flows occurring at different dates, the future cash flow is *discounted* to equate its value to cash flows received today (Ross et al. 2005 pg 61; Defusco et al 2015 pg 2-3). This is done by dividing the future cash flow by an interest rate or discount rate:

$$PV_1 = \frac{CF_1}{1 + r}$$

Where
PV_1 = Present value of future cash flow after one year
CF_1 = Cash flow after one year
r = Discount rate which is, typically, between 0 and 1 where for instance a 10 % discount rate would be 0.1

The discount rate can be illustrated by considering how much one would need to be compensated to loan $1000 to someone for one year. If that value is $100, then the interest rate is 10 %, which is the discount rate. The $1100 dollars that would be received in one year is equivalent to $1000 today when discounted using a 10 % discount rate.

To calculate present value for cash flows after multiple years, the numerator in the equation is raised to the power of the number of years that have passed:

$$PV_t = \frac{CF_t}{(1 + r)^t}$$

Where
PV_t = Present value of future cash flow after number of t years
CF_t = Cash flow in year t
r = Discount rate which is, typically, between 0 and 1

1.1.2. Net Present Value

Net present value is the difference between the present value of all cash inflows and the present value of all cash outflows over the period of an investment, where present value is future cash flow discounted to equate its value to cash flows received today (Ross et al. 2005 pg 61; Defusco et al. 2015 pg 2-3, 44-45; Defusco et al. 2001 pg 54-56; Budnick 1988 pg 894-895):

$$NPV = \sum_{t=0}^{T} \frac{(I_t - C_t)}{(1+r)^t}$$

Where:

I_t = Total cash inflow in time period t

C_t = Total cost in time period t

r = Discount rate

t = Time period, which is typically measured in years

T = Study period

Net present value, which accounts for the time value of money, is a common metric for examining an investment, and is considered a superior method over many other approaches (Ross et al. 2005 pg 223; Helfert 2001 pg 235). The net cash inflows for each time period are divided by one plus a selected discount rate raised to the power of the time period, t. The basic interpretation of net present value is that if it is positive, it means that the return on the investment is expected to exceed the discount rate. Cash flows are relative to the base case; thus, the base case is subtracted from alternatives. An anticipated follow-up question is what the rate of return is on the investment, as the net present value does not reveal this information.

1.1.3. Internal Rate of Return

Internal rate of return is a widely used metric for evaluating investments. It has been suggested that in some industries, it is the principal method used for such analyses. The internal rate of return is, essentially, the discount rate at which the net present value is zero. Thus, it is calculated by setting NPV equal to zero and solving for *r* (Ross et al. 2005 pg 152-153; Defusco et al. 2001 pg 44-49). Due to the nature of this calculation, individuals often use software or trial and error to identify the internal rate of return (i.e., select varying discount rates in order to identify the value where the net present value equals zero).

1.1.4. Payback and Discounted Payback Periods

The estimation of the payback period is the year in which benefits first exceed costs. Note that costs in subsequent years could result in benefits exceeding costs and then later costs exceed benefits again. The tool identifies the first year that benefits exceed costs. The discounted payback period is the same as the payback period except that it uses present values or discounts cash flows using the discount rate.

1.1.5. Benefit Cost Ratio (BCR)

The benefit cost ratio is the sum of cash inflows less cash out flows for years 1 through the study period, excluding the initial investment. This value is then divided by the initial investment. The values are relative to the base case; thus, the base case values would need to be subtracted.

1.2. Method for Sensitivity Analysis

To account for uncertainty, a probabilistic sensitivity analysis can be conducted using Monte Carlo methods. This technique is based on works by McKay, Conover, and Beckman (1979 pg 239-245) and by Harris (1984) that involves a method of model sampling. It can be implemented using various software packages such as the Smart Investment Tool. Specification involves defining which variables are to be simulated, the distribution of each of the variables, and the number of iterations performed. The software then randomly samples from the probabilities for each input variable of interest. Three common distributions that are used include triangular, normal, and uniform. For more information on Monte Carlo analysis, please see Thomas (2017).

For a Monte Carlo analysis, one must also select the number of iterations that the simulation will run. Each iteration is similar to rolling a pair of dice, albeit, with the probabilities having been altered. In this case, the dice determine the price of the bearings. The number of iterations is the number of times this simulation is calculated. The benefit of Monte Carlo analysis is in the situation where there are many variables that can fluctuate (e.g., price of energy, materials, and labor). Instead of having just one price fluctuating, maybe a dozen prices fluctuate.

2. Smart Investment Tool

The Smart Investment Tool is an Excel tool that calculates present value, net present value, internal rate of return, payback period in years, and discounted payback period in years. The tool can be downloaded at: https://www.nist.gov/services-resources/software/smart-investment-tool. The tool has been tested on Microsoft Excel Version 2308 Build 16.0.16731.20542 32-bit. The first screen the user sees after downloading and opening the tool is the "Intro" tab shown in Figure 2.1. To get started, the user can either click on the "Start" tab highlighted in blue at the bottom or click the "Let's Get Started" button. The "Start" tab provides a series of steps for using the tool along with equations for using the Monte Carlo Analysis function (see Figure 2.2).

After reviewing the instructions, the user needs to navigate to the "Parameters" tab by either clicking on it at the bottom or clicking the "Next" button. The "Parameters" tab, shown in Figure 2.3, is where the user begins entering information, including the number of alternatives plus the base case (maximum of 15), the base year, study period (maximum of 100 years), and whether the values are in constant or current dollars. Constant dollars are in terms of a single year while current dollars are in terms of the year in which the cost occurs. When using constant dollars, the discount rate primarily reflects the users time value of money (i.e., real discount rate). When using constant dollars, the discount rate needs to reflect the users time value of money along with a projected rate of inflation (i.e., nominal discount rate). After entering the relevant information, the user clicks the "Submit" button, which reveals a tab named "Calculate" and a tab for the base case and each alternative.

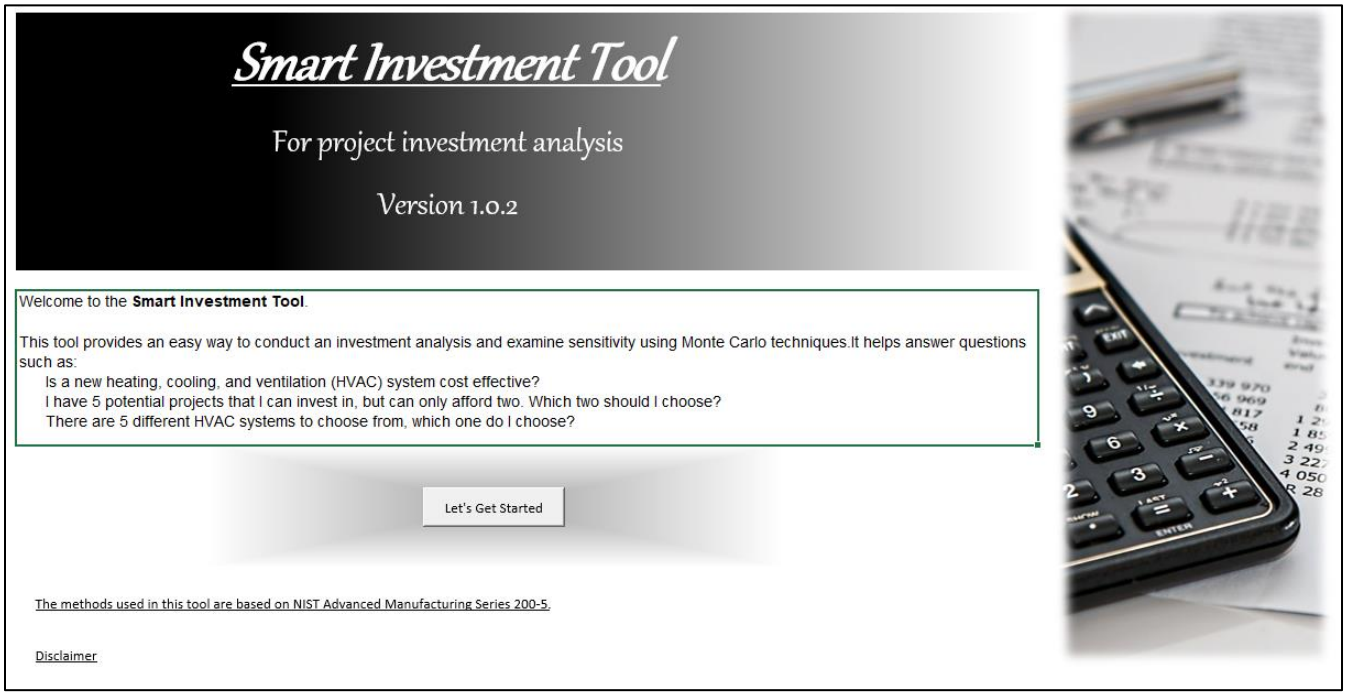


Figure 2.1: Intro Tab of the Smart Investment Tool

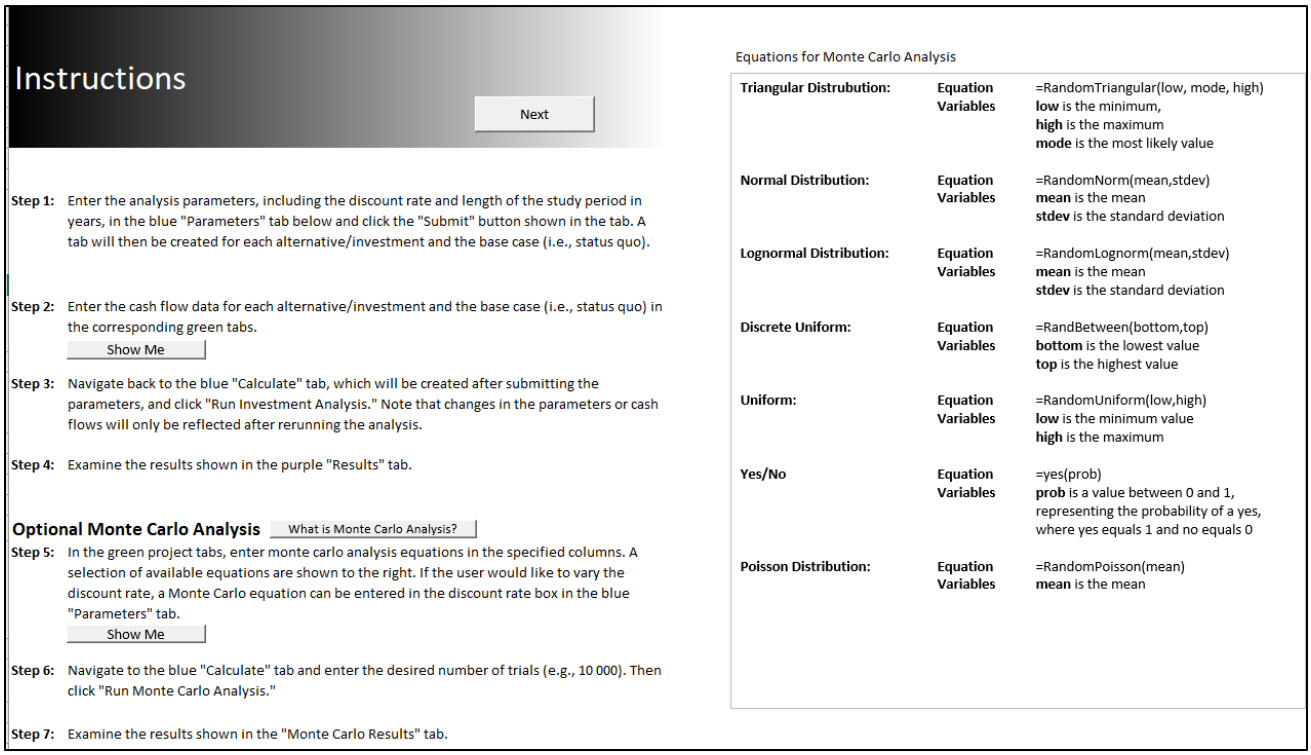


Figure 2.2: "Start" Tab

The “Calculate” Tab, shown in Figure 2.4, includes a button to “Run Investment Analysis” and to “Run Monte Carlo Analysis.” After entering data in the tabs for the Base Case and each alternative, the user clicks the “Run Investment Analysis” button to calculate the investment analysis results.

2.1. Investment Analysis

The base case and alternatives tabs (see example in Figure 2.5) allow the user to enter a name for the base case and alternatives along with up to one thousand cash flow items (e.g., costs or revenue) for the initial investment, future costs/revenue, and salvage value. Each cash flow item can have a name, short description, and indicate the relevant stakeholder. Cash inflows, including revenue or savings, must be entered as positive values while cash outflows such as costs and losses must be entered as negative values. The “Initial Investment” cash flow items occur at year zero.

Values for the initial investment are not adjusted in any way for estimating present value or net present value. “Future costs/revenue” occur at year one through the end of the study period. Again, the user can enter a name and description of each cash flow. The user must also enter a year of

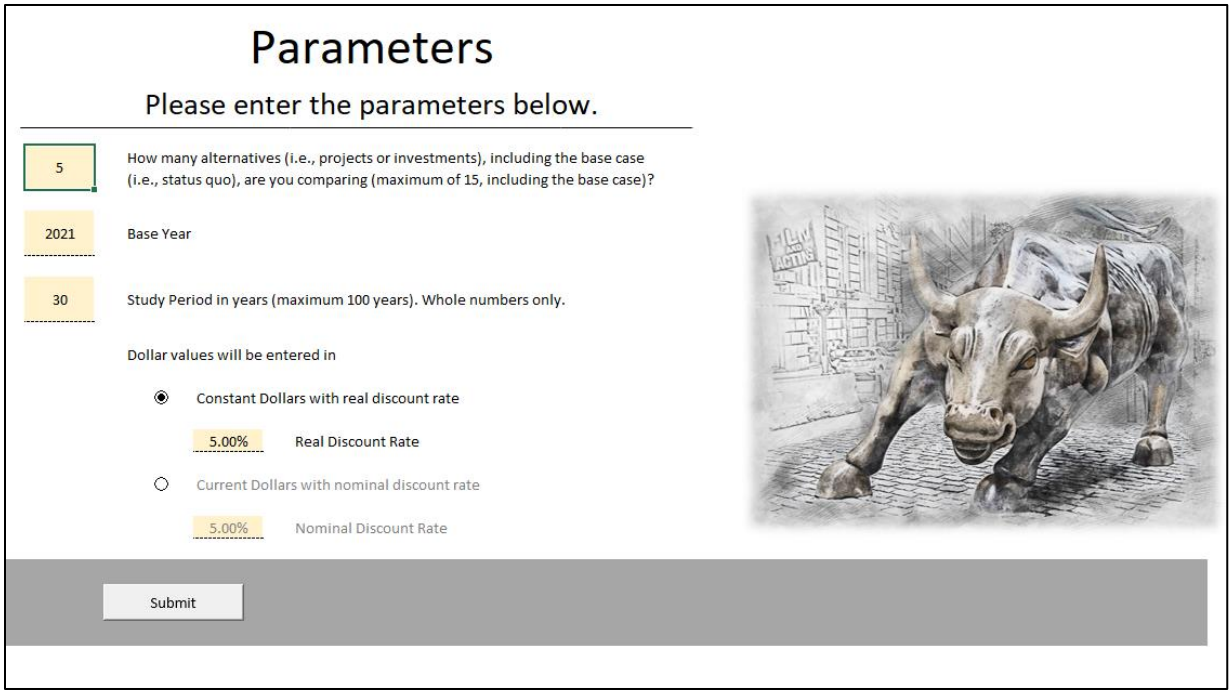


Figure 2.3: "Parameters" Tab

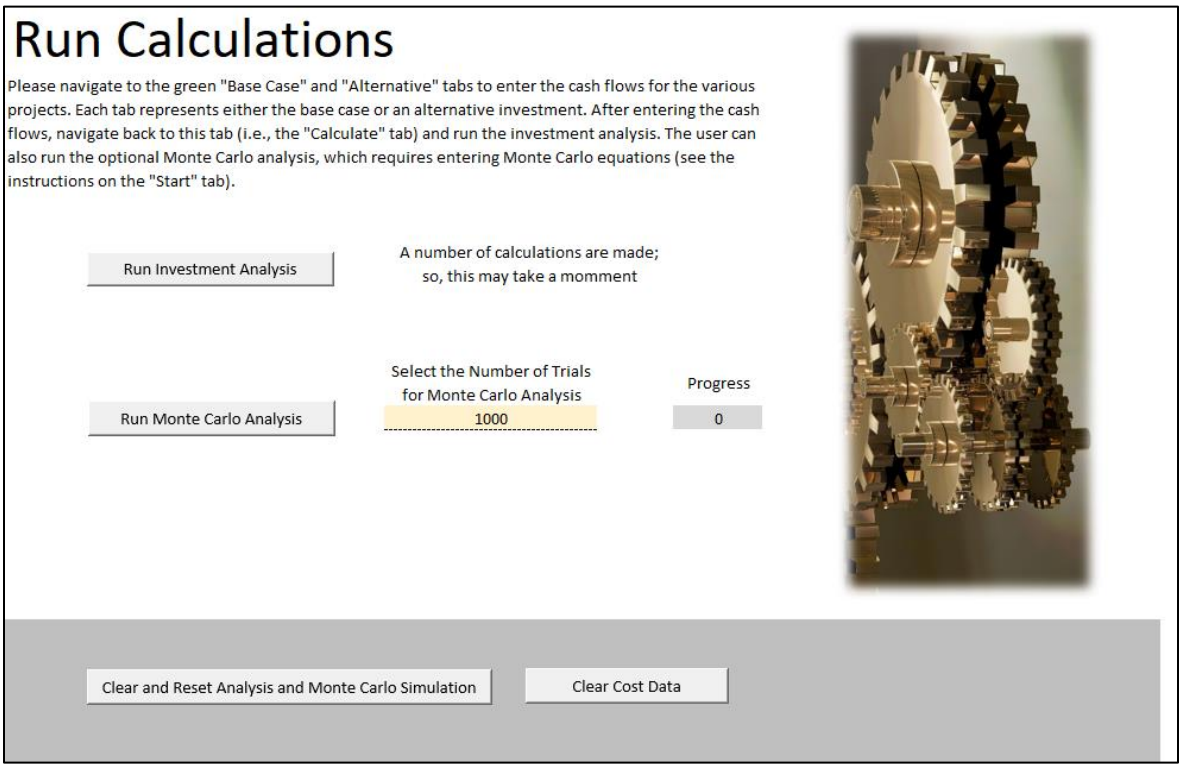


Figure 2.4: "Calculate" Tab

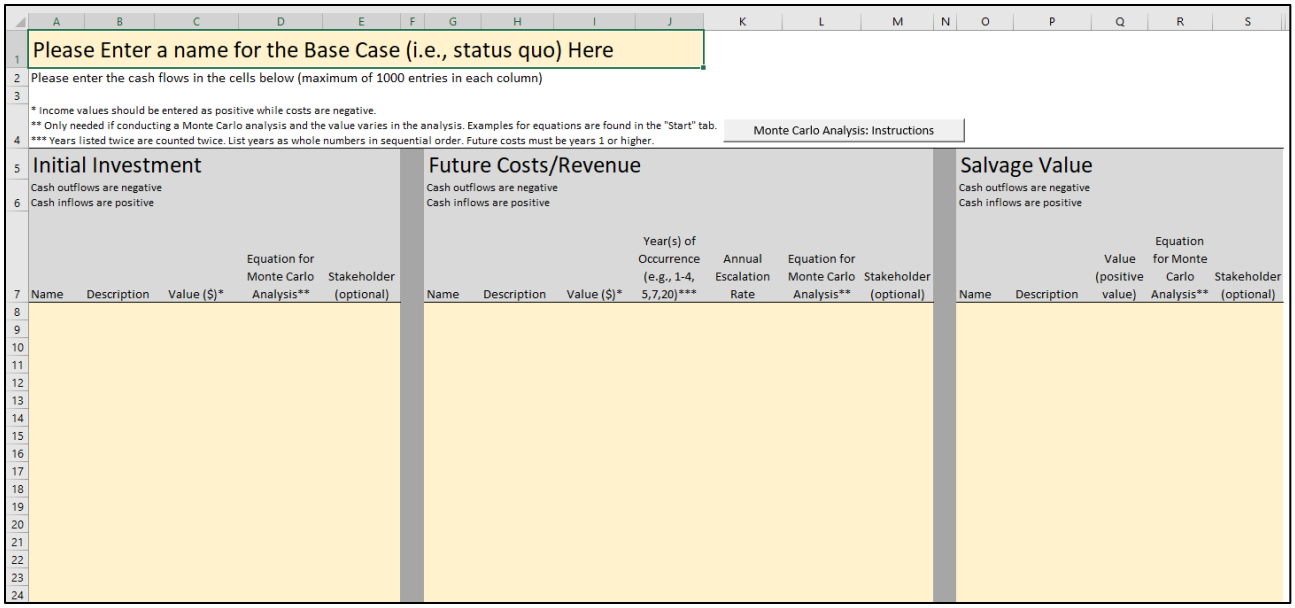


Figure 2.5: Tabs for the Base Case and Alternatives

occurrence in the "Year(s) of Occurrence" column. If the cash flow is recurring, the user can indicate the years of occurrence by entering the beginning and ending years with a hyphen in between. For instance, "1-8" indicates that the cash flow occurs in years one through eight. If the years are not sequential, then the user can use a comma to separate the years. For instance, "2,5,8" would indicate that the cash flow occurs in years 2, 5, and 8. Note that hyphens and commas can be used together to indicate both sequential and nonsequential years of occurrence (e.g., 1,5,8-10). "Future Costs/Revenue" are adjusted using the equation in Section 1.1.1 along with the discount rate and the year of occurrence indicated by the user to calculate net present value.

In the "Future Costs/Revenue" column there is an optional "Annual Escalation Rate" that allows the user to indicate a rate at which the cash flow increases. The escalation is calculated such that it escalates for every year of the study period; thus, if a $100 cost has a 10 % annual escalation rate, the cost in year one will be $110. If the cost occurs in year two it will be $121.

The "Salvage Value" category is for any value left at the end of the study period that is not accounted for, such as the value of machinery purchased for the investment. Similar to the other two categories, the user can enter a name, description, and indicate a relevant stakeholder. Salvage values are cash inflows and should be entered as positive values. Each of the cash flow categories (i.e., "Initial Investment," "Future Costs/Revenue," and "Salvage Value") have a column for an "Equation for Monte Carlo Analysis." In this column, the user can enter one of the distributions from the "Start" tab. This function is described in Section 2.2.

Once the user has entered all their cash flow data into the tool, they can calculate the present values, net present values, internal rate of return, payback period, and discounted payback period by navigating to the "Calculate" tab and click the "Run Investment Analysis" button. This

will reveal three tabs: “Results,” “Annual Present Values,” and “Annual NPV.” A discussion of interpreting results is found in Section 2.3.

2.2. Monte Carlo Analysis

To conduct a Monte Carlo Analysis, the user needs to enter equations in the “Base Case” and alternatives (e.g., “Alternative 1” and “Alternative 2”) tabs. There are seven distributions that the user can utilize, as shown in Table 2.1. For the cash flow items the user wants to vary, one of the equations must be entered into either the “Base Case” or alternatives tabs under one of the three columns labeled “Equation for Monte Carlo Analysis” (see example in Figure 2.6). For instance, suppose one of the cost items is fuel. The user estimates that it is a $5000 annual cost

Table 2.1: Monte Carlo Functions

Triangular Distribution:	**Equation**	=RandomTriangular(low, mode, high)
	Variables	**low** is the minimum, **high** is the maximum **mode** is the most likely value
Normal Distribution:	**Equation**	=RandomNorm(mean,stdev)
	Variables	**mean** is the mean **stdev** is the standard deviation
Lognormal Distribution:	**Equation**	=RandomLognorm(mean,stdev)
	Variables	**mean** is the mean **stdev** is the standard deviation
Discrete Uniform:	**Equation**	=RANDBETWEEN(bottom,top)
	Variables	**bottom** is the lowest value **top** is the highest value
Continuous Uniform:	**Equation**	=RandomUniform(low,high)
	Variables	**low** is the minimum value **high** is the maximum
Yes/No	**Equation**	=yes(prob)
	Variables	**prob** is a value between 0 and 1 that represents the probability of a yes, where yes equals 1 and no equals 0
Poisson Distribution:	**Equation**	=RandomPoisson(mean)
	Variables	**mean** is the mean

but might range between $4000 and $7000. They might use a triangular distribution and enter the following under the “Equation for Monte Carlo Analysis” column next to the $5000 cost:

=RandomTriangular(4000,5000,7000)

The user can then enter equations for any other values that they want to vary in a Monte Carlo analysis. If the user does not want to vary a cash flow, then it is not necessary to enter an equation.

Once the user has entered equations for all the cash flows they want varied, they can navigate to the “Calculate” tab. Next to the “Run Monte Carlo Analysis” button, there is a cell labeled “Select the Number of Trials for Monte Carlo Analysis.” As discussed in Section 1.2, to estimate an item a Monte Carlo analysis selects from a distribution and then iterates this process. The number of iterations needs to be selected by the user. Typically, 1000 or more iterations are used. Once the user enters the number of iterations, they can click the “Run Monte Carlo Analysis” button. Note that each time a Monte Carlo analysis is run it produces different results, as values are selected based on probabilities. After the analysis is complete, two tabs are revealed. The first is the ”Monte Carlo Results” tab, which displays statistics for each of the metrics: present value, net present value, internal rate of return, payback period, and discounted payback period. The lowest value (low), average, median, and highest value among the iterations (i.e., Monte Carlo simulations) for each metric (e.g., net present value and

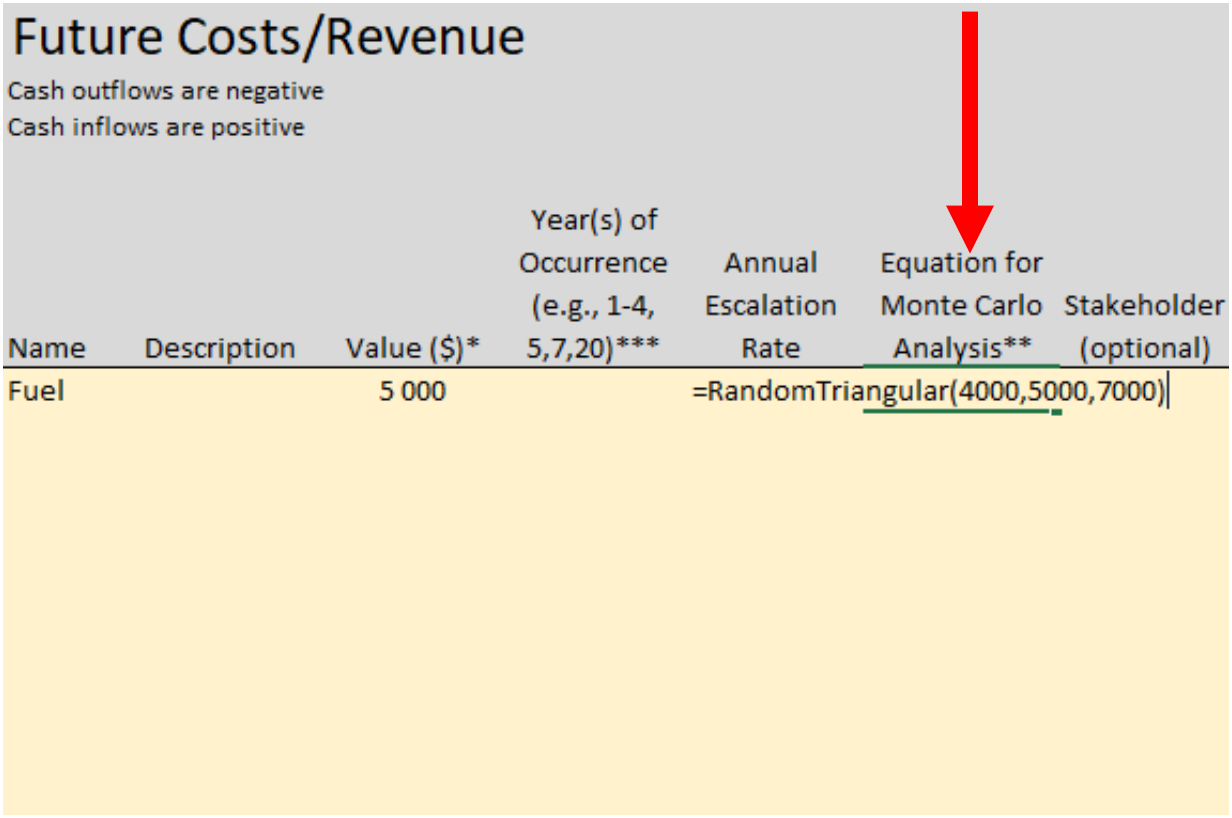


Figure 2.6: Monte Carlo Analysis Column for Future Costs/Revenue

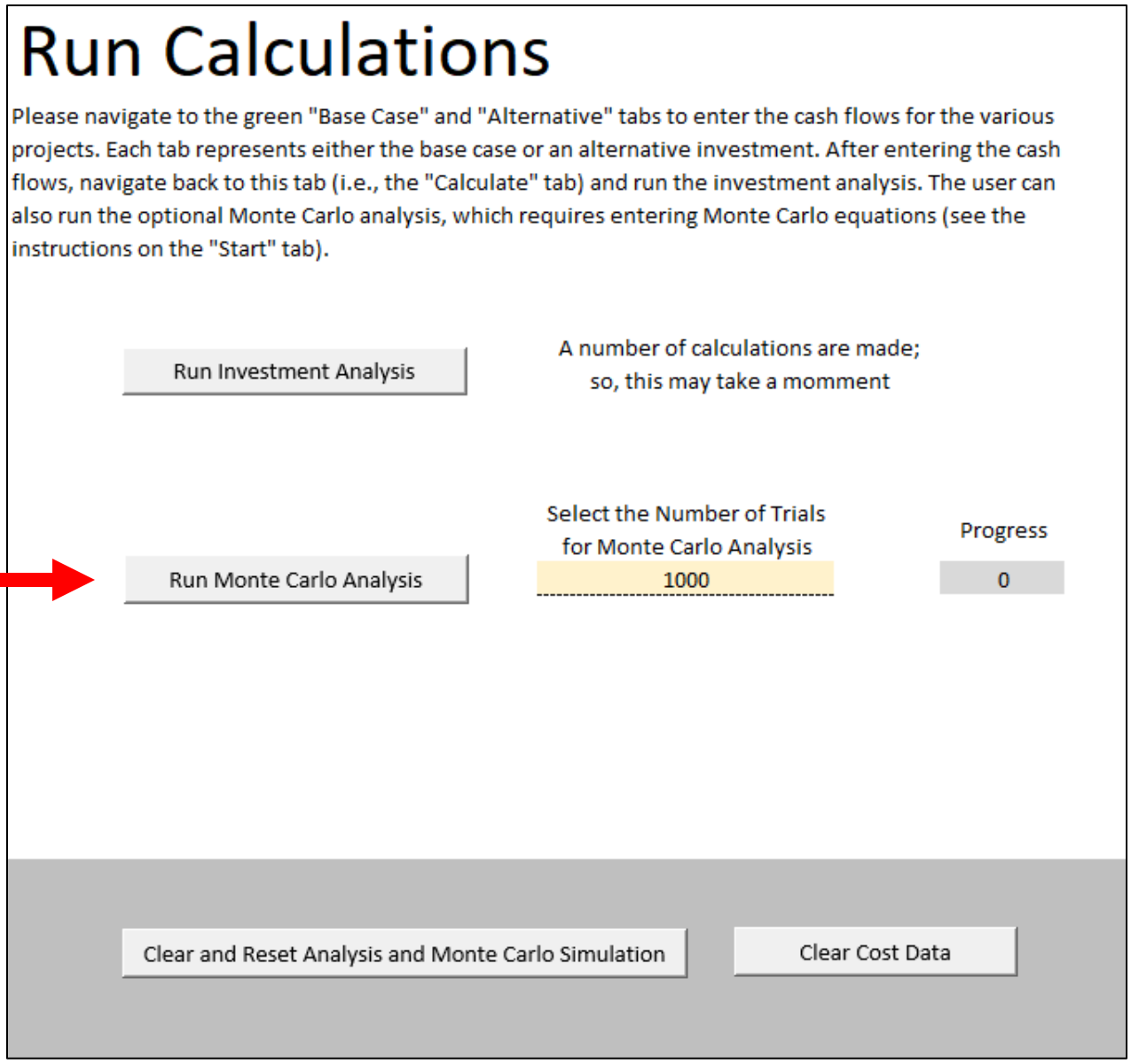


Figure 2.7: "Calculate" Tab

internal rate of return) is shown. The second tab, named “MC Data,” provides the estimated values for the metrics for each iteration. The user might need to scroll to the left to see the data. Users can use this data to calculate their own descriptive statistics, including the 95 % confidence interval.

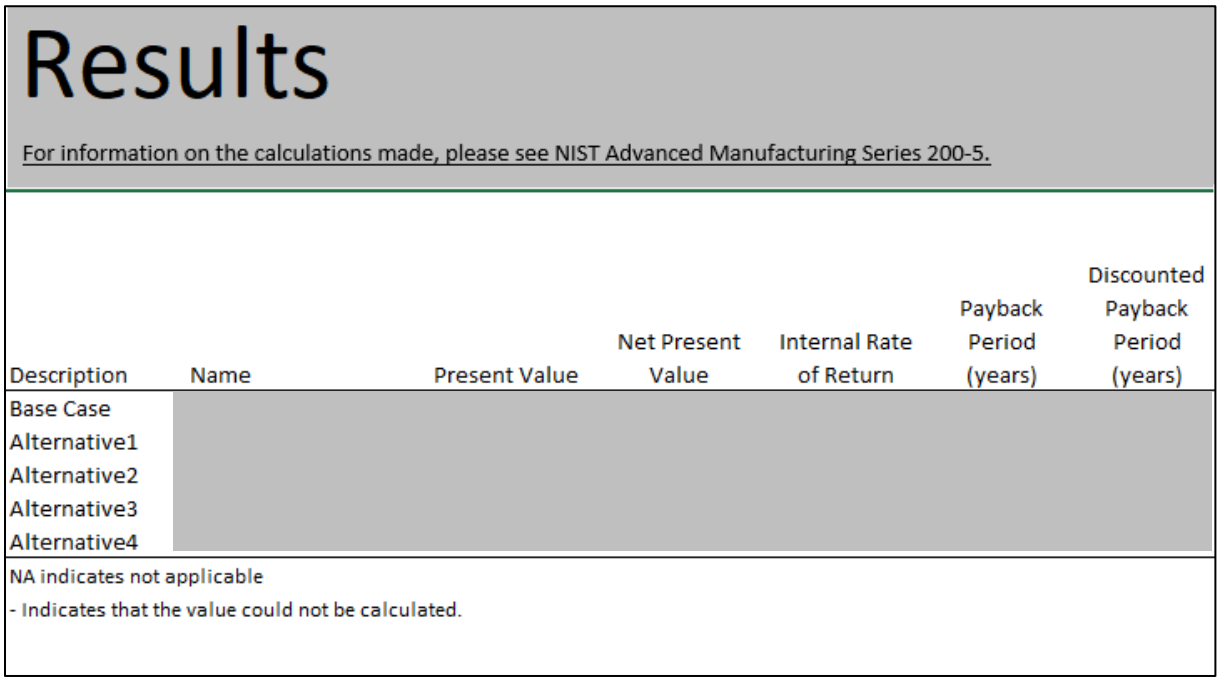
2.3. Results and Interpretation

Once the user has clicked the “Run Investment Analysis” tab and the “Run Monte Carlo Analysis” tab, five tabs are revealed with three of them being for the investment analysis and two being for the Monte Carlo analysis. The results tab shows the present value, net present

value, and internal rate of return (see Figure 2.8). A positive net present value indicates that the investment is economical when compared to the base case or the business as usual case. Since the examination of the alternatives is in comparison to the base case, there is no net present value, internal rate of return, payback period, or discounted payback period calculated. These cells indicate “NA” for not applicable. An internal rate of return that exceeds a user’s discount rate indicates an economical investment when compared to the base case. The payback period is more of an informational metric rather than one used to identify economical investments, but if the payback period is “None” then there is not a point in the study period where benefits exceed costs; thus, the investment is not economical. Many users may consider longer payback periods as being economically unfavorable.

The tab “Annual Present Values” presents the present value cash flows summed together for each year. The tab “Annual NPV” provides the sum of present value cash flows for each year less those for the “Base Case.” These two tabs are provided for informational purposes and by themselves without additional calculations do not indicate whether an investment would be considered economical.

The ”Monte Carlo Results” tab provides a statistical summary of the data in the “MC Data” tab when a Monte Carlo analysis is conducted. These values give an idea of the possible outcomes given the distributions entered by the user. The data in the “MC Data” tab can be used for further analysis such as identifying the percent of iterations that were cost effective.


Results

For information on the calculations made, please see NIST Advanced Manufacturing Series 200-5.

Description	Name	Present Value	Net Present Value	Internal Rate of Return	Payback Period (years)	Discounted Payback Period (years)
Base Case						
Alternative1						
Alternative2						
Alternative3						
Alternative4						

NA indicates not applicable

- Indicates that the value could not be calculated.

Figure 2.8: "Results" Tab

3. SITExpress

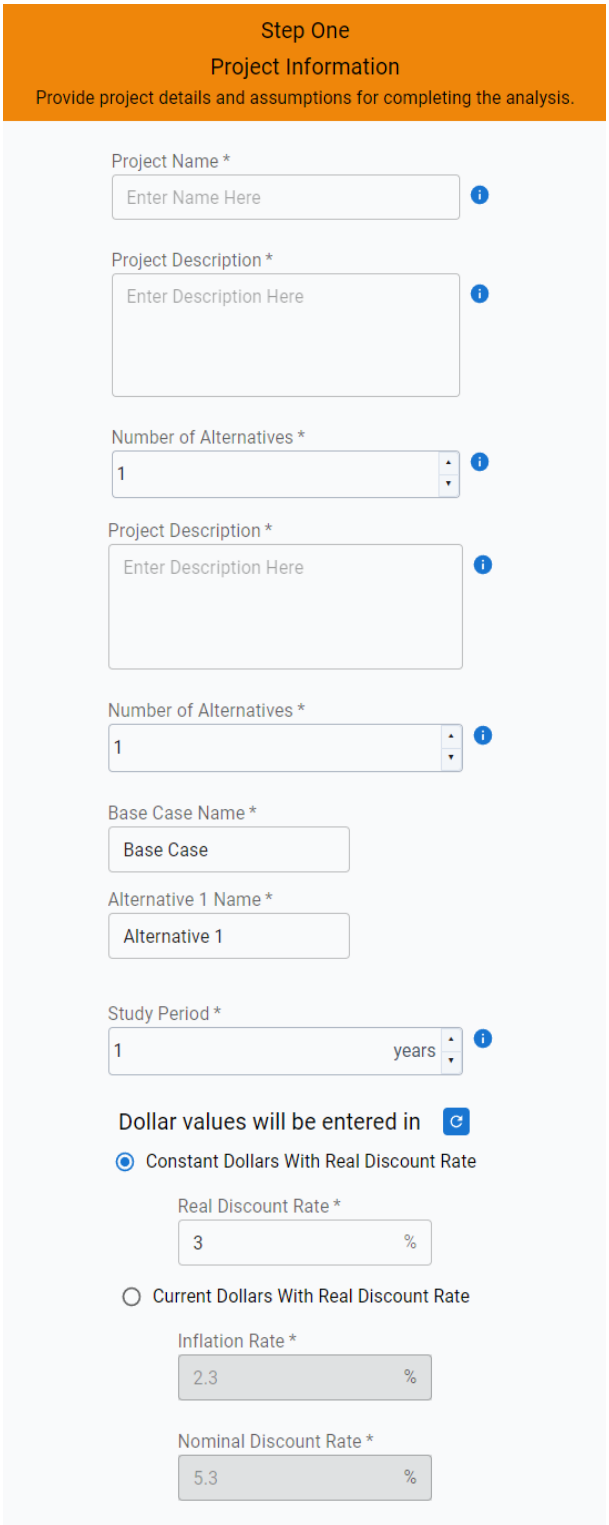
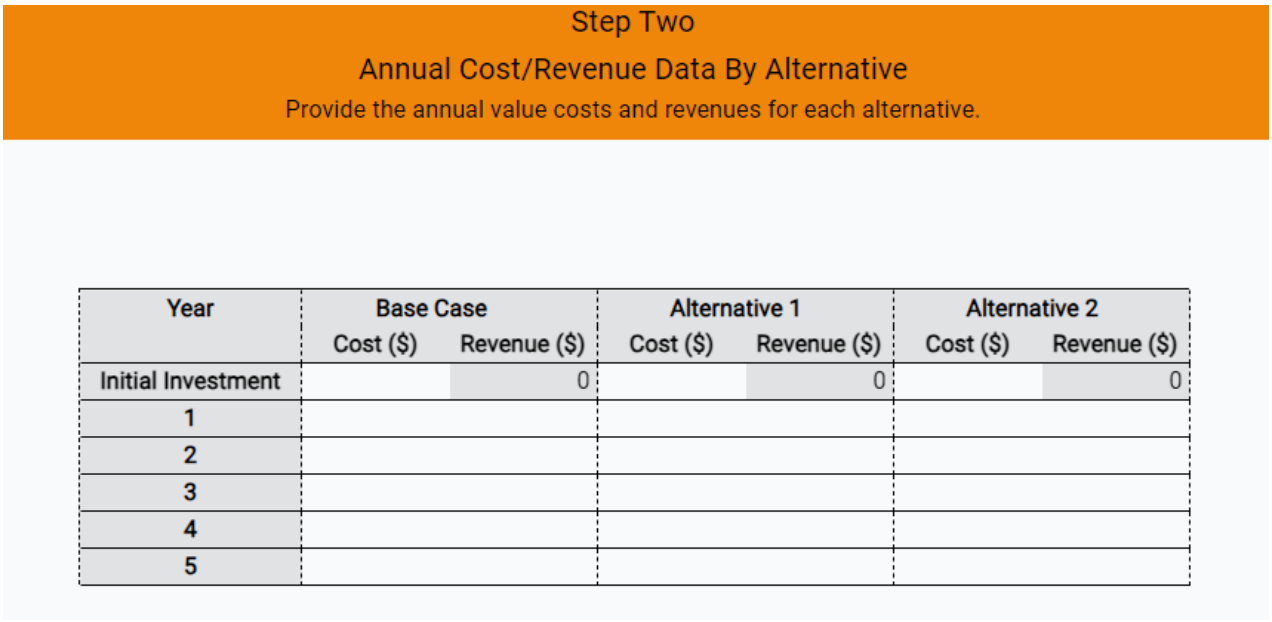


Figure 3.1: SITExpress, Step One

Smart Investment Tool Express (SITExpress) is a simplified online version of the Smart Investment Tool. It is located at: https://sitexpress.nist.gov/. All the data, information, and results are shown on a single webpage. In the first step (see Figure 3.1), which is found by scrolling down the page, the user inputs general information, including project name, description, the number of alternatives, name for the base case, alternative names, the study period, the discount rate, and whether the analysis is in current or constant dollars. There is a maximum of 5 alternatives and the study period can be no longer than 25 years. The user needs to enter text into the project name and description for the calculations to be completed. The labels for the base case and alternatives can be changed or left as the default text. The user will need to select a discount rate for the calculations. When using constant dollars, the discount rate is primarily the users time value of money (i.e., real discount rate). When using current dollars, the discount rate needs to reflect the users time value of money along with a projected rate of inflation (i.e., nominal discount rate). There is a field for the inflation rate; however, it is for the user's information and does not affect the calculations.

The second step (Figure 3.2), which is found by scrolling down the page further, is where the user enters cash flow data. Each year of the study period is listed on the left. The user can input one cost item for years 0 through to the end of the study period and one revenue item for years 1 through to the end of the study period along with an initial investment. Thus, the user might need to add



Year	Base Case		Alternative 1		Alternative 2	
	Cost ($)	Revenue ($)	Cost ($)	Revenue ($)	Cost ($)	Revenue ($)
Initial Investment		0		0		0
1						
2						
3						
4						
5						

Figure 3.2: SITExpress, Step Two

costs or revenue items that occur in the same year together to input in the tool. Users can manually type inputs or copy and paste from a spreadsheet (e.g., Excel). Once the data is entered, the user can click the "Run Results" button to calculate the results that appear in Step Three.

In Step Three, the results are displayed and include the present value, net present value, internal rate of return (IRR), payback period, discounted payback period, and benefit cost ratio (see Figure 3.3). The calculation of these items is discussed in Sections 1.1.1 through 1.1.5. The present value is for informational purposes. A positive net present value indicates that the investment is economical when compared to the base case. Since the examination of the alternatives is in comparison to the base case, there is no net present value, internal rate of return, payback period, or discounted payback period calculated for the base case. An IRR that exceeds a user's discount rate indicates an economical investment when compared to the base case. The payback period is more of an informational metric rather than one used to identify economical investments, but if the payback period is "None" then there is not a point in the study period where benefits exceed costs; thus, the investment is not economical. Many users may find that longer payback periods as being unfavorable. A positive benefit-cost ratio typically indicates an economical investment; however, it does not reflect the time value of money or inflation. Results are provided in a table as well as in graphical form by selecting on one of four tabs labeled "Present Value ($)," "Net Present Value ($)," "IRR (%)," and "BCR." Results can also be downloaded in a CSV or PDF file.

SITExpress calculates the results using NIST's Economic Evaluation Engine (E3) web application programming interface (API). E3 provides economic evaluation capabilities based on ASTM building economic standards including life-cycle cost analysis, benefit-cost analysis, profit maximization / cost-minimization, and risk-cost analysis. E3 is publicly accessible on a NIST

server as well as on GitHub for anyone to use for economic analysis, whether it is through a basic script calling on the E3 API, online interface that connects to the E3 API, or an executable program that is built on E3's capabilities. Additionally, users of E3 could provide expansions to the capabilities by developing the code and submitting it to NIST for review and incorporation. For more details about E3, please see NIST TN 2225r1.

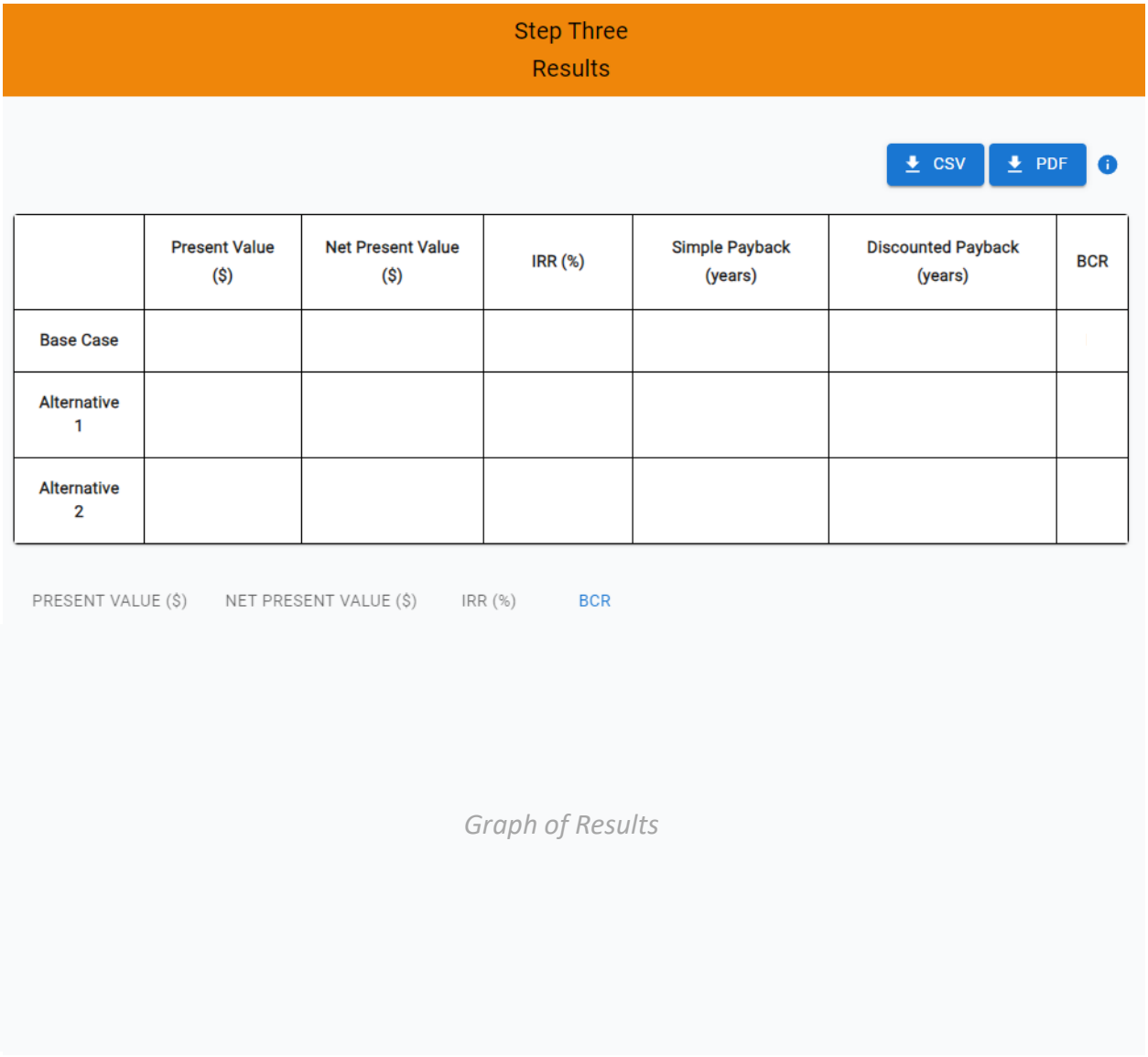


Figure 3.3: SITExpress, Step Three

4. Summary

This document provides guidance for using NIST's Smart Investment Tool and its express version SITExpress. These tools aid a user in conducting an investment analysis with a focus on those in the manufacturing industry; however, the methods can be used for any investment. The Smart Investment Tool is an Excel tool that allows users to specify detailed cash flows where they can enter multiple costs per year. It estimates net present value, internal rate of return, payback period, and examines sensitivity using Monte Carlo analysis. A user might opt for this tool in situations where they want to enter and/or edit many cost items and conduct more advanced analyses.

SITExpress is an express version of the Smart Investment Tool where it estimates similar metrics (net present value, internal rate of return, payback period, and the benefit cost ratio) from user data. The express version, however, is an online tool where the user enters aggregated total annual cash inflows and outflows; that is, the user only enters two values for each year: cash inflow and cash outflow. A user might opt for this tool if they want to make a quick investment calculation rather than conducting an extensive analysis.

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